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Rainer W. Hasse

February 1971

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Contents

Abstract	1
I. Introduction	3
II. Droplet Model Energy	6
III. Truncated Droplet Model Barrier Formula	14
IV. Parameterizations of the Nuclear Surface	20
V. Series Expansions for a Slightly Distorted Sphere and for Spheroids	28
VI. Calculations for Configurations of Tangent and Separated Fragments	33
VII. Numerical Calculations with General Parameterizations	35
VIII. Asymmetric Distortions	41
IX. Normal Modes of Oscillation	46
X. Discussion	48
XI. Summary	60
Acknowledgments	62
References	64
Tables	69
Figure Captions	78
Figures	83
Appendices:	
A1. Constants of the Droplet Model	126
A2. Numerical Methods and Accuracy	133
A3. Collection of Liquid Drop and Droplet Model Formulae	135
A4. Listings of the Numerical Results	145
A5. Listing of the Relative Strengths of the Droplet Model Parameters	169

STUDIES IN THE SHAPE DEPENDENCE OF THE DROPLET MODEL OF NUCLEI
(CURVATURE AND COMPRESSIBILITY EFFECTS)*

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February 1971

ABSTRACT

A study is made of the shape dependence of various terms appearing in the nuclear droplet model of Myers and Swiatecki. The new terms which arise here beyond those encountered in the liquid drop model are due to the curvature correction to the surface energy, the nuclear compressibility and the redistribution of the nuclear density caused by the Coulomb force. Shell and pairing energies are omitted because they have their origin in the microscopic rather than the macroscopic structure of nuclei.

The shape dependent droplet model which results is used with a variety of shape parameterizations to calculate nuclear saddle point shapes corresponding to the fission barrier. Various properties of these shapes are given such as the barrier heights, geometrical properties, and normal modes of oscillation. The stability of the reflection symmetric saddle points against asymmetric distortions is also investigated.

* Work partly done at the Physikalisches Institut der Universität Würzburg, 87 Würzburg, Germany, as a NATO fellow at the Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830 and at the Institut für Theoretische Physik der Universität Heidelberg, Abteilung für Kernphysik, 69 Heidelberg, Germany (present address).

Of the new terms which enter in this model the only one which has a major influence on the saddle point properties is the curvature correction to the surface energy. For reasonable estimates of the droplet model constants the other terms produce only small effects. Large values of the curvature correction coefficient favor the formation of a secondary minimum in the fission barrier of heavy elements. For super heavy elements this gives rise to the possibility of quasi molecular states.

The Coulomb redistribution energy is shown to favor the formation of asymmetric scission point configurations.

I. INTRODUCTION

Since the time when von Weizsäcker (1) and Bohr and Wheeler (2) developed the liquid drop model (LDM) of nuclei, numerous works have appeared which deal with the statics and the dynamics of this model.

Frankel and Metropolis (3) were the first to predict fission barriers by using an electronic computer to search for saddle points in deformation space. A series of papers from Swiatecki (4-6) and Cohen and Swiatecki (7,8) continued this work. Dynamical studies were not carried out until recently (9-14) because of the difficulty of solving the equations of motion.

On the other hand, in order to calculate nuclear masses and related quantities, many refinements have been applied to the LDM binding energy: Hill and Wheeler (15), Strutinskii (16), and Hilf and Süssmann (17) studied the curvature correction and Swiatecki (18,19) introduced the compressibility and the resulting Coulomb redistribution energy. The exchange term was already given by Bethe and Bacher (20) and the diffuseness term was added by Myers and Swiatecki (21,22) to result in a mass formula from the latter authors which fairly well reproduced the average trends of the experimentally known ground state masses, quadrupole moments and fission barriers.

The most recent and systematic studies in the subject of a macroscopic theory of nuclei were carried out by Myers and Swiatecki (23,24). In the leptodermous (thin surface) approach they expanded the charge independent part of the binding energy per nucleon in terms of the small quantities $A^{-1/3}$ and $I^2 = [(N-Z)/A]^2$ up to the second order. This is one order higher than in the LDM. The Coulomb energy was treated separately to include all terms like diffuseness, exchange and redistribution energies.

The resulting droplet model (DM) unifies most of the known contributions to the gross nuclear binding energy. However, the behavior of such a nucleus is not yet that of a real nucleus, because shell and pairing effects are not considered.

The parameters of the DM mass formula have not yet been fitted to nuclear ground state masses. However, with an estimated set of constants it did reproduce, the isotope shifts reasonably well (25) and predicted single particle wells (26).

In the first stages (23) the DM was only developed for spherical shapes and it, hence, could only be applied to the spherical ground states of nuclei. However, it was straightforward to generalize the results to deformed shapes (24).

The subject of this paper is to study the shape dependence of the DM. Since, in addition to the Coulomb and surface energies, only the curvature, Coulomb and surface redistribution, and compressibility energies depend upon deformation, the studies are restricted to these terms.

The shape dependences are evaluated in various parameterizations of the nuclear surface which cover a wide variety of deformations: For slightly deformed nuclei, an expansion of the radius vector in Legendre polynomials P_2 and P_4 will be used to yield expansions of the shape dependences in α_2 and α_4 . Spheroids and series expansions in terms of the eccentricities ϵ and e allow for prolate and oblate deformations. Configurations of tangent and separated fragments will be obtained by using the parameterizations of tangent and separated spheres and spheroids. The interval of deformations in between will be handled numerically by generalized spheroids (spheroids with an additional degree of freedom for the construction of a neck), by dumbbell shapes and by the so-called Nix shapes

which consist of three portions of quadratic surfaces. Other parameterizations will be mentioned and the advantages of one over the other parameterization will be discussed.

Saddle points are calculated by making the DM energy stationary with respect to certain deformation coordinates and various physical quantities at the symmetric saddle points are calculated such as length, neck radius, quadrupole moment, moments of inertia, and normal modes of oscillation. From the saddle point energies, fission barriers are obtained and compared with experiments. The symmetric saddle points are not always stable against asymmetric distortions. Therefore the critical Businaro Gallone points are investigated where the saddle loses its stability.

In most parts of this paper we shall restrict ourselves to a truncated form of the DM, i.e. we shall neglect the effect of the Coulomb energy on the dilation of the nucleus and on the neutron skin thickness. In addition, we will use an expanded form of the DM in order to consider the DM as the LDM with linear corrections. After having defined a set of parameters which are equivalent to the coefficients of the DM, a LDM like DM barrier formula is given.

As important results, we note here that the curvature energy has the effect of flattening the shape of the fission barrier and can even produce a secondary minimum in the barrier. This minimum is most pronounced in case of the heavy nuclei like actinides and goes over into a quasi molecular minimum for the super heavy nuclei. This effect was first found by v. Groote and Hilf (55) by using generalized spheroids; however, they did not determine whether the effect remains when other parameterizations are used or when the full droplet model shape dependence is employed. On the other hand, the Coulomb

redistribution energy can produce a minimum in the potential energy vs. mass ratio of two tangent fragments so that asymmetric fission may be favored.

II. DROPLET MODEL ENERGY

The derivation of the DM as performed by Myers and Swiatecki (23,24) is briefly outlined here.

The actual neutron and proton density distributions of a nucleus are divided into two regions, the bulk region with its densities ρ_N , ρ_Z and $\rho = \rho_N + \rho_Z$, and the surface region. Extrapolation of the bulk densities into the surface region defines the sharp effective radii R_N , R_Z , and R so that all neutrons, protons or nucleons, respectively, are contained inside these radii. These densities are taken to be the degrees of freedom of this two component system and the total energy, consisting of volume, surface and Coulomb energies, is written as a functional in the degrees of freedom.

The problem is simplified by the introduction of the quantities ϵ , the deviation of the bulk density ρ from its nuclear matter value ρ_0 ,

$$\epsilon = -\frac{1}{3} \frac{\rho - \rho_0}{\rho_0} \quad , \quad (2.1)$$

and δ , the difference between the neutron and proton bulk densities,

$$\delta = \frac{\rho_N - \rho_Z}{\rho} \quad . \quad (2.2)$$

(The quantity δ is in the first order the relative neutron excess I). The differences ϵ and δ are divided into two parts, their average values $\bar{\epsilon}$ and $\bar{\delta}$ and their deviations from their averages, $\tilde{\epsilon}$ and $\tilde{\delta}$ according to

$$\begin{aligned}\epsilon &= \bar{\epsilon} + \tilde{\epsilon} \\ \delta &= \bar{\delta} + \tilde{\delta}\end{aligned}\quad (2.3)$$

The total energy is now minimized with respect to variations in $\bar{\epsilon}$, $\bar{\delta}$, $\tilde{\epsilon}$, and $\tilde{\delta}$ to yield the equilibrium values. These are inserted into the total energy and terms are kept which are in the proper order of the leptodermous expansion, the basis of the DM. The stationary total energy then reads

$$\begin{aligned}E_{\text{total}} &= [-a_1 + J\bar{\delta}^2 - \frac{1}{2} K\bar{\epsilon}^2 + \frac{1}{2} M\bar{\delta}^4] \cdot A \\ &+ [a_2 + \frac{9J^2}{4Q} \bar{\delta}^2] \cdot A^{2/3} B_{\text{surf}} + a_3 A^{1/3} B_{\text{curv}} \\ &+ c_1 Z^2 A^{-1/3} B_{\text{Coul}} - c_2 Z^2 A^{1/3} B_{\text{red}} \\ &- c_3 Z^2 A^{-1} - c_4 Z^{4/3} A^{-1/3} - c_5 Z^2 B_{\text{sr2}}\end{aligned}\quad (2.4)$$

where

$$\bar{\delta} = [I + \frac{3c_1}{16Q} Z A^{-2/3} B_{\text{sr1}}] / [1 + \frac{9J}{4Q} A^{-1/3} B_{\text{surf}}] \quad (2.5)$$

$$\bar{\epsilon} = \frac{1}{K} [-2a_2 A^{-1/3} B_{\text{surf}} + c_1 Z^2 A^{-4/3} B_{\text{Coul}} + L \bar{\delta}^2] \quad (2.6)$$

Apart from A , N , Z , and I which specify the nucleus under consideration, the total energy contains two sets of quantities, constants and shape dependences. The constants in the notation of Myers and Swiatecki are as follows.

a_1 : volume energy coefficient
 a_2 : surface energy coefficient
 a_3 : curvature energy coefficient
 c_1 : Coulomb energy coefficient
 c_2 : Coulomb redistribution coefficient
 c_3 : Coulomb diffuseness coefficient
 c_4 : Coulomb exchange coefficient
 c_5 : surface redistribution coefficient of second kind
J: symmetry energy coefficient
K: compressibility coefficient
L: density-symmetry coefficient
M: symmetry anharmonicity coefficient
Q: effective surface stiffness coefficient.

The shape dependences are defined in the usual way to assume the value of unity for spherical shapes.

B_{surf} : surface energy shape dependence
 B_{Coul} : Coulomb energy shape dependence
 B_{curv} : curvature energy shape dependence
 B_{red} : Coulomb redistribution shape dependence
 B_{sr1} : shape dependence of the surface redistribution of the first kind
 B_{sr2} : shape dependence of the surface redistribution of the second kind

They will be discussed later on.

The first terms in each of the first three lines of Eq. (2.4) form the LDM binding energy

$$\begin{aligned}
 E_{\text{total}}^{\text{LDM}} = & -a_1 A && \text{(volume energy)} \\
 & + a_2 A^{2/3} B_{\text{surf}} && \text{(surface energy)} \\
 & + c_1 Z^2 A^{-1/3} B_{\text{Coul}} && \text{(Coulomb energy)} \quad . \quad (2.7)
 \end{aligned}$$

The additional DM energies which do not depend on $\bar{\epsilon}$ or $\bar{\delta}$ can be interpreted easily. They are

$$+ a_3 A^{1/3} B_{\text{curv}} \quad \text{(curvature energy)} \quad , \quad (2.8)$$

the correction to the surface energy due to the finite curvature of the surface,

$$-c_2 Z^2 A^{1/3} B_{\text{red}} \quad \text{(Coulomb redistribution energy)} \quad , \quad (2.9)$$

and

$$-c_5 Z^2 B_{\text{sr2}} \quad \text{(surface redistribution energy of second kind)} \quad , \quad (2.10)$$

which both come from the redistribution of the neutrons and protons due to compression of the nucleus, and

$$-c_3 Z^2 A^{-1} \quad \text{(diffuseness energy)} \quad , \quad (2.11)$$

$$-c_4 Z^{4/3} A^{-1/3} \quad \text{(exchange energy)} \quad , \quad (2.12)$$

which are corrections to the Coulomb energy for the diffuse surface and for the exchange effect caused by the Pauli principle.

There is a major difficulty in interpreting the rest of the additional terms of the DM because $\bar{\delta}$ is not simply a function of I but also of A , especially in the denominator. The second term in the denominator is only small compared with unity if the relation holds

$$A \gg \left(\frac{4Q}{9J}\right)^3 \approx 61. \quad (2.13)$$

This problem is discussed extensively in Ref. (23). For nuclei with $A^{1/3} = 6$ (actinides) the correction due to the denominator still reduces $\bar{\delta}$ to 60% of its original value.

Nevertheless, the expansion can be done formally but with a loss of numerical accuracy. Using

$$\bar{\delta} = \left[I + \frac{3c_1}{16Q} Z A^{-2/3} B_{\text{sr1}}^{1/2} \right] \cdot \left[1 - \frac{9J}{4Q} A^{-1/3} B_{\text{surf}} \dots \right], \quad (2.14)$$

and inserting Eqs. (2.6) and (2.14) into Eq. (2.4) yields the following symmetry energies.

$$+a_1 b_1 A I^2 \quad (\text{volume symmetry energy of first order}), \quad (2.15)$$

$$\text{with } b_1 = J/a_1,$$

$$-a_1 b_2 A I^4 \quad (\text{volume symmetry energy of second order}), \quad (2.16)$$

$$\text{with } b_2 = (L^2/K-M)/2a_1,$$

$$-a_2 b_3 A^{2/3} I^2 B_{\text{surf}} \quad (\text{surface symmetry energy}), \quad (2.17)$$

with $b_3 = 9J^2/4Qa_2 - 2L/K$. In the earlier mass formulae of Myers and Swiatecki (21,22) the quantities b_1 and b_3 are equal and are denoted by κ .

The finite compressibility of nuclear matter which is included in the DM gives rise to the compressibility energy

$$- \frac{1}{2KA} [2E_{\text{surf}} - E_{\text{Coul}}]^2. \quad (2.18)$$

It reflects both the compression by the surface tension and the dilation by the Coulomb energy. Together with the associated Coulomb redistribution energy, Eq. (2.9), the surface part of the compressibility energy was discussed earlier by Swiatecki (18,19). Equation (2.18) can be rewritten as

$$-a_4 A^{1/3} B_{\text{comp}} \left(1 - x \frac{B_{\text{Coul}}}{B_{\text{surf}}}\right)^2, \quad (2.19)$$

where $a_4 = 2a_2^2/K$ and x is the usual Bohr and Wheeler (2) fissility

$$x = \frac{E_{\text{Coul}}(\text{sphere})}{2E_{\text{surf}}(\text{sphere})}. \quad (2.20)$$

In the truncated form of the DM, the effect of the Coulomb energy on the dilation of the nucleus will be neglected as it is in Refs. (18,19). In this case the shape dependence of the compressibility energy is simply

$$B_{\text{comp}} = B_{\text{surf}}^2. \quad (2.21)$$

Apart from these energies, the expansion Eq. (2.14) yields more terms than can be easily interpreted, most of them square or cross terms. Two of them shall be mentioned here. The first one, because it is similar to the surface

redistribution energy of second kind in its dependence on A and Z and on shape,

$$+c_6 Z^2 A^{-1/3} B_{\text{srl}} \quad (\text{surface redistribution energy of first kind}) \quad (2.22)$$

with $c_6 = 9Jc_1^2/256 Q^2$, and the second one because it is numerically the largest,

$$+d_1 IZA^{1/3} B_{\text{srl}}^{1/2} \quad (\text{cross term between symmetry and surface redistribution of first kind}) \quad (2.23)$$

with $d_1 = 3Jc_1/8Q$.

Some of the energies, the volume energy and its associated symmetry energies of first and second order, the diffuseness, and the exchange energies, are not shape dependent and therefore only important in calculating ground state masses. Since this paper only deals with barrier energies, i.e. differences between saddle and ground state energies, they cancel out and do not enter into the calculations.

Hence in addition to the shape dependences of the LDM, i.e. the relative surface and Coulomb energies, only the relative curvature and compressibility energies and the three shape dependences of the redistribution energies appear in the DM.

The shape dependence of the curvature energy was found to be proportional to the surface integral over the reciprocal Gaussian principal curvature radii of a given point on the surface (cf. Refs. (15-17,27)) and the shape dependence of the compressibility energy is simply the square of the relative surface energy, Eq. (2.21). As regards the redistribution energies, their shape dependences are quite similar; in all of them the difference between an average and

the local Coulomb potential is involved. Explicitly, the relative Coulomb redistribution energy is proportional to the volume integral over the square of the difference between the local Coulomb potential at a point within the volume and the average Coulomb potential over the volume. The relative surface redistribution energies of first and second kind are proportional to the square of the surface integral over the difference between the local Coulomb potential on the surface and the average Coulomb potential over the volume, or to the surface integral over the square of the difference between the same quantities, respectively. The exact definitions of all shape dependences can be seen in Eqs. [2A] through [15A] of Table A3 in appendix 3.*

In addition to the shell and pairing energies we will also omit the so-called Wigner term, an energy which is a function of the neutron excess, $E_{\text{Wigner}} = f(|N-Z|)$ since it is still under investigation and merely important for the light neutron deficient nuclei.

After having given a short summary of the droplet model and having interpreted the energies involved, we present a table from which the magnitudes of the energy terms can be read off (Table I). For the computation of the single energies we used the set of constants calculated by Myers and Swiatecki (23) with the Thomas-Fermi model. However, the surface tension a_2 and the Coulomb strength c_1 , were re-adjusted to reproduce the LDM, as described in appendix 1. This appendix gives also other possibilities for determining the constants.

* Formulae from this table are referred to in square brackets, e.g. Eq. [12C] is the equation in row [12] and column [C].

It can be seen from Table I that the major part of the total energy comes from the volume and surface energies (including their symmetry energies) and from the Coulomb energy. The largest shape dependent correction from the DM is the curvature energy while the compressibility and redistribution energies are smaller by about an order of magnitude. Therefore in the following, we mostly confine ourselves to the effect of the curvature energy. From the magnitude of the last term, the cross term between symmetry and surface redistribution of first kind, one can see that the expansion Eq. (2.14) is still not appropriate even for this heavy nucleus. However, the expanded form will only be used to study the new shape dependences and B_{srl} is contained in the surface redistribution energy of first kind as well.

III. TRUNCATED DROPLET MODEL BARRIER FORMULA

The DM energy expression in its full generality as given by Eqs. (2.4) through (2.6) is the most advanced formula known for the description of the average trends of nuclear binding energies. It has, however, two major disadvantages in practical use.

- (i) The set of constants is only approximately known at present and
- (ii) Because of the denominator in the expression for $\bar{\delta}$, it cannot be completely separated into single energies. The first objection will be removed in the near future since investigations are presently done to fit the DM mass formula to experimentally known quantities (cf. appendix 1). The second point, the complexity of the DM energy, is a basic problem. Masses and fission barriers could be calculated numerically but, in contrast with the LDM, there would be a loss of distinctness in the results. Therefore, in addition to calculating

fission barriers with an electronic computer (see chapter 10), we used a truncated and linearized version of the DM energy to obtain analytical results.

The truncation of the model consists of neglecting the reaction of the Coulomb energy on the dilation of the nucleus and on the neutron skin. This means that all redistribution effects are omitted and also the influence of the Coulomb energy on the compressibility energy. The linearization of the DM energy consists of adapting the symmetry energies in their linear forms as given by Eqs. (2.15)...(2.17). The shape dependences of the redistribution energies, Eqs. (2.9), (2.10) and (2.22), however, will also be evaluated and the Coulomb redistribution energy by itself will be included in the discussion.

The truncated and linearized DM model energy, including the Coulomb redistribution energy, reads

$$\begin{aligned}
 E_{\text{total}} = & -a_1(1 - b_1 I^2 + b_2 I^4)A \\
 & + a_2(1 - b_3 I^2)A^{2/3}B_{\text{surf}} + a_3 A^{1/3}B_{\text{curv}} - a_4 A^{1/3}B_{\text{comp}} \\
 & + c_1 Z^2 A^{-1/3}B_{\text{Coul}} - c_2 Z^2 A^{1/3}B_{\text{red}} \\
 & - c_3 Z^2 A^{-1} - c_4 Z^4 A^{-1/3} \quad . \quad (3.1)
 \end{aligned}$$

The deformation energy of a nucleus is defined as the energy for some deformation minus the energy of the same but spherical nucleus. With the abbreviation*

$$K = 1 - b_3 I^2$$

* K is not to be confused with the compression modulus.

for the surface symmetry energy correction, the deformation energy can be written as

$$E_{\text{Def}} = a_2 K A^{2/3} (B_{\text{surf}} - 1) + a_3 A^{1/3} (B_{\text{curv}} - 1) - a_4 A^{1/3} (B_{\text{comp}} - 1) \\ + c_1 Z^2 A^{-1/3} (B_{\text{Coul}} - 1) - c_2 Z^2 A^{1/3} (B_{\text{red}} - 1) \quad (3.3)$$

For saddle shapes, E_{Def} gives the DM fission barrier height and hence is called E_{Bar} .

In order to obtain a LDM like DM barrier formula which does not depend explicitly on the mass and neutron numbers, the constants are transformed into a set of dimensionless parameters and an energy unit:

$$E^0 = E_{\text{surf}}^0 + E_{\text{curv}}^0 + 2E_{\text{comp}}^0 \\ \xi \equiv 1 - \nu = (\frac{1}{2} E_{\text{Coul}}^0 - E_{\text{red}}^0) / E^0 \\ \eta = E_{\text{curv}}^0 / E^0 \\ \zeta = -E_{\text{red}}^0 / E^0 \\ \chi = -E_{\text{comp}}^0 / E^0 \quad (3.4)$$

where a superscript zero denotes the value for the spherical nucleus. The definitions are arbitrary but chosen in this way that the relative barrier

$$B_{\text{Bar}}(\xi, \eta, \zeta, \chi) \equiv E_{\text{Bar}} / E^0 \\ = (B_{\text{surf}} - 1) + 2\xi(B_{\text{Coul}} - 1) + \eta(B_{\text{surf}} - B_{\text{curv}})$$

$$- \zeta(2B_{\text{Coul}} + B_{\text{red}} - 3) + \chi(2B_{\text{surf}} - B_{\text{comp}} - 1), \quad (3.5)$$

is a linear expression in the parameters and tends to zero as ξ tends towards unity or $u \equiv 1 - \xi$ to zero for arbitrary η, ζ, χ . In this case all the expressions in parentheses tend to zero separately. The quantity ξ is the DM equivalent to the LDM fissility x (cf. Eq. (2.20)) and u the equivalent to $u \equiv 1 - x$, which are frequently used in LDM calculations. The parameters η, ζ, χ are specific for the DM and measure the relative strengths of the curvature, compressibility and Coulomb redistribution energies, respectively. Other possibilities of defining dimensionless parameters which are closer to the LDM definition are in the case $\chi = 0$

$$\begin{aligned} E^{0'} &= E_{\text{surf}}^0 = E^0(1-\eta) \\ x &= \frac{1}{2} E_{\text{Coul}}^0 / E^{0'} = (\xi - \zeta) / (1 - \eta) \\ y &= E_{\text{curv}}^0 / E^{0'} = \eta / (1 - \eta) \\ z_S &= -E_{\text{red}}^0 / E^{0'} = \zeta / (1 - \eta), \end{aligned} \quad (3.6)$$

or

$$z_M = -2E_{\text{red}}^0 / E_{\text{Coul}}^0 = \zeta / (\xi - \zeta). \quad (3.7)$$

z_S is due to Swiatecki (28) and z_M is due to Myers (29). The relative barriers here read

$$\begin{aligned} B'_{\text{Bar}}(x, y, z_S) &= (B_{\text{surf}} - 1) + 2x(B_{\text{Coul}} - 1) \\ &+ y(B_{\text{curv}} - 1) - z_S(B_{\text{red}} - 1), \end{aligned} \quad (3.8)$$

or

$$B_{\text{Bar}}''(\xi, y, z_M) = (B_{\text{surf}} - 1) + y(B_{\text{curv}} - 1) + 2\xi \frac{1-y}{1+z_M} [B_{\text{Coul}} - 1 - \frac{1}{2} z_M (B_{\text{red}} - 1)] \quad (3.9)$$

Equation (3.8) is rather simple but the barrier tends toward zero as $x \rightarrow 1 + y - z_S$, while Eq. (3.9) is not linear in the parameters but has the requested property. A disadvantage of the definitions in Eq. (3.4) is that all parameters depend on most of the constants. Contrarily, each of the parameters in Eq. (3.6) are only ratios of two constants. However, neglecting quadratic terms in the small quantities $\eta, \zeta, \chi, y, z_S, z_M$, both sets of definitions are identical ($\xi \approx x, \eta \approx y, \zeta \approx z_S \approx z_M$).

In appendix 1, we give estimates of the DM correction parameters and average them over the region of the heavy nuclei (Table A2). This set of averaged parameters will be used as a reference set to indicate the results to be expected for realistic constants. However, they may change after a complete fit of the DM. In appendix 5, the constants in all definitions Eq. (3.4) as well as Eqs. (3.6) and (3.7) are listed separately for certain heavy nuclei together with the old Bohr and Wheeler fissility.

In earlier times, Strutinskii (16,30-32) and Tyapin (33) carried out calculations of barriers and effective moments of inertia by including the curvature energy. They incorporated the curvature energy into the surface energy and introduced an effective surface energy

$$E_{\text{eff}} = a_2 A^{2/3} (B_{\text{surf}} - \Gamma B_{\text{curv}}) \quad (3.10)$$

Taking E_{eff}^0 as energy unit, the relative effective surface energy reads

$$B_{\text{eff}} = (B_{\text{surf}} - \Gamma B_{\text{curv}})/(1 - \Gamma) \quad (3.11)$$

In order to compare their results with ours, one easily verifies that

$$-\Gamma = \gamma = \eta/(1 - \eta) \quad (3.12)$$

and that the fissility used by Strutinskii and Tyapin is equal to ξ in the absence of compression and Coulomb redistribution energies.

Apart from its energy, a nucleus in its saddle point may be described by the following geometrical quantities: the relative neck radius ρ_n is measured from the center of the droplet perpendicular to its axis of symmetry in units of

$$R_0 = r_0 A^{1/3} \quad (3.13)$$

and the relative half length ζ_0 measured in the same unit of length from the center along the axis of symmetry. The relative quadrupole moment Q will be used as an average measure for the saddle point deformation. According to Cohen and Swiatecki (8) it converts to the conventional quadrupole moment by the relation

$$Q_{\text{conv}} = \frac{3}{4\pi} Z R_0^2 Q \quad (3.14)$$

The relative parallel and perpendicular moments of inertia are measured in units of the moment of inertia of a sphere

$$\gamma^0 = \frac{2}{5} M R_0^2 \quad (3.15)$$

and naturally, the inverse relative effective moment of inertia

$$\gamma_{\text{eff}}^{-1} = \gamma_{\parallel}^{-1} - \gamma_{\perp}^{-1} \quad (3.16)$$

is given in units of $1/\gamma^0$.

In the discussion of the normal modes of oscillation, chapter 9, we shall need units of the stiffness C and the effective mass B which are

$$C^0 = E^0, B^0 = M R_0^2. \quad (3.17)$$

The unit of the squared frequency becomes

$$\omega_0^2 = E^0 / M R_0^2 \quad (3.18)$$

and the unit of time

$$t^0 = R_0 \sqrt{M/E^0}. \quad (3.19)$$

IV. PARAMETERIZATIONS OF THE NUCLEAR SURFACE

In calculating equilibrium shapes (i.e. saddle or minimum shapes) with a given shape dependent binding energy formula, two different methods can be applied. The first and most elegant method is to solve the Euler variational equations which are derived from the condition that the hydrostatic pressure is constant on the surface. This so called equilibrium surface method is outlined in papers by Gallone and Ghilardotti (34) and by Strutinskii and collaborators. The former authors applied this method to the LDM and Strutinskii to the LDM (35,36) and to the LDM with curvature energy (16,30-32). (Results of Strutinskii

in the figures will be denoted by S.) The solutions of the Euler equations determine the equilibrium surface point by point without any prescription of a family of shapes. This method gives the shapes exactly (apart from numerical inaccuracies). However, in order to apply this method to the DM, the Euler equations have to be modified for compressibility effects which has not yet been done.

On the other hand, the second method consists of predefining some arbitrary family of shapes which depends on some set of deformation coordinates $\{\alpha\}$. The shape dependent functions B_{surf} , B_{Coul} ... B_{sr2} then have to be calculated by use of any space coordinate system (usually spherical or cylindrical coordinates) and the standard equilibrium methods have to be applied to the deformation energy to give the equilibrium coordinate set $\{\hat{\alpha}\}$. This method gives only a more or less good approach to the exact equilibrium shapes because the finiteness of the number of deformation coordinates restricts the shapes in question. An infinite set of orthogonal coordinates would remove this restriction. Computer time requirements, however, limit the number of coordinates and one has to search for parameterizations which contain the least possible number of coordinates but give the best approach to the exact equilibrium shapes.

In the literature, there exists a variety of parameterizations and we will review some of the most important ones used to calculate saddle point shapes in the LDM.

Cohen and Swiatecki (8) (further on denoted by CS) used spherical space coordinates and a series expansion of the radius vector in terms of Legendre polynomials with the even deformation coordinates α_v , $v = 2, 4 \dots 18$ in the

reflection symmetric case. In order to study the stability of the equilibrium configuration against asymmetric distortions, the additional odd coordinates $\alpha_1, \alpha_3 \dots \alpha_{17}$ are added. This family of shapes gives accurate results compared with Strutinskii's exact method for the barriers in the interval $x \geq 0.3$ (see Fig. 1), but the neck radii are essentially different for $x \leq 0.7$. The parameterization fails in the vicinity of $x \geq 0$ (very light or uncharged nuclei) because it does not contain the exact saddle point shapes for this region (two tangent spheres). In this region the shape dependences can be obtained in closed form provided the series is truncated with α_4 . Then it is useful to describe small deviations from a sphere and the barriers are given analytically (cf. chapter 5).

Nix (10) (further on denoted by N) defined the nuclear surface in terms of three smoothly joined portions of quadratic surfaces (e.g. two spheroids connected by a hyperboloidal neck) with three symmetric deformation coordinates and three asymmetric ones. The space coordinates are of cylindrical type (ρ and ζ). In the case of reflection symmetric shapes, the surface function is given by

$$\rho^2 = \begin{cases} a_2^2 - \frac{a_2^2}{c_2^2} (\zeta + l_2)^2 \\ a_3^2 - \frac{a_3^2}{c_3^2} \zeta^2 \\ a_2^2 - \frac{a_2^2}{c_2^2} (\zeta - l_2)^2 \end{cases} \quad \text{for} \quad \begin{cases} -l_2 - c_2 \leq \zeta \leq -z_2 \\ -z_2 \leq \zeta \leq +z_2 \\ +z_2 \leq \zeta \leq l_2 + c_2 \end{cases} \quad (4.1)$$

By introducing the three alternate coordinates

$$\sigma_1 = 2 \ell_2 / a_2$$

$$\sigma_2 = a_3^2 / c_3^2$$

$$\sigma_3 = a_2^2 / c_2^2, \quad (4.2)$$

the geometrical parameters c_2 , ℓ_2 , z_2 , a_3 , and c_3 can be expressed by these by matching the surface function and its first derivative at the point z_2 . The coordinate a_2 further on is to be eliminated by means of the volume conservation.

This family of shapes includes the configurations of two tangent spheres and of one single sphere and hence gives accurate barriers in the total interval $0 \leq x \leq 1$, but the neck radii differ from the ones calculated by Strutinskii for $x \leq 0.7$. The practical use of this parameterization is very difficult since the middle portion may take seven different forms: oblate spheroid, sphere, prolate spheroid, cylinder, hyperboloid of one sheet, two tangent cones, and hyperboloid of two sheets. It also turns out that for fissilities close to unity, the saddle point shapes calculated are not prolate spheroids as they should be but still consist of three portions. Hence the barriers do not converge smoothly to zero as can be seen from Fig. 1.

The relative surface energy in Nix's parameterization can be obtained analytically (see Ref. 10) and similarly, the curvature energy. We only give here the contribution to the relative curvature energy from the middle portion of the volume; by inserting the proper values for the outer portions, the total

can be calculated easily. By using the abbreviations $x = a_3^2$, $y = a_3^2/c_3^2$, and $z = z_2$ according to Nix and $X = xy/(y - 1)$, $Y = y(y - 1)/x$, it reads

$$B_{\text{curv}}^{\text{middle}} = \frac{1}{4} \left\{ \begin{array}{ll} z + \sqrt{X} \arctg(z\sqrt{Y}) & \dots \dots \dots \text{oblate spheroid} \\ z + \sqrt{X} \ln \sqrt{\frac{1 + z\sqrt{-Y}}{1 - z\sqrt{-Y}}} & \dots \dots \dots \text{prolate spheroid} \\ z - \sqrt{X} \arctg(z\sqrt{Y}) & \dots \dots \dots \text{hyperboloid of one sheet} \\ z - \sqrt{\frac{X}{y}} - \sqrt{-X} \ln \sqrt{\frac{(1 + z\sqrt{-Y})(1 - \sqrt{1 - y})}{(1 - z\sqrt{-Y})(1 + \sqrt{1 - y})}} & \text{hyperboloid of two sheets} \\ z & \dots \dots \dots \text{sphere, cylinder, cones.} \end{array} \right. \quad (4.3)$$

For middle portion shapes close to a sphere, a cylinder or tangent cones, however, appropriate expansions may be used.

Lawrence (11,37) (further on denoted by L) also used cylindrical coordinates and assumed the square root of a polynomial of fourth degree in ζ as the distance ρ . This parameterization is a generalization of spheroids because it takes into account the next term of the expansion of ρ^2 in ζ^2 . Hence we call it here the family of generalized spheroids. The resulting barriers are fairly good in agreement with the exact ones for heavy nuclei, the error at $x = 0.7$ is about 3%. On the other hand, it fails completely for highly constricted saddle shapes with fissilities close to zero because it also

does not include the configuration of two tangent spheres. The advantage of this family of shapes is that it describes a sphere, spheroids, necked in shapes and a scission configuration with only two deformation coordinates.

In previous works (12-14) we have adapted Lawrence's parameterization and used slightly different symmetric coordinates ζ_0 (elongation) and ζ_2 (constriction) and generalized it to allow also for asymmetric shapes with the asymmetry coordinate ζ_1 ,

$$\zeta^2 = \lambda(\zeta_0^2 - \zeta_2^2)(\zeta_2^2 + (\zeta - \zeta_1)^2) \quad (4.4)$$

The changes were made to avoid "forbidden regions" in the intervals of the coordinates which were in Lawrence's notation due to volume conservation. Now, ζ_0 is half the length of the droplet along the axis of symmetry and ζ_2 is a measure of the constriction (or necking in). The neck radius of an axially symmetric shape in units of R_0 is $\rho_n = \zeta_0 \zeta_2 \sqrt{\lambda}$ with λ being the volume normalization factor. For $\zeta_2 \rightarrow \infty$, the shapes obtained are prolate spheroids with ζ_0 the large semi-axis and $\zeta_0^{-1/2}$ the small one. For $\zeta_2 = 0$ we obtain the configuration of two tangent (non spherical) fragments. Even configurations of separated fragments can be included with $\zeta_2^2 < 0$. A map of the possible shapes (symmetric, $\zeta_1 = 0$) can be seen in Fig. 2. Results with these shapes, which were not previously calculated by Lawrence, will be denoted by H. The shape dependences of the DM cannot be calculated in closed form when using generalized spheroids because the integrals involved are not solvable. Together with the geometrical quantities describing a saddle, they are listed in Eqs. [1H] through [15H].

Since a three parameter family of shapes like Nix's is not as convenient for numerical calculations as a two parameter family and since the generalized

spheroids fail in describing saddle points of light nuclei, we also studied dumbbell like shapes which are known to reproduce the LDM properties for $x \geq 0$. These were suggested by Cohen and Swiatecki (9) and form a subset of Nix's parameterization except that the three portions are not smoothly joined.

Dumbbells consist of two parts of spheres connected by a cylinder. In cylindrical coordinates the surface is given by

$$\rho^2 = \begin{cases} u^2 - (\zeta + \sigma_0)^2 \\ u^2 - \sigma_2^2 \\ u^2 - (\zeta - \sigma_0)^2 \end{cases} \quad \text{for} \quad \begin{cases} -\sigma_0 - u \leq \zeta \leq -\sigma_0 + \sigma_2 \\ -\sigma_0 + \sigma_2 \leq \zeta \leq +\sigma_0 - \sigma_2 \\ +\sigma_0 - \sigma_2 \leq \zeta \leq +\sigma_0 + u \end{cases} \quad (4.5)$$

The meaning of the coordinates, σ_0 elongation, σ_2 constriction and u radius of the spheres, can be seen from Fig. 3. The radius u is eliminated due to volume conservation by means of

$$u = \begin{cases} (-q + \sqrt{q^2 + p^3})^{1/3} + (-q - \sqrt{q^2 + p^3})^{1/3} - \frac{1}{2} \sigma_0 \\ \sigma_0 [\cos(\frac{1}{3} \arccos(-\frac{8q}{\sigma_0^3})) - \frac{1}{2}] \end{cases} \quad \text{for } q^2 + p^3 \begin{cases} \geq 0 \\ \leq 0 \end{cases} \quad (4.6)$$

where

$$p = - \left(\frac{\sigma_0}{2} \right)^2$$

$$q = \left(\frac{\sigma_0}{2} \right)^3 - \frac{3}{2} \cdot \frac{\sigma_0}{2} \cdot \sigma_2^2 + \frac{1}{2} \sigma_2^3 - \frac{1}{2} \quad (4.7)$$

A map of the possible dumbbell shapes is presented in Fig. 4, they are further on denoted by DB.

Since the relative energies of dumbbells are not listed in Table A3 and not written down in the literature the shape dependences of the surface and curvature energies, which can be evaluated in closed form, are given here. The Coulomb and Coulomb redistribution energies have to be calculated numerically.

$$B_{\text{surf}} = u(u + \sigma_2) + \rho_n(\sigma_o - \sigma_2) \quad (4.8)$$

The first part of Eq. (4.8) contains the surface area of the two sections of the spheres and the second part is the surface area of the connecting cylinder. The neck radius ρ_n is simply $\rho_n = \sqrt{u^2 - \sigma_2^2}$.

$$B_{\text{curv}} = u + \frac{1}{2}(\sigma_o + \sigma_2) - \frac{1}{2}\rho_n \arctg \frac{\sigma_2}{\rho_n} \quad (4.9)$$

The last part of Eq. (4.9) is due to the finite curvature of the edges of the dumbbells at the matching points. Generally, the relative curvature energy of one axially symmetric edge is $B_{\text{curv}}^{\text{edge}} = \frac{1}{4}\rho_n \phi_{\text{edge}}$, where ϕ_{edge} is the angle between the edge and the axis of symmetry. In the case of dumbbells, the edges are of convex type and the contribution to the curvature energy is negative.

The only one parameter family of shapes which covers the whole interval of deformations from the sphere to two tangent fragments and which can give reasonably good LDM barriers was introduced by Stavinskii et al. (38). It is the two-focus lemniscate (or Cassini curve). The error due to the restriction in shapes is about 10% at $x = 0.7$. It seems, however, that only one deformation coordinate limits the freedom of the shapes too much that this parameterization shall only be mentioned here.

All the parameterizations discussed above cover all deformations and are only suitable for numerical calculations (chapter 7). Therefore we shall

use special types of deformations to obtain analytical results in the limiting cases of slightly distorted spheres (saddle points of nuclei with fissilities close to unity) and of two tangent spheres or spheroids (fissilities close to zero). In the former case either spheroidal shapes are considered and the energies are expressed as series expansions in the eccentricity ϵ or the small deviations from the sphere are described by an expansion in α_2, α_4 and α_3, α_5 and the energies are expanded in terms of these parameters (chapter 5). The latter case will be discussed in chapter 6.

V. SERIES EXPANSIONS FOR A SLIGHTLY DISTORTED SPHERE AND FOR SPHEROIDS

In each of the following three chapters, the shape dependences of the DM will be evaluated for the kinds of deformation described earlier. They are independent of the expression for the total energy used. However, in order to study the influence of the DM correction energies, we also apply them to the truncated and linearized version of the DM energy expression as given by Eq. (3.5). In chapter 10, we shall also use the complete DM energy expression Eq. (2.4) to calculate fission barriers for a variety of nuclei.

In this chapter, we start with slightly distorted spheres which are most important and convenient in studying the fission barriers of heavy nuclei. The expansions of the relative Coulomb and surface energies, Eqs. [3B] and [4B], in power series of α_v are evaluated e.g. by Nossov (39) or Swiatecki (5) in closed form and the coefficients of any arbitrary power of α_v are known. It is possible to perform analogous analyses in application to the curvature, compressibility and redistribution energies. The compressibility energy is the most simple case because it is just the square of B_{surf} . However, in this chapter in order to obtain saddle points, we are only interested in the

coefficients of the even parameters up to the order α_4^2 . Hence in performing the series expansions, the radius vector $r(\theta)$ is treated as the one of a sphere plus correction, $r(\theta) = \lambda_0 [1 + \delta(\theta)]$, and $\delta(\theta)$, $d\delta/d\theta$, $d^2\delta/d\theta^2$ of Eq. [5G] are expanded up to the fourth order. Similarly, the Coulomb potential in the volume and on the surface, which are listed in Eqs. [25A] ... [26B], are treated in the same manner.

A remarkable result is that the coefficients of the α_v^2 in the expansion of the curvature energy are the same as in the surface energy. This fact is due to the similarity of the two integrals. These coefficients are known to be

$$B_{\text{curv}} \text{ or } B_{\text{surf}} = 1 + \sum_{v=2}^{\infty} \frac{(v-1)(v+2)}{2v+1} \alpha_v^2 + \dots \quad (5.1)$$

The expansion of the Coulomb redistribution energy (6B) was first performed by Swiatecki (28). Note that the coefficients of α_2^2 and α_2^3 in the expansion of the surface redistribution energy of second kind vanish which indicates a very weak shape dependence.

Let us review briefly the method for calculating saddle point shapes for a given energy expression (4,5). The relative energies are expanded into α_2 and α_4 up to the proper order, Eqs. [3B] ... [7B], and the relative barrier [2B] can then be written as

$$B_{\text{Bar}} = A\alpha_2^2 + B\alpha_2^3 + C\alpha_2^4 + D\alpha_2^2 \alpha_4 + E \alpha_4^2 \quad (5.2)$$

The coefficients A ... E depend only on the parameters ξ , η , ζ , and χ . The condition of equilibrium is

$$\frac{\partial B_{\text{Bar}}}{\partial \alpha_i} = 0 \quad i = 2, 4 \quad (5.3)$$

First we use $\partial B_{\text{Bar}} / \partial \alpha_4 = 0$ to yield the saddle point value of α_4 ,

$$\hat{\alpha}_4 = -\frac{D}{2E} \hat{\alpha}_2^2 \quad (5.4)$$

Inserting Eq. (5.4) into (5.2) gives the saddle point barrier as an expression only in terms of $\hat{\alpha}_2$

$$B_{\text{Bar}} = f(\hat{\alpha}_2) = A\hat{\alpha}_2^2 + B\hat{\alpha}_2^3 + \bar{C}\hat{\alpha}_2^4 \quad (5.5)$$

with $\bar{C} = C - D^2/4E$. Using now $\partial B_{\text{Bar}} / \partial \alpha_2 = 0$, we obtain

$$\hat{\alpha}_2 = -\frac{3B}{8\bar{C}} \left(1 - \sqrt{1 - \frac{32 A \bar{C}}{9B^2}} \right) \quad (5.6)$$

Expansion of the square root in Eq. (5.6) gives

$$\hat{\alpha}_2 = -\frac{2A}{3B} \left(1 + \frac{8 A \bar{C}}{9B^2} \dots \right) \quad (5.7)$$

and after inserting Eq. (5.7) into (5.4)

$$\hat{\alpha}_4 = -\frac{2 DA^2}{9 EB^2} \dots \quad (5.8)$$

The resulting saddle point coordinates are given in Eq. [16B] and the barrier in Eq. [2C].

The factor $980^3/135$ and the correction $-1160/255$ are due to the LDM. The following corrections arise from the DM: The barrier is increased

by the curvature energy, decreased by the Coulomb redistribution energy and not effected by the compressibility energy. However, the expansions (5.7) and (5.8) seem not to be adequate in the case of the Coulomb redistribution energy. Using the unexpanded formulae (5.4) and (5.6), the barrier is always increased by the Coulomb redistribution energy. A comparison between the results of the unexpanded and the expanded formulae can be seen in Table A6 of appendix 4. In the case of the curvature and the compressibility energies the expanded and the unexpanded formulae give reasonable agreement. For increasing Coulomb redistribution strength, however (cf. sub-table A6.c), the barriers obtained by using the expanded formulae are decreasing while the barriers obtained by using the unexpanded formulae and the numerically calculated barriers are both increasing.

The shape dependences for spheroids can be evaluated in closed form, Eqs. [2E] ... [15E] because the Coulomb potentials [27A] and [27B] are known. They are plotted in Fig. 5 vs. various abscissae e.g. half length ζ_0 , ratio of minor to major semi axes a/c and eccentricity e . The increasing shape dependence of the surface energy and the decreasing one of the Coulomb energy are well known. From the DM correction energies, the curvature and the compressibility energies have the strongest dependence on shape. The coefficient of the compressibility energy, however, is small and therefore the influence of the compressibility energy is also small. This is not true for the curvature energy which, as we shall see, has a major influence on the saddle shapes. The shape dependences of the redistribution energies are rather weak, the weakest of them is the one of the surface redistribution energy of second kind.

The formulae of the shape dependences for spheroids are rather complicated and it is not possible to calculate the saddle points analytically, hence we

expand them into a power series in ϵ up to the eighth degree. This high degree is necessary to obtain the coefficient of u^3 in the barrier expression. The expansions are made for prolate spheroids with the definition of the prolate eccentricity

$$\text{Major Semi-Axis} = \zeta_0 = (1 - \epsilon^2)^{-1/3} . \quad (5.9)$$

When dealing with oblate spheroids, the definition of the oblate eccentricity is similarly

$$\text{Minor Semi-Axis} = \zeta_0 = (1 + e^2)^{-1/3} . \quad (5.10)$$

With conversion between the prolate and the oblate eccentricities

$$e^2 = -\epsilon^2 \quad (5.11)$$

all formulae [1F] through [16F] and [16D] hold also for oblate spheroids.

The expansion of the relative barrier in a power series in terms of eccentricities up to the eighth order is

$$B_{\text{Bar}} = F\epsilon^4 + G\epsilon^6 + H\epsilon^8 . \quad (5.12)$$

The eccentricity of an equilibrium shape is then given to the appropriate order by

$$\epsilon^2 = -\frac{2F}{3G} \left(1 + \frac{8FH}{9G^2} \dots \right) . \quad (5.13)$$

Prolate spheroids give a maximum (corresponding to a saddle point) for nuclei with fissilities less than unity according to Eq. [16F] and with the

corresponding barrier [16D]. Compared with the barrier obtained from the expansion into Legendre polynomials, the dependence on η , ζ , and χ is the same, but as expected, the barrier is only accurate to the lowest (third) order in U . Even the sign of the fourth order term is opposite. This means that spheroidal shapes are only good saddle point shapes for very heavy nuclei with a fissility very close to unity.

Using oblate spheroids the analogue to Eq. [16F] is

$$\hat{e}^2 = -7U(1 - U + \frac{5}{3}\eta - \frac{2}{3}\zeta), \quad (5.14)$$

which means that there exists only an equilibrium when $U < 0$, or correspondingly $\xi > 1$, i.e., superheavy nuclei. Here we find that the equilibrium is a minimum with a negative barrier, Eq. [16D]. However, this minimum may be meaningless if one considers more degrees of freedom than only one oblate coordinate.

VI. CALCULATIONS FOR CONFIGURATIONS OF TANGENT AND SEPARATED FRAGMENTS

Static calculations with tangent fragments are important for two reasons: (i) for small fissilities (almost uncharged or very light nuclei), the configuration of two touching spheres is known to be the saddle point shape; (ii) it is the scission configuration for binary fission. However, the scission point is not a point of equilibrium since it lies on the decreasing side of the Coulomb potential. There are some objections to taking the configuration of two tangent spheres or spheroids as the scission point: (i) as shown by Swiatecki (6), the partition into more than two fragments becomes energetically more favorable for heavier nuclei; (ii) it has been shown (40) that configurations

of two touching fragments which each have also asymmetric P_3 and/or P_5 -deformations, are energetically essentially lower than two touching spheroids by means of the smaller Coulomb interaction energy. On the other hand, the configuration of two or more infinitely separated spheres is again a configuration of equilibrium.

For two tangent equal spheroids with eccentricity ϵ and $\zeta_0 = [4/(1 - \epsilon^2)]^{1/3}$ the total relative length of each of the spheroids, the relative energies read (9)

$$B_{\text{surf}} = \zeta_0^{-1} \left[1 + \frac{\arcsin \epsilon}{\epsilon \sqrt{1 - \epsilon^2}} \right], \quad (6.1)$$

$$B_{\text{curv}} = \frac{1}{2} \zeta_0 \left[1 + \frac{(1 - \epsilon^2) \ln \frac{1 + \epsilon}{1 - \epsilon}}{2\epsilon} \right] \quad (6.2)$$

and the Coulomb energy splits up into the Coulomb-self energy and the Coulomb-interaction energy according to (9)

$$B_{\text{coul, self}} = \zeta_0^{-1} \frac{\ln \frac{1 + \epsilon}{1 - \epsilon}}{2\epsilon} \quad (6.3)$$

and

$$B_{\text{coul, int}} = \frac{15}{4} \zeta_0^{-1} \sum_{n=0}^{\infty} \sum_{m=0}^{\infty} \frac{(2n+2m)!}{(2n+1)(2m+1)(2n+3)(2m+3)(2n)!(2m)! 2^n 2^m} \epsilon^{2(n+m)}. \quad (6.4)$$

The part of the double sum in Eq. (6.4) with indices $m = 0$ and $n = 0$ can be summed up to give

$$\frac{4}{3\epsilon^2} \left[1 + \frac{1}{2} \left(\frac{\epsilon}{2} - \frac{2}{\epsilon} \right) \ln \frac{1 + \epsilon/2}{1 - \epsilon/2} \right] - \frac{1}{9} \quad (6.5)$$

The total energy consisting of Coulomb, surface and curvature energies was made stationary to obtain the minimum eccentricities given in Fig. 6. From the upper part of this figure, we can see that the minimum shapes for small x -values are not effected by the additional curvature energy while for heavier nuclei, the curvature energy acts against the deformation of the fragments and the energy at "scission" becomes essentially higher.

The formulae for the relative energies of two tangent equal spheres are listed in Eqs. [11] - [15I] and it can be seen that for heavy nuclei the total energy for this kind of "scission" configuration is much higher than the one of spheroids. For instance, for $\xi = 1$, the difference is in the order of 100 MeV. Here the "scission" configuration of two tangent spheres has a higher energy than the ground state, which is unrealistic, while in the case of two tangent spheroids, about 70 MeV of potential energy is gained at the scission point. Calculations concerning the configuration of two unequal touching spheres are described in chapter 8.

As regards two infinitely separated spheres, the corresponding formulae are listed in Eqs. [2L] - [15L] and the total energy of such a system is plotted in the insert of Fig. 6. The energy expression in this case is linear in all parameters and hence the difference between the total energy of two infinitely separated spheres calculated without curvature energy and the one calculated with curvature energy is a constant.

VII. NUMERICAL CALCULATIONS WITH GENERAL PARAMETERIZATIONS

After having studied the limiting cases of small and large deformations, which correspond to very heavy and light (or uncharged) nuclei, the intermediate range is covered by numerical calculations. As outlined in chapter 4, the

parameterization of the nuclear surface is a critical factor in equilibrium point calculations and we shall see that the saddle shapes and energies for a given fissility will vary to some extent.

First we apply the two parameter family of generalized spheroids. The relative energies are calculated according to Eqs. [1H] through [15H] and the points of equilibrium are found by a standard equilibrium point method (see appendix 2).

The resulting barriers are displayed in Fig. 7. The upper part gives a comparison between the liquid drop barriers obtained by various authors together with the droplet model barriers for a particular choice of values for η , ζ , and χ . The lower three sets of curves are obtained by varying only one of the additional droplet model parameters η , ζ , or χ . The compressibility energy is seen to decrease the barrier by a very small amount. If one takes into account that $\chi \approx 0.02$, the influence of χ on the barrier is negligible. This can be seen from Fig. 8: the slope $\partial B_{\text{Bar}} / \partial \chi$ is negative and very small.

The influence of the Coulomb redistribution energy, represented by ζ , on the barrier energy is much more visible and it tends to increase the barrier. The slope $\partial B_{\text{Bar}} / \partial \zeta$ (see Fig. 9) is positive and about ten times larger than $\partial B_{\text{Bar}} / \partial \chi$.

The curvature energy, given by its relative strength η , has the largest effect of increasing the barrier, and if η is large enough, it introduces a second minimum into the fission barrier. This can be seen from Fig. 10 where the part of Fig. 7 is enlarged which corresponds to heavy nuclei. For $\eta \leq 0.1$, the barrier is just increasing. Following the curve $\eta = 0.12$ from $\xi = 1$ to lower ξ values, at $\xi = 0.762$ the barrier vs. fissility has a cusp and is

turning back to larger fissilities as a minimum until it again goes over into a saddle at $\xi = 0.783$. This happens again at $\xi = 0.718$, with the exception that the minimum curve now ends near $\xi = 0.750$. The corresponding shape of this point is almost completely necked in (see Figs. 15,16) and therefore the second saddles belonging to these minima would correspond to configurations of separated fragments.

Taking an even larger curvature strength of $\eta = 0.16$, Fig. 10 shows that at $\xi = 0.785$ the saddle goes over into a minimum which stays a minimum until $\xi = 1.072$, where the configuration of tangent fragments in this parametrization is reached. Since we know from the LDM calculations with the parametrization of generalized spheroids that the error in the barriers increases rapidly with increasing deformation, it is very likely that the parametrization fails also to describe this very constricted minima.

Due to this behavior of the family of generalized spheroids we performed similar equilibrium point studies by parametrizing the nuclear shape as a dumbbell, Eq. (4.5). From Fig. 1 we can see that the barriers are only accurate for fissilities very close to zero and the corresponding highly necked in saddle shapes; the errors in the LDM barriers increase rapidly for larger fissilities. We therefore can also expect that the dumbbells describe the minima obtained with large curvature strengths.

The results of the numerical equilibrium point calculations using dumbbells for $\eta = 0.16$ and $\xi > 0.75$ are given in Fig. 11. The turning of the saddle point curve into minima happens here at $\xi = 0.815$, the minima go over into a second saddle at $\xi = 0.895$ which again become minima at $\xi = 0.880$ and these minima extend beyond $\xi = 1.1$. However, in this neighborhood there is

another turning point and the resulting saddle point line extends over the total interval of ξ down to $\xi = 0$. The saddle points around $\xi \approx 0.887$ are probably spurious because in this region the dumbbell constriction coordinate σ_2 has a rather rapid transition from very small to large values (cf. Fig. 18), while the dumbbell elongation coordinate σ_0 (Fig. 17) and the radius coordinate u (Fig. 19) remain almost unchanged. According to Fig. 4 this means a rapid transition from cigar like to dumbbell like shapes.

The relative energies of the first saddle and the second minimum are only slightly effected by use of the two different parametrizations and for large ξ -values and small η -values the energies of the first saddle agree very well with the results of Strutinskii (cf. Fig. 13). However, for small fissilities, the barriers obtained by use of generalized spheroids are too large compared with Strutinskii.

Since there is still some doubt concerning the best choice of deformation parameters (the generalized spheroids fail for large deformations, the dumbbells fail for small deformations and the new second minima seem to have medium deformations), the three parameter family of Nix shapes, Eq. (4.1), was investigated.

Figure 12 gives the numerically computed relative barriers for $\eta = 0$ and 0.16 with the Nix shapes: the second minima for large curvature strengths do appear also but are less pronounced and less deep. The appearance is limited to the fissility region $0.785 \leq \xi \leq 0.847$. The corresponding equilibrium coordinates σ_1 , σ_2 , and σ_3 are drawn in Fig. 20 and the relative half lengths and neck radii in Fig. 21.

From this result, we can conclude that a second minimum exists for heavy nuclei and for a large curvature tension independent of the choice of the

parametrization of the nuclear shape. In an earlier paper, Cohen and Swiatecki (7) obtained also second minima for heavy nuclei without curvature energy but with parameterizing the shape by some very restricted families like spindles, cylinders and a number of tangent spheres of different size, and showed the influence of arbitrary parameterizations on the barrier energy. Nix (9) also obtained spurious minima by parameterizing the surface in terms of two overlapping spheroids. On the other hand, Strutinskii (32) showed, using the method of Euler equations (no restriction to the shapes), that the inclusion of the curvature energy increases the barriers and also the relative inverse effective moments of inertia (see Fig. 29). However, Strutinskii included only small curvature parameters, $-\Gamma = 0.1$ which corresponds to $\eta = 0.091$, and therefore he did not obtain a second minimum. However, his results indicate that he would have found second minima if he had investigated larger values of the curvature correction.

Figures 22 through 32 show the relative energies B_{Coul} , B_{surf} , B_{curv} , B_{red} , B_{sr1} , B_{sr2} , and B_{comp} , and the quantities Q , $\gamma_{\parallel}$, $\gamma_{\perp}$, γ_{eff}^{-1} for the equilibrium shapes. All the numerically calculated quantities at the saddle points show the properties predicted by the analytical results of the limiting cases: For $\xi \leq 1$, the dependence on the fissility is quadratic (cf. Eqs. [3C] - [15C]) and for $\xi \geq 0$, the dependence is linear. From Fig. 25, where the relative Coulomb redistribution energy is shown, it can be seen why the expansions in α_2 and α_4 close to the spherical configuration are no longer exact for fissilities $\xi \lesssim 0.8$. This energy falls off to values less than unity after having reached its maximum at $\xi \approx 0.85$. This can also be extracted from results obtained with spheroids: The saddle point eccentricities Eq. [16F] in the next order approximation in ζ read

$$\hat{\epsilon}^2 = 70(1 - \nu - \frac{2}{3}\zeta - \frac{404}{9}\nu^2 + \frac{111}{45}\nu\zeta + \frac{4}{9}\zeta^2 \dots) \quad (7.1)$$

The higher order terms in $\nu\zeta$ and ζ^2 are all positive and after having inserted Eq. (7.1) into the barrier formula Eq. [2F], the correction to the barrier due to these higher order terms would be negative. The Coulomb redistribution energy is the only energy which has this behavior, all the other energies show a very smooth transition from the quadratic dependence to a linear one.

As given by Eq. [15C], the relative surface energy of second kind has a very weak ξ -dependence close to $\xi = 1$, the falling off starts here at about $\xi = 0.85$ and it is about constant in the interval $0.85 \leq \xi \leq 1$.

In order to obtain a barrier formula which reflects the droplet model corrections, the numerical results are fitted by the method of least squares. Good approximations for heavy nuclei are

$$B_{\text{Bar}} = 0.70\nu^3(1 + 0.16\nu + 2.9\eta + 9.9\eta^2 + 5.1\zeta - 0.38\chi) \quad (7.2)$$

for $0.9 \leq \xi \leq 1$, $\eta \leq 0.1$, $\zeta \leq 0.015$, $\chi \leq 0.08$

and

$$B_{\text{Bar}} = 0.30(1 + 1.25\eta + 1.6\eta^2 + 3.0\zeta - 0.30\chi) - 0.40\xi(1 + 0.71\eta) \quad (7.3)$$

for $0.3 \leq \xi \leq 0.6$, $\eta \leq 0.1$, $\zeta \leq 0.015$, $\chi \leq 0.08$,

for the light nuclei. In the transition region $0.3 \leq \xi \leq 0.9$, no satisfactory low order fits can be obtained. The approximate Eqs. (7.2) and (7.3) above given are in reasonably good agreement with the LDM expressions from Cohen and

Swiatecki (8)

$$\begin{aligned} B_{\text{Bar}} &= 0.83 u^3 & \text{for } 2/3 < x < 1 \\ B_{\text{Bar}} &= 0.38(3/4 - x) & \text{for } 1/3 < x < 2/3, \end{aligned} \quad (7.4)$$

where x is again the LDM fissility and $u = 1 - x$.

VIII. ASYMMETRIC DISTORTIONS

In order to study the stability of the equilibrium shapes against asymmetric distortions, we at first deal with slightly distorted spheres and, following Swiatecki (5), expand the relative barrier into a power series of α_i ($i = 2 \dots 5$). This expansion in the proper order can be written as

$$\begin{aligned} B_{\text{Bar}} = \text{Eq. (5.2)} &+ F\alpha_3^2 + G\alpha_2\alpha_3^2 + H\alpha_2^2\alpha_3^2 \\ &+ I\alpha_4\alpha_3^2 + J\alpha_2\alpha_3\alpha_5 + L\alpha_5^2. \end{aligned} \quad (8.1)$$

The symmetric coefficients were discussed previously in chapter 5 (see Eq. [2B]) and the asymmetric ones $F \dots L$ can be seen in Eq. [2D].

Using the condition for an equilibrium $\partial B_{\text{Bar}} / \partial \alpha_5 = 0$ yields

$$\hat{\alpha}_5 = - \frac{J}{2L} \hat{\alpha}_2 \hat{\alpha}_3. \quad (8.2)$$

Insertion of Eqs. (5.8) and (8.2) into Eq. (8.1) gives

$$B_{\text{Bar}} = f(\hat{\alpha}_2) + g(\hat{\alpha}_2) \hat{\alpha}_3^2 \quad (8.3)$$

with $f(\hat{\alpha}_2)$ given previously in Eq. (5.5), and

$$g(\hat{\alpha}_2) = F + G\hat{\alpha}_2 + \bar{H}\hat{\alpha}_2^2 \quad (8.4)$$

where

$$\bar{H} = H - \frac{ID}{2E} - \frac{J^2}{4L} \quad (8.5)$$

Now using $\partial B_{\text{Bar}}/\partial \alpha_3 = 0$ would always give $\hat{\alpha}_3 = \hat{\alpha}_5 = 0$ as a result. This was expected and means that also in the DM, only symmetric saddle points are shapes of absolute equilibrium. However, if $g(\hat{\alpha}_2) < 0$, the symmetric saddle points are no longer stable with respect to asymmetric distortions. Hence $g(\hat{\alpha}_2)$ is a measure of the stability of the symmetric saddle points. After having inserted Eq. (8.5) into Eq. (8.4) the explicit form of $g(\hat{\alpha}_2)$ is

$$\begin{aligned} g(\hat{\alpha}_2) = & \frac{15}{49} (1 - \frac{8}{3} \zeta) - \frac{52}{147} \nu (1 - \frac{35}{13} \eta + \frac{280}{39} \zeta) \\ & - \frac{2578292}{712215} \nu^2 (1 + 0.131391\eta - 8.143434\zeta + 0.859398\chi) \end{aligned} \quad (8.6)$$

Finally, by setting Eq. (8.6) equal to zero, we can obtain the so called critical Businaro-Gallone (41-43) fissility

$$\xi_{\text{BG}}^{\text{sphere}} = 0.7540 + 1.053\eta - 0.4953\zeta + 0.0882\chi \quad (8.7)$$

This value is not very close to unity and therefore the expansion (8.6) is no longer accurate and $\xi_{\text{BG}}^{\text{sphere}}$ obtained in this way is only a rough estimate of the true value.

We therefore make a similar expansion assuming the saddle point shapes to be configurations of two unequal touching spheres. This expansion will hold only for very small fissilities and we again will have a rough estimate, but on the other side of the ξ -scale.

We use the parameterization Eq. [1J] with μ being the ratio of radii of the two touching spheres and get the relative energies [3J] ... [15J]. We now expand into a power series of $v = \mu - 1$ and obtain the expansions [3K] ... [15K]. The second derivative of the relative energy plays now the role of $g(\alpha_2)$. It reads

$$\frac{\partial^2 E_{B,sc}}{\partial v^2} = -0.62996 + 1.04993\xi - 0.16374\eta - 11.2440\xi + 0.32748\chi \quad (8.8)$$

Again by setting Eq. (8.8) equal to zero we can obtain the critical Businaro-Gallone fissility

$$\xi_{BG}^{sc} = 0.6 + 0.1560\eta + 10.709\xi - 0.3119\chi \quad (8.9)$$

The stability of the numerically calculated saddle points and minima in the parameterization of generalized spheroids can be studied by modifying the parameterization [1H] to allow also for asymmetric shapes. The definition of the asymmetry parameter is as follows (12,13)

$$\rho^2 = \lambda(\zeta_0^2 - \zeta^2)(\zeta_2^2 + (\zeta - \zeta_1)^2) \quad (8.10)$$

with

$$\lambda^{-1} = \zeta_0^3 \left(\frac{1}{5} \zeta_0^2 + \zeta_1^2 + \zeta_2^2 \right) \quad (8.11)$$

For each saddle and minimum calculated, the stiffness with respect to asymmetry, $C_{\zeta_1} = \partial^2 B_{\text{Bar}} / \partial \zeta_1^2$ is obtained by the approximation $C_{\zeta_1} = \frac{2}{\zeta_1} [B_{\text{Bar}}(0) - B_{\text{Bar}}(\zeta_1)]$ with fixed $\hat{\zeta}_0$ and $\hat{\zeta}_2$ and $\zeta_1 = 0.05$. The stiffnesses are listed in Table A4 in the entry CZ1 and plotted in Fig. 33. From this table, the calculated critical Businaro-Gallone fissilities $\xi_{\text{BG}}^{\text{calc}}$ can be found by extrapolation. Good approximations, which fit the numerical data are

$$\xi_{\text{BG}}^{\text{calc}} = \begin{cases} 0.422 + 1.14\eta + 11.9\zeta - 0.25\chi \\ 0.422 + 0.75\eta + 9.7\eta^2 + 11.9\zeta - 0.25\chi \end{cases} \quad \text{for } \eta \leq \begin{cases} 0.04 \\ 0.08 \end{cases} \quad (8.12)$$

A comparison of the critical Businaro-Gallone fissility values obtained with the three methods described above is given in Table 2. In comparing the three Eqs. (8.7), (8.9), and (8.12), we see that the sphere approximation is only accurate in its η -dependence. The sign of the ζ -dependence is wrong as it is in the expression for the barrier in the Legendre polynomial expansion: At $\xi \leq 1$, $B_{\text{red}} > 1$ rather than $B_{\text{red}} \approx 0.4$ at $\xi \approx 0.4$ after having passed its maximum at $\xi \approx 0.85$ (see Fig. 25). The χ -dependence also has the wrong sign because the compressibility energy is a higher order correction to the relative barrier (only terms in α_2^4 and $\alpha_2^2 \alpha_3^2$ enter, cf. Eqs. [2B] - [2D]).

On the other hand, the tangent spheres approximation gives rather good results compared with the calculated values with regard to both sign and magnitude. The curvature and the Coulomb redistribution corrections shift the critical ξ_{BG} to larger values while the compressibility corrections lower it. The LDM critical $x_{\text{BG}} = \xi_{\text{BG}}(\eta = \zeta = \chi = 0)$ came out to about 0.422 which is in good agreement with calculations of CS ($x_{\text{BG}} = 0.394$) or Strutinskiĭ ($x_{\text{BG}} = 0.4$).

The second part of this chapter deals with touching spheres of any mass ratio in order to study the possibility of asymmetric saddle points or asymmetric configurations which are unstable only with respect to the fission degree of freedom.

The relative energies for such configurations are listed in Eqs. [3J] - [15J] and plotted vs. the ratio of radii in Fig. 34. It can be seen that all three redistribution energies have their maximum values not at symmetry as the others do, but at ratios of radii of 0.38, 0.43, and 0.53 for B_{sr1} , B_{sr2} , and B_{red} , respectively. This means that the Coulomb redistribution energy and the surface redistribution energy of second kind which are proportional to the negative of B_{red} , B_{sr2} , respectively, show minima at these ratios while the surface redistribution energy of first kind shows a maximum. The surface redistribution energies tend to cancel each other and hence may be neglected. Figure 35 shows the total energy for such configurations vs. the ratio of radii.

This minimum is only strongly marked if one assumes unrealistic large Coulomb redistribution strength. Such a minimum occurs when

$$\zeta \geq 0.4 - 0.3\xi \quad . \quad (8.13)$$

The lowest ζ -value is 0.1 for $\xi = 1$.

If the total energy vs. asymmetry is very flat as it is for nuclei fulfilling the Eq. (8.9), i.e. $\xi \geq 0.85$ and $\zeta = 0.025$, a minimum may show up also for realistic low ζ -values. These minima are plotted in Fig. 36 vs. the Coulomb redistribution strength. The points of bifurcation where the minima disappear into the symmetric minimum/maximum are determined by Eq. (8.9). The

corresponding energies for the minima, maxima and second minima are plotted in Fig. 37. Here, the differences between the dashed and the full lines give the depths of the second minimum relative to the nearest maximum, which are in the order of 0 ... 4 MeV. For a given fissility and for a given ζ , in this range where the secondary minimum occurs, this one is always energetically the lowest configuration.

If one would assume adiabaticity of the motion at the scission point as it is done in static calculations, asymmetric fission could be concluded from these results. Actually, asymmetric fission (with low excitation energies) occurs for heavy nuclei and the second minimum described above also appears only for large fissilities.

IX. NORMAL MODES OF OSCILLATION

In this section, the influence of the curvature and Coulomb redistribution energies on the dynamic behavior near the (spherical) ground state and the saddle point is studied. Unfortunately, the effective masses B_{nm} in the relative kinetic energy of the system

$$T = \frac{1}{2} \sum_{n,m} B_{nm} \dot{\alpha}_n \dot{\alpha}_m \quad (9.1)$$

(α denotes here any set of deformation coordinates) are only known in the pure LDM; that means only under the assumption of an irrotational and non-viscous motion of an incompressible liquid drop. Therefore, it would be inconsistent to study the influence of the compressibility energy without knowledge of the effective masses of a compressible drop. However, as pointed out earlier, the influence of the compressibility parameter χ is a second order effect and hence does not effect the results in question.

The method of small oscillations (44) consists of expanding the relative deformation energy into a power series of second degree in the deformation coordinates

$$V = \frac{1}{2} \sum_{n,m} C_{nm} (\alpha_n - \alpha_n^0)(\alpha_m - \alpha_m^0) \quad (9.2)$$

where the α^0 denote equilibrium values, and calculating the stiffnesses C_{nm} with respect to the chosen set of deformation coordinates.

Starting with the ground state, no oscillations in terms of the eccentricity ϵ are possible because the series expansion of the relative deformation energy starts with the fourth degree. However, oscillations in terms of ϵ^2 are possible. The results for the stiffnesses, effective masses and squared eigenfrequencies

$$\omega^2 = C/B \quad (9.3)$$

are listed in [17B] - [21B]. The frequency by itself is proportional to the ground state energy of the particular oscillator mode in question.

As regards the expansion^{*} in terms of α_v , there exist infinitely many even (symmetric) and odd (asymmetric) α_v -oscillations. It can be seen from Eqs. [17C] - [21C] that only the redistribution parameter ζ enters into the stiffnesses; the curvature parameter η does not enter because of the similarity of the expansions of the relative surface and curvature energies. Therefore the resulting squared frequencies depend only on ζ , in addition to ξ or u .

* The coordinates used by Wilets (45) convert to the ones used in this work by means of $\alpha_\lambda = \sqrt{(2\lambda + 1)/4\pi}$.

The frequency of the α_2 mode agrees with the frequency of the ϵ^2 mode and is not effected by the redistribution energy. The frequencies of the other modes calculated, α_4 , α_3 , and α_5 , are lowered by the redistribution energy by relative amounts of 1.783 ζ , 2.667 ζ , and 1.281 ζ , respectively, but due to the discussion in chapter 6 numerical calculations probably would give the opposite sign.

The saddle point stiffnesses with respect to ϵ and α_v are evaluated at the equilibrium saddle point deformation $\hat{\epsilon}$ and $\hat{\alpha}_v$. The saddle point $\hat{\alpha}_4$ -deformation is set to be zero because the effective masses have only been calculated for this case. The resulting squared frequencies are therefore only correct in the lowest order in U and in Eqs. [22C] through [24C] the second order coefficients are incorrect. In this order, cross terms in the stiffnesses and in the effective masses can be neglected because they only contribute to the next order as shown by Nix (44). This means that the various α_v -modes can be treated as uncoupled modes, in other words, the eigenvectors can be treated as orthogonal ones.

As it can be seen in Eqs. [24A] and [24C], the ϵ mode and the α_2 mode play now the role of the fission mode because their squared eigenfrequencies are negative. They are equal to the lowest order in U and are again not shifted by η and ζ . In contrast, the squared eigenfrequency of the α_4 and the α_3 modes are again lowered by ζ . These modes now play the roles of the first vibrational mode and the first asymmetry mode, respectively.

X. DISCUSSION

In this chapter, the consequences are discussed drawn from the results of the above studies: (i) the appearance of the secondary minimum at large

deformations and large curvature coefficients, (ii) the influence of the curvature energy on the barrier heights and on the reciprocal effective moments of inertia, (iii) the appearance of an asymmetric minimum in the potential energy of two tangent fragments with varying ratio of radii, and (iv) the shift of the critical Businaro-Gallone point to heavier nuclei due to the DM corrections.

A second minimum at large deformations close to the scission point (in contrast to the secondary minimum from the shell wiggles) has been assumed for static scission point calculations by several authors (46-50) and obtained by Nörenberg (51) with the quasimolecular model, by Scheid and Greiner (52) with a quasimolecular optical potential model, by Mosel and Scharnweber (53,54) with a two-centre deformed oscillator model, and by v. Groote and Hilf (55) with the LDM plus curvature energy. Other second minima which have been found at large deformations were entirely due to an inappropriate parameterization of the nuclear surface.

For example, Siemens and Bethe (56) proposed that the stability of superheavy nuclei is caused by a minimum in the LDM deformation energy of a single spheroid without allowing for a necking in degree of freedom. However, as Takahashi et al. (57) and Wong (58) pointed out, such a configuration will tend towards scission since a small constriction leaves the surface energy almost unchanged but lowers the Coulomb energy significantly. On the other hand, an additional curvature energy will try to cancel the lack in Coulomb energy to yield a stable minimum. This can be seen from Fig. 38 where the energy and the corresponding deformation coordinates, i.e. half relative length and neck radius, are plotted against the curvature tension for a fictive

superheavy nucleus with $\xi = 1$. This nucleus might be in the interval $^{260}_{111}$ through $^{360}_{128}$. In the upper part of this figure, we see the energy of the Siemens and Bethe spheroid for $\eta = 0$ and the much lower energy of the configuration of two tangent spheroids. As regards the dumbbells and generalized spheroids, a minimum curvature strength of $\eta = 0.12$ or 0.15 , respectively, is required to give a second minimum for these types of deformation and this particular superheavy nucleus. The corresponding saddle (there can only be a secondary saddle because the first saddle in the case $\xi = 1$ coincides with the ground state) in the generalized spheroids parameterization is not observed due to the failure to describe accurately saddle point shapes with small necks. In this case, the lower part of this figure indicates that the neck radius goes to zero. The energies calculated with generalized spheroids are always lower than the ones calculated with dumbbells because due to the Coulomb repulsion, the nuclear matter tends to accumulate at the outermost parts of the nucleus rather than in the middle. This is not true for the saddle point shapes of light or uncharged nuclei with small fissilities (two tangent spheres). Here the Coulomb energy is very small or even vanishing so that the polarization effect is negligible. In the latter case the dumbbells are a good family of shapes.

In Fig. 39, the deformation energies of the same hypothetical nucleus but with a fixed curvature strength of $\eta = 0.16$ are plotted vs. deformation, here taken as the relative neck radius. Actually, only the points of equilibrium are known and the curves are interpolated between them. The chosen curvature strength corresponds to a curvature coefficient of $a_3 = 17.3$ MeV and is rather large compared with values calculated by Myers and Swiatecki (23) or v. Groote

and Hilf (55) (cf. appendix 1). Here the secondary minimum lies 43 MeV or 67 MeV below the ground state, for generalized spheroids or dumbbells, respectively, and the secondary saddle lies 7 MeV above the secondary minimum for dumbbells.

As regards the Nix shapes, for superheavy nuclei with $\xi = 1$, the lower limit of η at which a quasi molecular minimum occurs is larger than 0.16 or the upper limit of ξ for $\eta = 0.16$ is 0.85. For this reason the quasi-molecular equilibrium for superheavy nuclei is not well established but may be due to the parameterization. On the other hand, for the above reason we can also not conclude from the fact that the family of Nix shapes does reproduce the LDM barriers for light nuclei very well that they work also well for the highly necked in equilibrium shapes of very heavy nuclei and large curvature tension; but there is an evidence for this because the saddle point energies e.g. for $\xi = 0.8$ and $\eta = 0.16$ with the Nix shapes are lower than with the dumbbells.

Figure 40 is similar to Fig. 39 but is obtained by using the Nix shapes and plotting the potential of various nuclei here vs. the half relative length as deformation coordinate. The second minimum, which does not appear for $\xi = 0.78$ (^{228}Th), is about 1.2 MeV deep compared with the neighboring saddles for $\xi = 0.8$ (^{232}U) and it gets smaller and is located at larger deformations for $\xi = 0.82$ (^{244}Am) and $\xi = 0.84$ (^{247}Bk) and finally it vanishes for $\xi = 0.86$ (^{251}Es). The dashed line indicated by $x = 0.776$ is the corresponding LDM potential energy (10) in the vicinity of the saddle point, also for ^{232}U . The LDM curve is not much different from the DM curve in the small deformation region but it falls off towards scission without having a wriggle.

For comparison, in the lower part of this figure, we indicate the range of the shell effect humps obtained by various authors (54,59-61) by applying

the Strutinskii prescription to the single particle energy levels of a deformed potential. The deformations of these shell wiggles are listed in Table 3. It can be seen that the presently known shell energy wiggles exist at much smaller deformations than the secondary minimum from the curvature energy which causes wiggles close to the scission point. In the recent studies of Mosel and Scharnweber (54) with a two-centre deformed oscillator model, the full region of deformation from the spherical configuration over the scission line to infinitely separated fragments can be covered by use of the old Nix parameterization (9) of overlapping, tangent and separated spheroids. They obtained in addition to the primary and secondary minima and saddles a minimum and a saddle which may be caused by the fragment shells and the interaction of the potentials of the fragments. They are very closely located to the ones obtained in this work and even the depth of about 1 MeV agrees very well. However, it is not clear whether the ternary minimum of Mosel and Scharnweber is really due to shell effects or only due to the known failure of the parameterization of two spheroids.

To conclude the discussion of the secondary (or ternary) minimum we can say that the potential energy surface of a leptodermous system in the DM is different from the ordinary LDM potential in two aspects: (i) The transition from the Bohr-Wheeler family of saddle point shapes which belongs to the cubic part of the relative barrier energy in $U = 1 - \xi$ and which includes shapes like sphere, spheroids and long and slightly necked in shapes, to the Frankel-Metropolis family which corresponds to the linear part of the relative barrier energy in ξ and which includes short and highly constricted shapes is shifted to larger fissilities.* (ii) Simultaneously, with increasing curvature tension,

* For a more detailed discussion of the Bohr-Wheeler and the Frankel-Metropolis families cf. Ref. (7).

the fission barrier becomes more and more flat until a second minimum is created. The critical curvature tension is about $a_3 = 10$ MeV. This means that in the DM shell effects at the top of the fission barrier up to the scission point are more likely to yield new saddles, maxima or minima as in in the LDM.

Particularly for very large deformations calculations of shell and pairing energies are under investigation by various authors. Shell effects at the scission point together with the very flat potential energy surface may result in a new class of quasi molecular minima. In application to superheavy nuclei, these may only be stable in this state and can be formed during the fusion of heavy ions with less energy than hitherto thought.

The different families of shapes and the transitions from one to the other are illustrated in Fig. 41. The upper sequence of shapes are the saddle point shapes passed through in the LDM. For $1 \geq \xi \geq 0.6$ it is the Bohr-Wheeler family and for $0.6 \geq \xi \geq 0$ it is the Frankel-Metropolis family. With increasing curvature tension, the potential energy shows a cusp and the equilibrium is a minimum yet with a linear dependence of the relative barrier on ξ . Hence the Frankel-Metropolis family is reached earlier. This means that the shapes neck in rapidly as one goes toward lighter nuclei up to the configuration of tangent fragments. With an even larger curvature tension an additional minimum may occur.

In application to fission, we know that the sequence of saddle point shapes defines a deformation (or fission) coordinate. This sequence is usually called t-family (6) or y-family (15,60), where $t = y = 1 - x$. So Fig. 41 can also be interpreted as the shapes of a nucleus en route to scission plotted

against the deformation coordinate. Here $\xi = 1$ represents the spherical ground state, $\xi = 0$ the scission configuration and one, two or three saddles are passed over and none, one or two minima are passed through in between depending on the strength of the curvature energy. However, the t-family is only a good deformation coordinate in the immediate vicinity of the saddle and one should not use it to describe the scission point where the discrepancy between the t-family and a proper deformation coordinate is evident. The t-family leads to a scission configuration of two tangent spheres (the saddle point configuration of $x = 0$), while a dynamical calculation would lead to a scission configuration of two tangent pear-shaped fragments with the larger parts at the outer corners because of the Coulomb repulsion.

For testing the set of LDM plus DM constants obtained by Myers (see appendix 1), the saddle point energies were calculated in the DM, Eq. (2.4), with the family of generalized spheroids without expanding the denominator of $\bar{\delta}$ or neglecting terms in $\bar{\delta}$ or $\bar{\epsilon}$. These theoretical saddle energies are to be compared with the experimental ones which simply are the measured fission barriers minus the shell correction of the ground state. The shell correction by itself is the difference between the experimental ground state mass and the theoretical mass of the spherical ground state.

Since the ground state masses in the LDM are much better known than in the DM, the shell corrections of Myers and Swiatecki (22) are assumed. The quantities in question are listed in Table 4 for those nuclei whose fission barriers are either known from fission cross section measurements (62-72) or can be inferred from fission half lives (62,73). The latter are converted to fission barriers according to the formula (3)

$$\text{Fission Barrier} = a(b + 10 \log t_{1/2}[\text{sec}]) \text{ MeV}, \quad (10.1)$$

with two sets of the constants a and b

$$a = 0.125, \quad b = 21.5 \quad \text{Ref. (21)} \quad (10.2)$$

$$a = 0.115, \quad b = 21.0 \quad \text{Ref. (74)}$$

and averaging over the results. However, this conversion procedure is not expected to give accurate results because the structure of the potential energy due to shell effects is not recognized. Bjørnholm (75) is presently doing a similar analysis which takes this effect into account.

Since the fissility ξ is no longer a good measure for the location of the nucleus on the periodic table because the full DM mass formula is not a linear expression in the energies the results in Fig. 42 are plotted against Z^2/A . In addition, in order to get information about the critical Z^2/A -value, theoretical barriers for the very heavy nuclei with $Z \geq 102$ are inserted which were obtained by using the expansions of the shape dependences in α_2 and α_4 about a sphere, Eqs. [3B] ... [6B], [14B] and [15B].

The general behavior of the theoretical barriers is the same as in Fig. 7 where we took the linearized mass formula and the reference set in η , ζ , χ and the influence of the curvature energy is also approximately the same. There are three discrepancies between the theoretical and the experimental energies: (i) in the region of heavy nuclei, where the Bohr-Wheeler family of shapes is effective, the theoretical barriers are too small and (ii) in the region of the light nuclei below Radium, the region of the Frankel-Metropolis family of barriers, the experiments indicate that the calculated barriers are

too large; (iii) for nuclei lighter than Plutonium, the slope of the barriers of isotopes seems to be too small compared with the experimental one.

The former two effects are typical for a too large curvature energy, especially the slope of the barriers in the Frankel-Metropolis family in the light nuclei region. The failure of the family of generalized spheroids there gives rise only to an error of at most 4% and the difference between the theoretical and the experimental saddle energy amounts to 60% for Lutetium. Furthermore the fact that the LDM constants are not refitted completely to reproduce the experimental ground state masses can not explain these discrepancies either. A better set of LDM constants merely can shift the theoretical curves to heavier or lighter nuclei or can scale them up without changing significantly the structure of the curves.

From this we can conclude that a curvature tension of $a_3 = 9.34$ MeV as calculated by Myers and Swiatecki (23) with the Thomas-Fermi Model is not able to give accurate fission barriers rather than a curvature tension like 6.8 MeV (Refs. (13,55)).

The third discrepancy of the slope of the barriers of isobaric nuclei with Z^2/A arises from the very strong neutron excess dependence of the DM. As outlined earlier, the DM depends on I in a more complicated way than the LDM and a comparison with the LDM is aggravated by the unexpanded denominator in $\bar{\delta}$, Eq. (2.5). Using an approximation for the denominator yields for the surface asymmetry energy coefficient $b_3 \approx 3 \dots 5$ with the present set of constants instead of 1.8 which fits the experiments best in the LDM. A large surface symmetry energy coefficient reduces the surface energy which makes the nucleus more unstable, or in other words it shifts the LDM fissility

$$x = \frac{Z^2/A}{2 a_2 (1 - b_3 I^2)/c_1} \quad (10.3)$$

to larger values and makes the barrier energy smaller.

Another comparison between the experiments and the DM is possible for the reciprocal effective moments of inertia which have been obtained by various authors from measured fission-fragment anisotropies (76-81). In preparing Fig. 43, we used the family of generalized spheroids and the average set in η , ζ , χ . They are plotted against the fissility ξ (bottom scale) and the equivalent Z^2/A (top scale).*

In comparing the theory with the experiments, one has to be cautious because in the literature, different analyses are involved which may lead to different answers. Nevertheless, the slopes of both curves agree rather well but the maximum and the point where the curve passes zero are not reproduced. This was expected because the location of the theoretical curve relative to the fissility scale is given approximately by the average critical Z^2/A -value which with the present set of constants came out to be 45.5. Extrapolating the experimental points yields about 44. Referring to Eq. (10.3) this means that either the surface tension is too large or the Coulomb coefficient is too small.

The $(Z^2/A)_{\text{crit}}$ could not be extrapolated accurately from the barrier energies because the slope of the barrier curve goes to zero in contrast to the reciprocal effective moments of inertia which have a finite slope of (cf. Eq. [13C])

* Note that in Strutinskii's (32) Fig. 2 the experimental points are placed erroneously and only by mistake fit the curve with $-\Gamma = 0.1$.

$$\left. \frac{\partial \gamma_{\text{eff}}^{-1}}{\partial \xi} \right|_{\xi=1} = -\frac{7}{2} \left(1 + \frac{5}{3} \eta - \frac{2}{3} \zeta \right) \approx -4. \quad (10.4)$$

However, even in the barrier energies there is some indication that the critical Z^2/A -value should be about 44 ... 45 since the barriers of the isotopes of element 110 vanish.

All the discrepancies in the barrier energies and in the inverse effective moments of inertia will hopefully be removed if the constants of the droplet model are fitted in a self-consistent manner as described in appendix 1.

The last points of discussion are the asymmetric minimum in the potential energy for configurations of two tangent fragments arising from the Coulomb and the surface redistribution energies and the shift of the critical Businaro-Gallone point to heavier nuclei. They will be treated very briefly because they probably are not very significant.

The fact that the Coulomb redistribution energy creates a minimum in the potential energy of two tangent spheres was first noted by Swiatecki (19). Although the relative surface redistribution energies of first and second kind have also asymmetric minima, they do not contribute to an asymmetric minimum in the total energy because they are of the same order of magnitude but of opposite sign. Together with the circumstance that this minimum only appears for heavy nuclei, one could be led to the conclusion that the DM favors asymmetric fission. However, for realistic small Coulomb redistribution energy coefficients the minimum either disappears or is so small that it is not felt by the motion of the nucleus en route to scission.

On the other hand, due to the existence of the quasi-molecular minimum or to the fact that the potential energy vs. deformation is flattened by the

curvature energy, one might combine both effects to a stable configuration of a heavy nucleus which is highly deformed and consists of two nascent fragments of different size. In the presence of shell and pairing energies, the same discussion holds also here as for the curvature minimum: They can more easily work on a potential which is flat or already has a minimum, here in the asymmetry degree of freedom.

Recent experiments from Pate (82) indicate that fission is observed down to very light nuclei like Copper with fissilities $x = 0.26$ or $\xi = 0.31$. This seems to be in contradiction to the prediction of the critical Businaro-Gallone point which in the LDM is located at $x = 0.4$ (Silver) and in the DM is shifted to $\xi = 0.64$ (Lutetium). The x_{BG} corresponds to a nucleus where the saddle point loses its stability against asymmetric distortions and hence for nuclei with fissilities smaller than x_{BG} , spallation should be predominant. However, Pate's experiments were done with the Mica technique and only fragments heavier than ^{12}C can be counted. Therefore the light fragments from the spallation process are not recognized and no statements about the probability of spallation can be made, but the very low fission cross section indicates that the fission probability for these light nuclei is very low.

Physically, the critical Businaro-Gallone point has to be interpreted as the nucleus at which the fission and the spallation modes are equally even likely. The lack of knowledge about the spallation cross section therefore hinders us in comparing the theoretical x_{BG} with experiments.

Experiments which measure the fission cross sections of light nuclei are also valuable for checking another point of the theory: The maximum saddle

point energy* in the LDM occurs for nuclei with $A \approx 125$ and $E_{\text{Bar}} \approx 68$ MeV and in the DM for $A \approx 140$ and $E_{\text{Bar}} \approx 79$ MeV. If the light nuclei could be fissioned where the barriers start to decrease again, a valuable contribution to testing the LDM and DM constants could be made.

XI. SUMMARY

We have given an application of the droplet model of nuclei which was recently presented by Myers and Swiatecki (23). In calculating fission barriers we used the droplet model mass formula (which does not include shell or pairing effects) and a linearized and truncated version of it as well in order to obtain not only numerical but also analytical results which can be interpreted more easily. In the latter case, the droplet model can be taken as the liquid drop model with corrections which arise from the curvature of the surface and from effects caused by the finite compressibility of nuclear matter. It turned out that the curvature correction is the largest additional energy and, hence, we confined ourselves mostly to studying the influence of the curvature energy on the fission barriers.

In calculating fission barriers and geometrical quantities which describe the saddle point deformations, we used a variety of shape parameterizations to cover the complete interval of deformations and limiting cases like slightly distorted spheres or two tangent spheres. The stability of the saddle points against asymmetric distortions and the normal modes of oscillation at the saddles were also briefly investigated.

* The following numbers were obtained by using the linear dependence of the relative barrier on the fissility for the Frankel-Metropolis family in the two tangent sphere approximation Eq. (21).

From a comparison between the experimental barrier heights and the ones calculated with the DM using the present set of constants in it, which were estimated by Myers and Swiatecki with the Thomas Fermi approximation, we concluded that the curvature tension of 9.34 MeV is too large. A value of about 6 MeV or less would result in a much better agreement between experiment and theory. A lower limit for the curvature tension is the value zero due to Süssmann (83): The LDM without curvature energy is indifferent with respect to "porcupine like" deformations; adding a cylinder shaped spike of finite length and infinitely small radius in the LDM does not influence the energy of an equilibrium shape. On the other hand, in the DM, a positive curvature energy is added by such types of deformation which is proportional to the length of the spike and hence the total energy becomes larger. This effect is most drastic at the scission point. In the LDM, the shape of equilibrium with minimum energy in the subspace of tangent fragments is the configuration of two infinitely separated spheres which are connected by an infinitely thin thread. Adding a small amount of curvature energy prevents the construction of this unrealistic neck.

Generally, the curvature energy has (i) the effect of increasing the barrier and (ii) of flattening the shape of the barrier. If the curvature tension would be large enough, even a second minimum would be introduced into the potential energy vs. deformation. This occurs only for heavy nuclei, and, especially for superheavy nuclei, the second minimum goes over into a quasi-molecular minimum near the scission point. These secondary minima are stable with respect to asymmetric deformations.

Among the other corrections, the Coulomb redistribution energy is important despite the fact that it is small: It can introduce a minimum into

the potential energy vs. asymmetry and, hence, may contribute to the explanation of asymmetric fission.

In appendix 1, we readjusted the LDM constants (surface tension and Coulomb strength) for the DM corrections by performing one step in a self-consistent calculation of the complete set of constants in the mass formula. Other possibilities of fitting the constants are also discussed.

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Table 1. Energies of the nucleus ^{236}U in the spherical ground state.

volume	-3699.8 MeV
volume symmetry of first order	+ 267.6 MeV
volume symmetry of second order	- 13.7 MeV
surface	+ 708.8 MeV
surface symmetry	- 61.3 MeV
curvature	+ 57.7 MeV
compressibility	- 4.4 MeV
Coulomb	+ 982.0 MeV
diffuseness	- 30.2 MeV
exchange	- 36.8 MeV
Coulomb redistribution	- 7.7 MeV
surface redistribution of second kind	- 4.2 MeV
(surface redistribution of first kind	+ 2.7 MeV)
(cross term between symmetry and surface	
redistribution of first kind	+ 59.4 MeV)

Table 2. Comparison of the calculated Businaro-Gallone fissilities where the saddle point loses its stability with respect to asymmetric distortions. (sphere: expansion in $\alpha_2, \alpha_3, \alpha_4, \alpha_5$; calc.: generalized spheroids; tangent spheres: expansion in ν , where $\nu = \mu - 1$ and μ is the ratio of radii) For comparison, the values obtained in the liquid drop model by Cohen and Swiatecki (8) or Nix (10) are 0.394 or 0.396, respectively.

η	ζ	χ	Sphere	ϵ_{BG}		Tangent spheres
				Calc.		
0	0	0	0.754	0.422		0.600
0.04	0	0	0.796	0.4675		0.606
0.08	0	0	0.838	0.544		0.612
0	0.008	0	0.750	0.517		0.686
0	0.016	0	0.746	0.620		0.771
0	0.024	0	0.742	0.722		0.857
0	0.032	0	0.738	0.793		0.943
0	0	0.04	0.7575	0.412		0.5875
0	0	0.08	0.761	0.4015		0.575
0	0	0.12	0.7645	0.391		0.5625
0	0	0.16	0.768	0.381		0.550
0.0917	0.0113	0.0229	0.847	0.639		0.728

Table 3. Comparison of the deformations (ζ_0 = half relative length, ρ_n = relative neck radius) of the primary, secondary and ternary minima and saddles obtained by Tsang (59) Nix (61) and Mosel and Scharnweber (54) for an actinide nucleus.

Author	Primary Minimum		Primary Saddle		Secondary Minimum		Secondary Saddle		Ternary Minimum		Ternary Saddle	
	ζ_0	ρ_n	ζ_0	ρ_n	ζ_0	ρ_n	ζ_0	ρ_n	ζ_0	ρ_n	ζ_0	ρ_n
C. F. Tsang	1.20	0.96	1.22	0.87	1.57	0.83	1.87	0.80	-----	-----	-----	-----
J. R. Nix	1.12	0.94	1.29	0.86	1.43	0.79	1.62	0.69	-----	-----	-----	-----
U. B. Mosel	1.13	0.94	1.33	0.86	1.48	0.82	1.81	0.68	2.30	0.49	2.68	0.00
This work	1.00	1.00	1.63	0.70	-----	-----	-----	-----	2.25	0.37	2.37	0.23

Table 4. Fission barrier heights. Ref. a) through i) are barrier measurements and Refs. j) and k) are fission half-life measurements. The latter ones are converted to barriers by means of Eq. (10.1). The column "Shell Energy" lists the shell correction of the ground state and is taken from Ref. (22). "Experimental Saddle Energy" = "Experimental Barrier" + "Shell Energy". The "Theoretical Barrier" is the droplet model saddle point energy minus the spherical ground state energy.

Compound Nucleus	Z^2/A	ξ	Exp. Barrier	Shell Energy	Exp. Saddle Energy	Theoret. Saddle Energy	Ref.
$^{173}\text{Lu}_{71}$	29.14	.6214	27.3	-0.47	26.83	40.53	i
$^{179}\text{Ta}_{73}$	29.77	.6376	26.2	-0.39	25.81	37.33	i
$^{188}\text{Os}_{76}$	30.72	.6620	23.7	-1.67	22.03	32.21	i
$^{187}\text{Os}_{76}$	30.89	.6635	22.5	-1.49	21.01	31.98	i
$^{186}\text{Os}_{76}$	31.05	.6650	22.5	-1.47	21.03	31.73	i
$^{191}\text{Ir}_{77}$	31.04	.6701	22.8	-2.31	20.49	30.42	i
$^{189}\text{Ir}_{77}$	31.37	.6731	21.7	-1.50	20.2	29.95	i
$^{198}\text{Hg}_{80}$	32.32	.6976	21.8	-6.07	15.73	24.36	h
$^{201}\text{Tl}_{81}$	32.64	.7057	22.3	-7.65	14.65	22.41	h
"	"	"	22.5	"	14.85	"	e

(continued)

Table 4 (continued)

Compound Nucleus	Z^2/A	ξ	Exp. Barrier	Shell Energy	Exp. Saddle Energy	Theoret. Saddle Energy	Ref.
$^{209}\text{Bi}_{83}$	32.96	.7195	22.6	-11.34	11.26	18.80	h
"	"	"	20.6	"	9.27	"	r
$^{207}\text{Bi}_{83}$	33.28	.7222	21.2	- 9.95	11.25	18.39	h
"	"	"	20.6	"	10.66	"	f
$^{212}\text{Po}_{84}$	33.28	.7278	18.6	- 7.75	10.85	16.72	h
$^{211}\text{Po}_{84}$	33.44	.7290	21.5	- 8.82	12.68	16.53	i
$^{210}\text{Po}_{84}$	33.60	.7304	20.4	- 9.99	10.41	16.33	h
"	"	"	18.6	"	8.61	"	f
$^{213}\text{At}_{85}$	33.92	.7386	16.8	- 6.34	10.46	14.22	h
"	"	"	15.8	"	9.47	"	f
$^{227}\text{Ra}_{88}$	34.11	.7576	8.30	0.82	9.12	7.71	j
$^{233}\text{Th}_{90}$	34.76	.7743	6.44	0.45	6.89	5.68	a
$^{232}\text{Th}_{90}$	34.91	.7754	5.95	0.49	6.44	5.66	a

(continued)

Table 4 (continued)

Compound Nucleus	Z ² /A	ξ	Exp. Barrier	Shell Energy	Exp. Saddle Energy	Theoret. Saddle Energy	Ref.
²³² Pa ₉₁	35.69	.7871	6.18	0.11	6.29	4.81	a
²³⁹ U ₉₂	35.41	.7911	6.29	0.07	6.36	4.17	c
"	"	"	6.15	"	6.22	"	a
²³⁸ U ₉₂	35.56	.7922	5.60	0.01	5.61	4.16	g
"	"	"	5.80	"	5.81	"	a
²³⁷ U ₉₂	35.71	.7932	6.40	-0.33	6.07	4.15	a
²³⁶ U ₉₂	35.86	.7943	5.44	-0.11	5.33	4.13	c
"	"	"	5.80	"	5.69	"	b
²³⁵ U ₉₂	36.02	.7955	5.75	-0.28	5.47	4.11	a
²³⁴ U ₉₂	36.17	.7967	5.30	0.35	4.95	4.09	c
"	"	"	5.20	"	4.85	"	b
²³³ U ₉₂	36.33	.7979	5.49	-0.46	5.95	4.07	a
²³⁸ Np ₉₃	36.34	.8038	6.04	-0.67	5.37	3.50	a
²³⁷ Np ₉₃	36.49	.8050	5.49	-0.54	4.95	3.49	a

(continued)

Table 4 (continued)

Compound Nucleus	Z ² /A	ξ	Exp. Barrier	Shell Energy	Exp. Saddle Energy	Theoret. Saddle Energy	Ref.
²⁴⁴ Pu ₉₄	36.21	.8090	4.60	-0.34	4.26	2.99	1
²⁴² Pu ₉₄	36.51	.8111	4.70	-0.50	4.20	2.97	1
²⁴¹ Pu ₉₄	36.66	.8122	6.20	-0.83	5.37	2.96	b
"	"	"	6.30	"	5.47	"	b
²⁴⁰ Pu ₉₄	36.82	.8134	4.85	-0.67	4.18	2.95	c
"	"	"	4.70	"	4.03	"	b
²³⁹ Pu ₉₄	36.97	.8145	5.48	-1.00	4.48	2.93	a
²³⁸ Pu ₉₄	37.13	.8158	4.70	-0.88	4.32	2.92	1
²³⁶ Pu ₉₄	37.44	.8183	4.55	-0.74	3.81	2.88	1
²⁴⁴ Am ₉₅	36.99	.8206	6.21	-0.87	5.34	2.49	d
²⁴² Am ₉₅	37.29	.8229	6.40	-1.20	5.20	2.46	b
²⁴¹ Am ₉₅	37.45	.8241	6.00	-1.18	4.82	2.45	b
²⁵⁰ Cm ₉₆	36.86	.8258	4.10	-0.90	3.20	2.08	1

(continued)

Table 4 (continued)

Compound Nucleus	Z^2/A	ξ	Exp. Barrier	Shell Energy	Exp. Saddle Energy	Theoret. Saddle Energy	Ref.
$^{248}\text{Cm}_{96}$	37.16	.8279	4.25	-0.98	3.27	2.07	1
$^{246}\text{Cm}_{96}$	37.46	.8301	4.35	-1.17	3.18	2.06	1
$^{244}\text{Cm}_{96}$	37.77	.8324	4.25	-1.21	3.04	2.04	1
$^{242}\text{Cm}_{96}$	38.08	.8349	4.25	-1.42	2.83	2.01	1
$^{240}\text{Cm}_{96}$	38.40	.8375	4.15	-1.40	2.75	1.98	1
$^{250}\text{Bk}_{97}$	37.64	.8373	5.80	-1.13	4.67	1.70	k
$^{249}\text{Bk}_{97}$	37.79	.8384	4.35	-1.35	3.00	1.70	1
$^{252}\text{Cf}_{98}$	38.11	.8468	3.65	-1.27	2.38	1.38	1
$^{250}\text{Cf}_{98}$	38.42	.8491	3.95	-1.81	2.14	1.37	1
$^{248}\text{Cf}_{98}$	38.73	.8515	3.85	-1.92	1.93	1.35	1
$^{246}\text{Cf}_{98}$	39.04	.8541	3.85	-1.93	1.92	1.33	1
$^{254}\text{Fm}_{100}$	39.37	.8682	3.35	-1.89	1.46	.855	1

(continued)

Table 4 (continued)

Compound Nucleus	Z^2/A	ξ	Exp. Barrier	Shell Energy	Exp. Saddle Energy	Theoret. Saddle Energy	Ref.
$^{248}\text{Fm}_{100}$	40.32	.8761	2.75	-2.13	0.60	.806	m
$^{246}\text{Fm}_{100}$	40.65	.8790	2.55	-2.00	0.55	.784	m
$^{245}\text{Fm}_{100}$	40.82	.8806	2.62	-2.00	0.62	.772	m
$^{244}\text{Fm}_{100}$	40.98	.8821	2.62	-2.00	0.62	.759	m

^aE. K. Hyde (62)^bI. Halpern (63)^cJ. A. Northrop et al. (64)^dD. K. Butler and R. K. Sjoblom (65)^eD. S. Burnett et al. (66)^fJ. R. Huizenga et al. (67)^gB. D. Wilkins et al. (68)^hA. Khodai-Joopari (69)ⁱS. G. Thompson (70)^jYu. A. Babenko et al. (71)^kP. E. Vorotnikov et al. (72)^lE. K. Hyde (62) (from half-lives)^mM. Nurmia et al. (73) (from half-lives)

(continued)

FIGURE CAPTIONS

- Fig. 1. Errors in percent in the relative barriers obtained with various parameterizations. Notations: CS: Cohen and Swiatecki (8), S: Strutinskii (32), N: Nix (10), L: Lawrence (37), DB: dumbbells; for instance N: CS means $[B_{\text{Bar}}(N) - B_{\text{Bar}}(\text{CS})]/B_{\text{Bar}}(N)$.
- Fig. 2. Examples of shapes contained in the parameterization of generalized spheroids. Note that a sphere, spheroids and configurations of tangent fragments are possible shapes.
- Fig. 3. Geometrical quantities of the dumbbell parameterization.
- Fig. 4. Examples of shapes contained in the dumbbell parameterization. The inserted curves give lines of constant radii of the spheres which are eliminated by the condition of constant volume, Eq. (4.7). For convenience, the parameters are measured in units of $2^{-1/3}$.
- Fig. 5. The shape dependences for spheroids plotted vs. the relative half length ζ_0 , the ratio of minor to major semi axis a/c and the prolate eccentricity ϵ .
- Fig. 6. The relative energy at "scission", the half relative length and the eccentricity of the minimum configuration of two tangent spheroids for $\eta = 0$ and 0.16. For comparison, the relative energy of the configuration of two infinitely separated spheres is plotted in the insert.
- Fig. 7. Numerically computed barriers. The upper part gives a comparison of liquid drop model barriers obtained by using different parameterizations: $S(-\Gamma = 0)$: Strutinskii, DB: dumbbells, N: Nix, L: Lawrence, H: Hasse (this work), CS: Cohen and Swiatecki. In addition, $S(-\Gamma) = 0.1$ gives the results of Strutinskii with a finite curvature energy and the heavy line

gives the results with the droplet model with use of the reference set in η , ζ , and χ . The three lower bunches of curves are the results of the droplet model with the parameterization of generalized spheroids and various values of η , ζ , and χ . Here only the energies are plotted which correspond to the first saddle point.

Fig. 8. The relative barriers obtained by use of the parameterization of generalized spheroids, plotted vs. the compressibility parameter χ .

Fig. 9. The relative barriers obtained by use of the parameterization of generalized spheroids plotted vs. the Coulomb redistribution parameter ζ .

Fig. 10. The relative saddle point and minimum shape energies obtained by use of the parameterization of generalized spheroids for $\eta = 0, 0.04, 0.08, 0.12$, and 0.16 .

Fig. 11. The relative saddle point and minimum shape energies obtained by use of the parameterization of dumbbells for $\eta = 0.16$.

Fig. 12. The relative saddle point and minimum shape energies obtained by use of the Nix-parameterization for $\eta = 0$ and 0.16 .

Fig. 13. The relative saddle point energies (minimum shape energies are omitted) obtained by use of the parameterization of generalized spheroids ($\xi = 0.8 \dots 0.3$) and dumbbells ($\xi = 0.1$), plotted vs. η . Also shown are the results of Strutinskii for $-\Gamma = 0$ and 0.1 . These points are connected by a dashed line.

Fig. 14. Half the relative lengths of the equilibrium shapes. (For notations cf. Fig. 7).

Fig. 15. Constriction coordinates of the equilibrium shapes of generalized spheroids (For notations cf. Fig. 7).

- Fig. 16. Relative neck radii of the equilibrium shapes (For notations cf. Fig. 7).
- Fig. 17. Dumbbell elongation coordinates of the equilibrium shapes for $\eta = 0.16$ in the heavy and $\eta = 0$ in the light nuclei region.
- Fig. 18. Dumbbell constriction coordinates of the equilibrium shapes for $\eta = 0.16$ in the heavy and $\eta = 0$ in the light nuclei region.
- Fig. 19. Radii of the spheres in the dumbbell parameterization of the equilibrium shapes for $\eta = 0.16$ in the heavy and $\eta = 0$ in the light nuclei region.
- Fig. 20. Nix parameters for the equilibrium shapes with $\eta = 0$ and 0.16 .
- Fig. 21. Relative half lengths ζ_0 and neck radii ρ_n of the equilibrium shapes obtained by use of the Nix parameterization.
- Fig. 22. Relative Coulomb energies of the equilibrium shapes (For notations cf. Fig. 7).
- Fig. 23. Relative surface energies of the equilibrium shapes (For notations cf. Fig. 7).
- Fig. 24. Relative curvature energies of the equilibrium shapes (For notations cf. Fig. 7).
- Fig. 25. Relative Coulomb redistribution energies of the equilibrium shapes (For notations cf. Fig. 7).
- Fig. 26. Relative surface redistribution energies of first kind of the equilibrium shapes (For notations cf. Fig. 7).
- Fig. 27. Relative surface redistribution energies of second kind of the equilibrium shapes (For notations cf. Fig. 7).
- Fig. 28. Relative compressibility energies of the equilibrium shapes (For notations cf. Fig. 7).

- Fig. 29. Relative quadrupole moments of the equilibrium shapes (For notations cf. Fig. 7).
- Fig. 30. Relative parallel moments of inertia of the equilibrium shapes (For notations cf. Fig. 7).
- Fig. 31. Relative perpendicular moments of inertia of the equilibrium shapes (For notations cf. Fig. 7).
- Fig. 32. Inverse relative effective moments of inertia of the equilibrium shapes (For notations cf. Fig. 7).
- Fig. 33. Asymmetry stiffnesses (second derivatives of the barrier energy with respect to the asymmetry coordinate ξ_1) of the equilibrium shapes (For notations cf. Fig. 7). Positive stiffnesses mean that the shape in question is stable with respect to asymmetric distortions. Note that the stiffnesses corresponding to the second minima appearing at $\eta = 0.12$ and 0.16 are positive. The fissilities where the stiffnesses go through zero determine the Businaro-Gallone points.
- Fig. 34. The relative energies of configurations of two tangent spheres are plotted vs. the ratio of radii.
- Fig. 35. The total relative deformation energies of configurations of two tangent spheres plotted vs. the ratio of radii with ξ as parameter.
- Fig. 36. The ratios of radii corresponding to maximum (full lines) and minimum (dotted lines) energies of the configuration of tangent spheres. Points indicate the points of bifurcation at symmetry.
- Fig. 37. The relative total energies corresponding to the results of Fig. 36.
- Fig. 38. Relative barriers, half lengths and neck radii of the saddle point and minimum shapes of a superheavy nucleus with $\xi = 1$ ($^{260}_{111} \dots ^{360}_{128}$)

plotted vs. the curvature parameter η . The indicated spheroidal shape was discussed by Siemens and Bethe; it is not a stable configuration.

Fig. 39. The potential energy of a superheavy nucleus with $\xi = 1$, $\eta = 0.16$ ($a_3 = 17.3$ MeV) and with its energy unit $E^0 = 770$ MeV plotted vs. deformation, here taken as the relative neck radius, obtained by use of the parameterizations of generalized spheroids and dumbbells. The shapes of the points of equilibrium are also shown.

Fig. 40. The potential energy of various nuclei obtained by use of the Nix parameterization with $\eta = 0.16$, ($a_3 = 16.5$ MeV), plotted vs. deformation, here taken as the half relative length. The corresponding shapes of equilibrium are also shown. The curve with $\xi = 0.82$ in the droplet model belongs to ^{232}U , the dashed curve in the liquid drop model belongs to the same nucleus. The wriggly curve with error bars at the bottom of the figure indicates the range of the shell effects (cf. Table 3).

Fig. 41. Schematic drawing of various saddle point and minimum energy shapes, depending on the strength of the curvature energy (see text). This drawing can also be seen as plotted against some fission or deformation coordinate; then it gives the various paths from the ground state over one, two or three saddles and through none, one or two minima to scission.

Fig. 42. Theoretical barriers obtained by using the full droplet model Eq. (2.4). The experimental data (62-73) are taken from Table 4.

Fig. 43. Theoretical reciprocal effective moments of inertia obtained by using the parameterization of generalized spheroids and the reference set of η , ζ , and χ , compared with experiments. Note that the absolute location of the theoretical curve depends strongly on the critical Z^2/A value assumed.

Fig. 1

Fig. 2

ORNL-DWG 70-1706

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

XBL 707-1631

Fig. 10

Fig. 11

XBL 706-3045

Fig. 12

Fig. 13

Fig. 14

Fig. 15

Fig. 16

Fig. 17

Fig. 18

Fig. 19

XBL707 - 3509

Fig. 20

XBL 707 - 3511

Fig. 21

Fig. 22

Fig. 23

Fig. 24

Fig. 25

Fig. 26

Fig. 27

Fig. 28

Fig. 29

Fig. 30

Fig. 31

ORNL-DWG 69-9441

Fig. 32

Fig. 33

XBL 707-1627

Fig. 34

XBL 707-1628

Fig. 35

XBL 707-1629

Fig. 36

XBL 707-1633

Fig. 37

Fig. 38

XBL706-3044

Fig. 39

Fig. 40

XBL707-3512

ORNL-DWG 69-12876

Fig. 41

XBL 707-3508

Fig. 42

ORNL-DWG 70-1705

Fig. 43

APPENDICES

A1. Constants of the Droplet Model

The coefficients of the additional energy terms of the DM are the crucial point in the present status of the DM: The LDM constants can easily be obtained by fitting the LDM mass formula to the some 1200 experimental ground state masses provided proper shell and pairing energies are taken into account. On the other hand, the correction energies due to the DM are one or two orders of magnitude smaller and mostly have a weak A-dependence. Therefore it is not suitable to apply the same fitting procedure because it is likely that one only shifts some amount of energy e.g. from the surface energy into the curvature energy or vice versa and the resulting curvature coefficient has still a large uncertainty.

Fortunately, the shape dependences of the surface and of the curvature energies are rather different so that one may fit e.g. the fission barriers or the total kinetic energies of the fission fragments. In the first case, one deals with B_{curv} evaluated at the saddle point and in the second case at the scission point. The first procedure was applied by v. Groote and Hilf (55) to yield $6 \text{ MeV} \leq a_3 \leq 8 \text{ MeV}$ with 6.8 MeV being the most probable value and the second one by Schade (84) to yield $1.9 \text{ MeV} \leq a_3 \leq 20 \text{ MeV}$ with 3 MeV being the most probable value.

More fundamental approaches without fitting to the experimental data were done by Moszkowski (85) with a Hartree-Fock model with simple interactions, the result is about 9 MeV for the term proportional to $A^{1/3}$ and by Schade and Hilf (86) with the Fermi gas model with the result $1.9 \text{ MeV} \leq a_3 \leq 13 \text{ MeV}$, both without considering the compressibility energy.

From the results of the present work (cf. chapter 10) we concluded that a curvature tension of larger than about 9 MeV is not able to explain fission barriers and that the most probable value is very likely less than about 7 MeV.

Myers chose a different way to get estimates of the coefficients of the DM energies. The constants $a_1 \dots a_3, c_1 \dots c_5, J \dots Q$ were calculated by him on the basis of the Thomas-Fermi model as follows: Taking the constants a_1, a_2, J , and c_1 from previous works, where they were fitted at the liquid drop model with shell and pairing effects, a corresponding set of parameters of a velocity-dependent spherical symmetric nuclear Yukawa potential of the form

$$V(r,p) = - \underset{\text{unlike}}{C_{\text{like}}} \frac{e^{-r/a}}{r/a} \left[1 - \left(\frac{p}{b} \right)^2 \right] \quad (\text{A1.1})$$

was calculated. These parameters are C_{like} the interaction strength between "like" particles, C_{unlike} , the interaction strength between "unlike" particles, $b^2/2M$, the energy of a particle with the critical momentum b where the force becomes repulsive, and a , the range of the interaction. With the potential (A1.1), the remaining DM constants were determined.*

The set of LDM plus DM constants obtained by Myers in this way is listed in Table A1. The constant b_3 , the surface symmetry energy constant, came out to $b_3 = 5.114$ or, taking the average reduction due to the denominator of $\bar{\delta}$ Eq. (2.5) into account, to about $b_3 = 3$. These values are to be compared with $b_3 = 1.7826$ from previous works of Myers and Swiatecki (21,22). Since the above given values from the Thomas-Fermi calculations do not seem to be consistent with the latter one, we used $b_3 = 1.7826$ throughout this work.

* Recently, the momentum dependence was refined to a Lorentzian form $[c + \{1 + (p/b)^2\}^{-1}]$ with the additional parameter c fitted to the surface thickness.

Table A1. The liquid drop model constants taken as input parameters for the Thomas-Fermi model and the resulting droplet model constants.

$a_1 = 15.677 \text{ MeV}$	$a_2 = 18.56 \text{ MeV}$	$a_3 = 9.34 \text{ MeV}$	$a_4 = 2.337 \text{ MeV}$
$b_1 = 1.79$	$b_2 = 1.566$	$b_3 = 5.114 (1.7826)^*$	
$c_1 = 0.717 \text{ MeV}$	$c_2 = 0.0001479 \text{ MeV}$	$c_3 = 0.8412 \text{ MeV}$	
$c_4 = 0.5475 \text{ MeV}$	$c_5 = 0.0005008 \text{ MeV}$	$c_6 = 0.001971 \text{ MeV}$	

* This value, due to W. D. Myers and W. J. Swiatecki, Nucl. Phys. 81, 1 (1966), is used in this work.

The DM constants obtained in this way, however, are not expected to be the best possible for two reasons: (i) The input parameters were taken from the LDM which fitted best the experimental ground-state masses. Because of the additional energies in the binding energy formula (2.4) or (3.1), this is no longer true for the DM. (ii) The resulting DM constants depend strongly on the form of the Thomas-Fermi potential.

The way of refitting the constants in fact should be as follows: Taking an input set of constants from the LDM with shell and pairing effects, the DM constants are to be calculated with the Thomas-Fermi model. Then only the LDM constants are fitted again to the experimental ground state masses (and maybe also to the fission barriers) but with the DM mass formula including shell and pairing effects. With the new set of LDM constants again one has to enter into the Thomas-Fermi model until the set of LDM constants plus the set of DM constants is self-consistent.

In this work, we performed only the next step in a self-consistent calculation in the following way: Dealing only with curvature, compressibility and Coulomb redistribution effects, it is obvious that the first two energies are mainly corrections to the surface energy while the third energy is mainly a correction to the Coulomb energy. The procedure of refitting the LDM constants (in the spherical case) is now to equate the average over some interval $A_- \leq A \leq A_+$ of the surface energy to the refined surface energy including curvature and compressibility energies, and the average over the same interval of the Coulomb energy to the refined Coulomb energy including the Coulomb redistribution energy.

$$a_2 \bar{K} \bar{A}^{2/3} = a_2' \bar{K} \bar{A}^{2/3} + (a_3 - a_4) \bar{A}^{1/3} \quad (A1.2)$$

$$c_1 \bar{Z}^2 \bar{A}^{-1/3} = c_1' \bar{Z}^2 \bar{A}^{-1/3} - c_2 \bar{Z}^2 \bar{A}^{1/3} .$$

Here $K = 1 - b_3 I^2$ and the bars stand for the average over some A interval.

In the valley of beta-stability of heavy nuclei,*

$$I = \frac{A^{2/3}}{175} \quad (A1.3)$$

is a good approximation for the neutron excess and we made use of this formula in order to work only with mass numbers.

After having performed a least squares minimizing process we are led to

$$\begin{aligned} a_2' &= a_2 - (a_3 - a_4) \overline{(KA^{1/3})^{-1}} \\ c_1' &= c_1 + c_2 \bar{A}^{2/3} . \end{aligned} \quad (A1.4)$$

The averages are given by

$$\begin{aligned} \overline{(KA^{1/3})^{-1}} &= \frac{3}{2} \cdot \frac{A_+^{2/3} - A_-^{2/3}}{A_+ - A_-} + \frac{1}{2} \cdot \frac{b_3}{175} (A_+ + A_-) \\ \bar{A}^{2/3} &= \frac{3}{5} \cdot \frac{A_+^{5/3} - A_-^{5/3}}{A_+ - A_-} . \end{aligned} \quad (A1.5)$$

Further on we will need also the average surface symmetry factor

* This formula is derived from a LDM including volume, volume symmetry, surface symmetry, and Coulomb energies:

$$I = \frac{1}{4} c_1 A^{5/3} / (a_1 b_1 A - a_2 b_3 A^{2/3} + \frac{1}{4} c_1 A^{5/3}) \approx c_1 A^{2/3} / 4 a_1 b_1 \approx A^{2/3} / 175 .$$

$$\bar{K} = 1 - \frac{3b_3}{7 \cdot 175^2} \cdot \frac{A_+^{5/3} - A_-^{5/3}}{A_+ - A_-} \quad (A1.6)$$

The averages given above are listed in Table A2 for two averaging intervals: $60 \leq A \leq 300$ and $150 \leq A \leq 300$ (heavy nuclei). Also listed are the mass numbers A_s and A_c and the proton numbers Z_s and Z_c where the averaging processes of the surface (s) and Coulomb (C) energies are best, e.g.,

$$A_s = [\bar{K} \cdot (KA^{1/3})^{-1}]^{-3},$$

$$A_c = (A^{2/3})^{3/2},$$

$$Z_{\frac{s}{c}} = \frac{1}{2} A_{\frac{s}{c}} (1 - A_{\frac{s}{c}}^{2/3}/175) \quad (A1.7)$$

For the heavy nuclei interval, $^{224}\text{Ra}_{88}$ is the nucleus for which the fits are best for both the surface and Coulomb energies. We again mention here that the refitted constants a_2' and c_1' are obtained by just performing one step of the self-consistent calculation and hence still need not necessarily give the best results.

Table A2 gives also values for $\overline{(Z^2/A)_{\text{crit}}}$, the average of the critical Z^2/A -value where the saddle point and the spherical ground state coincide:

$$\overline{(Z^2/A)_{\text{crit}}} = \overline{\left(\frac{Z^2}{A\xi} \right)} \quad (A1.8)$$

In case of the heavy nuclei, it is about 45.5 somewhat lower than the old LDM value (21,22) of 46.5. The critical Z^2/A depends strongly on the surface tension a_2 , the surface symmetry energy constant b_3 and the Coulomb energy strength c_1 . Taking $b_3 = 2.7$ according to Seeger (87) or the

Table A2. The refined constants and mean quantities obtained by averaging the droplet model correction energies.

	Average values in the interval	
	$60 \leq A \leq 300$	$150 \leq A \leq 300$
$(KA^{1/3})^{-1}$	0.1948	0.1789
$A^{2/3}$	31.31	36.84
$\bar{K}$	0.9388	0.9107
a'_2	17.20	17.31
c'_1	0.7216	0.7225
A_s	163.5	224.4
A_C	175.2	223.6
Z_s	67.8	88.5
Z_C	71.9	88.3
$(Z^2/A)_{crit}$	46.5	45.5
$\bar{\eta}$	0.1005	0.0917
$\bar{\zeta}$	0.0082	0.0113
$\bar{\chi}$	0.0251	0.0229

effective value of about 3.0 derived above, and a_2 and c_1 from Table A2, the average critical Z^2/A value would be 44. Then the experimental barriers and inverse effective moments of inertia would be reproduced much better (see chapter 10). Strutinskii (32) obtained $(Z^2/A)_{\text{crit}} = 45$ with a curvature tension of about $a_3 = 10$ MeV. In a recent paper, Myers (26) proposed a new set of LDM and DM constants in order to calculate single particle potential wells from the droplet model. With $a_2 = 22$ MeV, $b_3 = 4.35$, and $c_1 = 0.745$ MeV, we obtain refined values of $a_2' = 20.79$ MeV, $c_1' = 0.750$ MeV, and $(Z^2/A)_{\text{crit}} = 52.7$, which is even larger than before.

The rest of the table lists the average relative droplet model strengths $\bar{\eta}$, $\bar{\zeta}$, and $\bar{\chi}$ which were obtained in the same way and used throughout this paper as reference set. In Table A7 of appendix A5, however, the relative strengths η , ζ , and χ are listed for some particular heavy nuclei and one can see that the actual values of the parameters do not deviate too much from the average ones.

A2. Numerical Methods and Accuracy

In this section we give some details of the numerical procedures and the accuracies.

The case of generalized spheroids is the most simple because of the smoothness of the shapes. Here a 32 point-Gaussian integration was sufficient to integrate the one fold integrals B_{surf} (Eq. [4H]) and B_{curv} (Eq. [5H]), the two fold integrals B_{sr1} , B_{sr2} (Eqs. [14H], [15H]) and the three fold integrals B_{coul} (Eq. [3H]) and B_{red} (Eq. [6H]). The integrand in the Coulomb potential (see Eq. [25A]) does not give rise to difficulties as long as it is integrated by a Gaussian formula because the end points where $\rho\bar{\rho} = 0$ are not reached. However, if $\zeta = \bar{\zeta}$, the argument of the elliptic integrals is unity and in this case the integrand of the Coulomb potential simply is 2ρ .

The relative deformation energy was computed at the corners of a pentagon around an estimated starting point and iterated until certain criteria for the parameters and the energy were reached. This procedure led to equilibrium shapes with an accuracy in the energy of 0.01% for moderately deformed nuclei ($\xi > 0.7$) and 0.5% for highly deformed nuclei ($\xi \approx 0.3$). The loss in accuracy comes from the longer shapes which are still integrated with the same number of Gaussian points (cf. the results of Lawrence (37) with table A4.a). The Coulomb energies and the Coulomb redistribution energies which were calculated with two different methods, the Coulomb energy with a triple integration without elliptic integrals, and the Coulomb redistribution energy with the Coulomb potential which involves elliptic integrals, can be checked against each other because the following identity holds for all deformations

$$\bar{\phi} = \frac{6}{5} B_{\text{Coul}} \quad (\text{A2.1})$$

After the saddle point was located, a small asymmetric distortion was applied to the shape according to Eq. (8.10). The asymmetry stiffness was calculated and the quantities ρ_n , Q , $\gamma_{\parallel}$, $\gamma_{\perp}$, γ_{eff}^{-1} , B_{sr1} , B_{sr2} were determined at the symmetric saddle point.

On the other hand, as regards dumbbells, a Gaussian formula is not appropriate for integration if one does not divide the integration interval, because of the sharp corners in the shape. We hence divided the integration interval into three parts according to the three sections of the dumbbell and integrated by means of a 24 point Simpson rule in each section with special care taken at the end points. With this method, the Coulomb energy can be calculated with an accuracy of about 0.1%, while the redistribution energies have an

uncertainty of about 5%. The error in the relative barrier is mainly due to the Coulomb energy because the surface and curvature energies can be calculated analytically; this error increases from 0 to 0.2% as the fissility decreases from one to zero.

A3. Collection of Liquid Drop and Droplet Model Formulae

Table A3 lists most of the available formulae concerning the shape dependences of the liquid drop model and the droplet model. The following formulae are taken from other authors:

W. J. Swiatecki (28) [6A], [6B], [6D], [6E], [6J]
 W. J. Swiatecki (5) [3B], [4B], [3D], [4D]
 S. Cohen and W. J. Swiatecki (8) [25A]
 R. W. Hasse (13) [3E], [4E], [5E], [4H], [5H], [10H], [11H], [12H]
 J. Trepulka (40) [5D], [5G]
 J. N. P. Lawrence (37) [3H], [26A]
 J. R. Nix (44) [17C], [18C]
 S. Flügge (88) [27A]

Table A3. Collection of liquid drop and droplet model formulae

- a: Definitions
- b: Slightly distorted sphere, including saddle point values (expansion in α_2, α_4)
- c: Slightly asymmetrically distorted sphere (expansion in α_3 and α_5)
- d: Spheroids, including expansions in ϵ .
- e: General expressions in spherical and cylindrical coordinates, including unexpanded formulae in α_2 and α_4 and generalized spheroids.

- f: Two tangent and n infinitely separated spheres
- g: Small oscillations about the spherical ground state and the deformed saddle point
- h: Various formulae for the Coulomb potential in the volume and on the surface.

t5

Quantity	General Definition [A]
Shape [1]	Equilibrium-surface method
Relative barrier [2]	$B_{\text{Bar}} = B_{\text{Def}} - B_{\text{Def}}^0$
Relative Coulomb energy [3]	$B_{\text{Coul}} = \frac{15}{16\pi^2} \int d\tau \int d\tau' \frac{1}{ r-r' }$
Relative surface energy [4]	$B_{\text{surf}} = \frac{1}{4\pi} \int dS$
Relative curvature energy [5]	$B_{\text{curv}} = \frac{1}{8\pi} \int dS (r_{\text{min}}^{-1} + r_{\text{max}}^{-1})$ *
Relative redistribution energy [6]	$B_{\text{red}} = \frac{175}{4\pi} \int d\tau (\phi - \bar{\phi})^2 - \frac{175}{3} (\phi^2 - \bar{\phi}^2) +$
Relative compressibility energy [7]	$B_{\text{comp}} = B_{\text{surf}}^2$
Neck radius [8]	$\rho_n = r(\frac{\pi}{2}) = \rho(0)$
Half length [9]	$\zeta_0 = r(0)$
Relative quadrupole moment [10]	$Q = \int d\tau (3\zeta^2 - r^2)$
Relative parallel moment of inertia [11]	$J_{\parallel} = \frac{15}{8\pi} \int d\tau \rho^2$
Relative perpendicular moment of inertia [12]	$J_{\perp} = \frac{1}{2} J_{\parallel} + \frac{15}{8\pi} \int d\tau \zeta^2$
Inverse relative effective moment of inertia [13]	$J_{\text{eff}}^{-1} = J_{\parallel}^{-1} - J_{\perp}^{-1}$
Relative surface redistribution energy of first kind [14]	$B_{\text{sr1}} = \frac{25}{16\pi^2} [\int dS (\phi_s - \bar{\phi})]^2$ † $= 25\bar{\phi}_s^2 - 60\bar{\phi}_s B_{\text{Coul}} B_{\text{surf}} + 36 B_{\text{Coul}}^2 B_{\text{surf}}^2$
Relative surface redistribution energy of second kind [15]	$B_{\text{sr2}} = \frac{25}{4\pi} \int dS (\phi_s - \bar{\phi})^2$ ** $= 25\bar{\phi}_s^2 - 60\bar{\phi}_s B_{\text{Coul}} + 36 B_{\text{Coul}}^2 B_{\text{surf}}$

* r_{min} and r_{max} are the Gaussian main curvature radii of the surface element dS .

† $\bar{\phi}$ is the relative Coulomb potential of the volume element $d\tau$,
 $\bar{\phi}$ is the relative mean Coulomb potential over the volume, $= 6 B_{\text{Coul}}/5$
 $\bar{\phi}^2$ is the relative mean squared Coulomb potential over the volume.

‡ ϕ_s is the relative Coulomb potential at the surface of the surface element dS ,
 $\bar{\phi}_s$ is the relative mean Coulomb potential over the surface.

** $\bar{\phi}_s^2$ is the relative mean squared Coulomb potential over the surface.

Table A3.a

t6

Slightly distorted sphere (spherical coordinates, symmetric)		
	General expressions [B]	Saddle points [C] †
Shape [1]	$r = \lambda_0^{-1} [1 + a_2 P_2(\cos\theta) + a_4 P_4(\cos\theta)]$ $\lambda_0^{-1} = 1 - \frac{1}{5}a_2^2 - \frac{2}{105}a_3^2 - \frac{2}{25}a_4^2$ $- \frac{2}{35}a_2^2 a_4 - \frac{1}{9}a_4^2 \dots$	-----
B _{Bar} [2]	$\frac{2}{5}a_2^2 u - \frac{4}{35}a_2^3 (1 - \frac{2}{3}u - \frac{5}{3}\eta + \frac{2}{3}\zeta)$ $+ \frac{48}{1225}a_2^4 (1 - \frac{85}{8}u - \frac{7}{3}\eta + \frac{28433}{528}\zeta - \frac{49}{12}\chi)$ $- \frac{16}{35}a_2^2 a_4 (1 - \frac{3}{4}u - \frac{3}{8}\eta + \frac{67}{22}\zeta)$ $+ \frac{17}{27}a_4^2 (1 + \frac{10}{17}u - \frac{1000}{561}\zeta) \dots$	$\frac{98}{135}u^3 (1 - \frac{116}{255}u + \frac{10}{3}\eta - \frac{4}{3}\zeta + 0\chi) \dots$
B _{Coul} [3]	$1 - \frac{1}{5}a_2^2 - \frac{4}{105}a_2^3 - \frac{51}{245}a_2^4 - \frac{6}{35}a_2^2 a_4 - \frac{5}{27}a_4^2 \dots$	$1 - \frac{49}{45}u^2 (1 - \frac{464}{765}u + \frac{10}{3}\eta - \frac{4}{3}\zeta) \dots$
B _{surf} [4]	$1 + \frac{2}{5}a_2^2 - \frac{4}{105}a_2^3 - \frac{66}{175}a_2^4 - \frac{4}{35}a_2^2 a_4 + a_4^2 \dots$	$1 + \frac{98}{45}u^2 (1 - \frac{974}{765}u + \frac{10}{3}\eta - \frac{4}{3}\zeta) \dots$
B _{curv} [5]	$1 + \frac{2}{5}a_2^2 + \frac{16}{105}a_2^3 - \frac{82}{175}a_2^4 + \frac{2}{35}a_2^2 a_4 + a_4^2 \dots$	$1 + \frac{98}{45}u^2 (1 - \frac{124}{765}u + \frac{10}{3}\eta - \frac{4}{3}\zeta) \dots$
B _{red} [6]	$1 + \frac{2}{5}a_2^2 + \frac{16}{105}a_2^3 - \frac{34043}{13475}a_2^4$ $+ \frac{668}{385}a_2^2 a_4 + \frac{1330}{891}a_4^2 \dots$	$1 + \frac{98}{45}u^2 (1 - \frac{124}{765}u + \frac{10}{3}\eta - \frac{4}{3}\zeta) \dots$
B _{comp} [7]	$1 + \frac{4}{5}a_2^2 - \frac{8}{105}a_2^3 - \frac{104}{175}a_2^4 - \frac{8}{35}a_2^2 a_4 + 2a_4^2 \dots$	$1 + \frac{196}{45}u^2 (1 - \frac{974}{765}u + \frac{10}{3}\eta - \frac{4}{3}\zeta) \dots$
ρ_n [8]	$1 - \frac{1}{2}a_2^2 - \frac{1}{5}a_2^3 + \frac{3}{8}a_4^2 \dots$	$1 - \frac{7}{6}u (1 - \frac{58}{255}u + \frac{5}{3}\eta - \frac{2}{3}\zeta) \dots$
ζ_0 [9]	$1 + a_2 - \frac{1}{5}a_2^2 + a_4 \dots$	$1 + \frac{7}{3}u (1 - \frac{37}{255}u + \frac{5}{3}\eta - \frac{2}{3}\zeta) \dots$
Q [10]	$\frac{8}{5}\pi a_2 (1 + \frac{4}{7}a_2^2) \dots$	$\frac{56}{15}\pi u (1 + \frac{206}{255}u + \frac{5}{3}\eta - \frac{2}{3}\zeta) \dots$
J _H [11]	$1 - a_2 + \frac{3}{7}a_2^2 \dots$	$1 - \frac{7}{3}u (1 - \frac{389}{255}u + \frac{5}{3}\eta - \frac{2}{3}\zeta) \dots$
J _L [12]	$1 + \frac{1}{2}a_2 + \frac{9}{7}a_2^2 \dots$	$1 + \frac{7}{6}u (1 + \frac{1396}{255}u + \frac{5}{3}\eta - \frac{2}{3}\zeta) \dots$
J _{eff} ⁻¹ [13]	$\frac{3}{2}a_2 + \frac{6}{7}a_2^2 \dots$	$\frac{7}{2}u (1 + \frac{206}{255}u + \frac{5}{3}\eta - \frac{2}{3}\zeta) \dots$
B _{sr1} [14]	$1 - \frac{2}{5}a_2^2 - \frac{4}{105}a_2^3 - \frac{457}{1225}a_2^4 - \frac{8}{105}a_2^2 a_4 + \frac{8}{9}a_4^2 \dots$	$1 - \frac{98}{45}u^2 (1 - \frac{622}{765}u + \frac{10}{3}\eta - \frac{2}{3}\zeta) \dots$
B _{sr2} [15]	$1 + 0a_2^2 + 0a_2^3 - \frac{243}{245}a_2^4 + \frac{4}{7}a_2^2 a_4 + \frac{91}{81}a_4^2 \dots$	$1 + 0u^2 \dots$

† The saddle-point a 's are [16E] $a_2 = \frac{7}{3}u (1 - \frac{134}{255}u + \frac{5}{3}\eta - \frac{2}{3}\zeta) \dots$, $a_4 = \frac{168}{85}u^2 \dots$

Table A3.b

t7

Slightly distorted sphere (spherical coordinates, asymmetric) General expressions [D]	
Shape [1]	$r = \lambda_0^{-1} \left[1 + \sum_{n=1}^5 \alpha_n P_n(\cos \theta) \right]$ $\text{with } \lambda_0^{-1} = 1 - \frac{1}{5}\alpha_2^2 - \frac{2}{105}\alpha_2^3 + \frac{2}{25}\alpha_2^4 - \frac{2}{35}\alpha_2^2\alpha_4 - \frac{1}{9}\alpha_4^2 - \frac{1}{7}\alpha_3^2 - \frac{4}{105}\alpha_2\alpha_3^2 + \frac{59}{1225}\alpha_2^2\alpha_3^2$ $- \frac{20}{231}\alpha_2\alpha_3\alpha_5 - \frac{1}{11}\alpha_5^2 - \frac{2}{77}\alpha_3^2\alpha_4 \dots$ $\text{and } \alpha_1 = -\frac{27}{35}\alpha_2\alpha_3 \dots$
B _{Bar} [2]	$[2B] + \frac{15}{49}(1 + \frac{4}{3}\nu - \frac{8}{3}\zeta)\alpha_2^2 - \frac{16}{49}(1 - \frac{23}{30}\nu - \frac{35}{12}\eta + 4\zeta)\alpha_2\alpha_3^2 \quad \dagger$ $- \frac{243116}{622545}(1 + \nu - \frac{810117}{243116}\eta - \frac{530072285}{26074191}\zeta + \frac{88935}{60779}\chi)\alpha_2^2\alpha_3^2$ $- \frac{148}{539}(1 + \nu - \frac{210}{37}\eta + \frac{2720}{407}\zeta)\alpha_3^2\alpha_4 - \frac{5000}{5929}(1 + \nu - \frac{539}{750}\eta + \frac{579809}{107250}\zeta)\alpha_2\alpha_3\alpha_5$ $+ \frac{114}{121}(1 + \frac{20}{57}\nu - \frac{10440}{8151}\zeta)\alpha_5^2 \dots$
B _{Coul} [3]	$[3B] - \frac{10}{49}\alpha_3^2 - \frac{92}{735}\alpha_2\alpha_3^2 + \frac{2133718}{3112725}\alpha_2^2\alpha_3^2 - \frac{60}{539}\alpha_3^2\alpha_4 - \frac{5960}{17787}\alpha_2\alpha_3\alpha_5 - \frac{20}{121}\alpha_5^2 \dots$
B _{surf} [4]	$[4B] + \frac{5}{7}\alpha_3^2 - \frac{8}{105}\alpha_2\alpha_3^2 - \frac{23736}{13475}\alpha_2^2\alpha_3^2 - \frac{4}{77}\alpha_3^2\alpha_4 - \frac{40}{231}\alpha_2\alpha_3\alpha_5 + \frac{14}{11}\alpha_5^2 \dots$
B _{curv} [5]	$[5B] + \frac{5}{7}\alpha_3^2 + \frac{92}{105}\alpha_2\alpha_3^2 - \frac{41271}{13475}\alpha_2^2\alpha_3^2 + \frac{116}{77}\alpha_3^2\alpha_4 + \frac{100}{231}\alpha_2\alpha_3\alpha_5 + \frac{14}{11}\alpha_5^2 \dots$
B _{red} [6]	$[6B] + \frac{60}{77}\alpha_3^2 + \frac{1144}{735}\alpha_2\alpha_3^2 - \frac{12432175744}{12371384025}\alpha_2^2\alpha_3^2 + \frac{12200}{5929}\alpha_3^2\alpha_4$ $+ \frac{4433580}{847847}\alpha_2\alpha_3\alpha_5 + \frac{26600}{17303}\alpha_5^2 \dots$
B _{comp} [7]	$[7B] + \frac{10}{7}\alpha_3^2 - \frac{16}{105}\alpha_2\alpha_3^2 - \frac{43622}{13475}\alpha_2^2\alpha_3^2 - \frac{8}{77}\alpha_3^2\alpha_4 - \frac{80}{231}\alpha_2\alpha_3\alpha_5 + \frac{28}{11}\alpha_5^2 \dots$

† Factors denoted by question marks are not important.

Table A3.c

t8

Spheroid (cylindrical coordinates)		
	All deformations [E]	Small deformations [F] †
Shape [1]	$\zeta^2/\zeta_0^2 + \zeta_0 \rho^2 = 1$ with $\epsilon^2 = 1 - \zeta_0^{-3}$	
B_{Bar} [2]	$\frac{(B_{\text{surf}}-1)+2\zeta(B_{\text{Coul}}-1)}{+n(B_{\text{surf}}-B_{\text{Coul}})-\zeta(2B_{\text{Coul}}+B_{\text{red}}-1)-\chi(B_{\text{surf}}-1)^2}$	$\frac{2}{45}\epsilon^4 - \frac{4}{945}\epsilon^6 + (1-\frac{32}{3}\epsilon^2 + \frac{2}{3}\epsilon^4) \dots$ *
B_{Coul} [3]	$\frac{1}{2\epsilon\zeta_0} \ln \frac{1+\epsilon}{1-\epsilon} - \zeta_0^{-1} K$ ‡	$1 - \frac{1}{45}\epsilon^4 - \frac{64}{2835}\epsilon^6 - \frac{58}{2835}\epsilon^8 \dots$
B_{surf} [4]	$\frac{1}{2\zeta_0} (1 + \frac{\zeta_0^2}{\epsilon} \arcsin \epsilon) - \frac{1}{2}(\zeta_0^{-1} + A)$ **	$1 + \frac{2}{45}\epsilon^4 + \frac{116}{2835}\epsilon^6 + \frac{101}{2835}\epsilon^8 \dots$
B_{curv} [5]	$\frac{1}{2}(\zeta_0 + \frac{1}{2\epsilon\zeta_0} \ln \frac{1+\epsilon}{1-\epsilon})$	$1 + \frac{2}{45}\epsilon^4 + \frac{136}{2835}\epsilon^6 + \frac{131}{2835}\epsilon^8 \dots$
B_{red} [6]	$\frac{3}{4}\zeta_0^{-2} [3K^2 - \frac{10}{\epsilon^2}K(K-1) + \frac{15}{\epsilon^2}(K-1)^2]$ with $K = \frac{1}{2\epsilon} \ln \frac{1+\epsilon}{1-\epsilon}$	$1 + \frac{2}{45}\epsilon^4 + \frac{136}{2835}\epsilon^6 + \frac{4009}{99225}\epsilon^8 \dots$
B_{comp} [7]	$\frac{1}{4\zeta_0^2} (1 + \frac{\zeta_0^2}{\epsilon} \arcsin \epsilon)^2$	$1 + \frac{4}{45}\epsilon^4 + \frac{232}{2835}\epsilon^6 + \frac{346}{4725}\epsilon^8 \dots$
ρ_n [8]	$\zeta_0^{-1/2}$	$1 - \frac{1}{6}\epsilon^2 \dots$
ζ_0 [9]	ζ_0	$1 + \frac{1}{3}\epsilon^2 \dots$
Q [10]	$\frac{8}{15} \pi \zeta_0^2 \epsilon^2$	$\frac{8}{15} \pi \epsilon^2 \dots$
J_{H} [11]	ζ_0^{-1}	$1 - \frac{1}{3}\epsilon^2 \dots$
J_L [12]	$\frac{1}{2} (\zeta_0^2 + \zeta_0^{-1})$	$1 + \frac{1}{6}\epsilon^2 \dots$
J_{eff}^{-1} [13]	$\zeta_0 - \frac{2}{\zeta_0^2 + \zeta_0^{-1}}$	$\frac{1}{2}\epsilon^2 \dots$
B_{sr1} [14]	[14A] with $\bar{\phi}_s = \frac{3}{32}\zeta_0^{-1}$ †† [8LB _{surf} + M(A - $\zeta_0^{-1}(1-2\epsilon^2)$)]	$1 - \frac{2}{45}\epsilon^4 - \frac{124}{2835}\epsilon^6 - \frac{1219}{33075}\epsilon^8 \dots$
B_{sr2} [15]	[15A] with $\bar{\phi}_s^2 = \frac{9}{32}\zeta_0^{-1}$ [8L ² B _{surf} + $\frac{1}{8}M(A(4L+M) - \zeta_0^{-1}(4L(1-2\epsilon^2) + M(1 + \frac{2}{3}\epsilon^2 - \frac{8}{3}\epsilon^4)))$]	$1 + 0\epsilon^4 + 0\epsilon^6 + \frac{16}{11025}\epsilon^8 \dots$

† The saddle-point eccentricity is [16F] $\epsilon^2 = 7u(1-u+5n/3-2\zeta/3) \dots$ [16B] and [16F] are connected by [16C] $\delta_2 = \frac{1}{3}\epsilon^2(1 + \frac{10}{21}\epsilon^2 + \frac{92}{315}\epsilon^4) \dots$, $\delta_4 = \frac{3}{35}\epsilon^4 \dots$

* For comparison, the relative barrier for spheroidal saddle points is

[16D] $B_{\text{Bar}} = \frac{98}{135} u^3 (1 + \frac{23}{6}u + \frac{10}{3}n - \frac{4}{3}\zeta + 0\chi) \dots$

‡ $K = \frac{1}{2\epsilon} \ln \frac{1+\epsilon}{1-\epsilon}$

** $A = \zeta_0 \frac{1/2 \arcsin \epsilon}{\epsilon}$

†† $L = K + \frac{K-1}{\epsilon^2}$ and $M = \frac{1}{\epsilon^2} (K - 3\frac{K-1}{\epsilon^2})$

Table A3.d

General expressions (all deformations, symmetric)		
	Spherical coordinates [G]	Cylindrical coordinates [H]
Shape [1]	see [1B]	$\rho^2 = \lambda(\zeta_0^2 - \zeta^2)(\zeta_2^2 + \zeta^2)$ $\lambda^{-1} = \zeta_0^2(\frac{1}{5}\zeta_0^2 + \zeta_2^2)$
B_{Bar} [2]	$(B_{\text{surf}} - 1) + 2\xi(B_{\text{Coul}} - 1) + \eta(B_{\text{curv}} - B_{\text{surf}})$ $-\zeta(2B_{\text{Coul}} + B_{\text{red}} - 3) - \chi(B_{\text{surf}} - 1)^2$	
B_{Coul} [3]	$\frac{1}{2} \int_0^\pi d\theta \phi_s(\theta) r^3(\theta)$	$\frac{15}{4\pi} \int_0^{\zeta_0} d\zeta \int_0^\pi dy \int_0^{2\pi} d\phi \cdot$ $\frac{\zeta \rho^2 \sin^2 \phi}{\zeta(1-y) + [\zeta^2(1-y)^2 + \rho^2 + \rho_1^2 - 2\rho_1 \rho_2 \cos \phi]^{1/2}}$ with $\rho_1 = \rho(\zeta - \zeta_0)$, $\rho_2 = \rho(\zeta - \zeta_0)$
B_{surf} [4]	$\frac{1}{2} \int_0^\pi d\theta \sin \theta r(r^2 + r'^2)^{1/2}$ with $r' = dr/d\theta$	$\int_0^{\zeta_0} d\zeta \rho(1 + \rho'^2)^{1/2}$ with $\rho' = d\rho/d\zeta$
B_{curv} [5]	$\frac{1}{4} \int_0^\pi d\theta \left\{ \frac{r \sin \theta (2r^2 + 3r'^2 - rr'')}{r^2 + r'^2} - r' \cos \theta \right\}$ with $r' = dr/d\theta$, $r'' = d^2r/d\theta^2$	$\frac{1}{2} \int_0^{\zeta_0} d\zeta \frac{1 + \rho'^2 - \rho \rho''}{1 + \rho'^2}$ with $\rho' = d\rho/d\zeta$, $\rho'' = d^2\rho/d\zeta^2$
B_{red} [6]	[6A] with $\frac{r}{\phi^2} = \frac{3}{2} \int_{-1}^1 d\cos \theta \int_0^\pi dr r^2 \sin \theta \phi^2(r, \theta)$	[6A] with $\frac{\rho}{\phi^2} = 3 \int_0^{\zeta_0} d\zeta \int_0^\pi d\rho \phi^2(\zeta, \rho)$
B_{comp} [7]	B_{surf}^2 see [4G]	B_{surf}^2 see [4H]
ρ_n [8]	$\lambda_0^{-1} (1 - \frac{1}{2}a_2 + \frac{3}{8}a_4)$	$\zeta_2 [\zeta_0 (\frac{1}{5}\zeta_0^2 + \zeta_2^2)]^{-1/2} = \zeta_0 \zeta_2 \sqrt{\lambda}$
ζ_0 [9]	$\lambda_0^{-1} (1 + a_2 + a_4)$	ζ_0
Q [10]	$\frac{4}{5} \pi \int_{-1}^1 dx P_2(x) r^5(x)$, $x = \cos \theta$	$\frac{8}{5} \pi \zeta_0^5 \left\{ \frac{\frac{1}{7}\zeta_0^2 + \frac{1}{3}\zeta_2^2}{\zeta_0^2(\frac{1}{5}\zeta_0^2 + \zeta_2^2)} - \frac{1}{3} \frac{\frac{1}{21}\zeta_0^4 + \frac{2}{7}\zeta_0^2\zeta_2^2 + \zeta_2^4}{\zeta_0^6(\frac{1}{5}\zeta_0^2 + \zeta_2^2)^2} \right\}$
J_H [11]	$\frac{1}{2} \int_{-1}^1 dx [1 - P_2(x)] r^5(x)$, $x = \cos \theta$	$\zeta_0^{-1} \frac{\frac{1}{21}\zeta_0^4 + \frac{2}{7}\zeta_0^2\zeta_2^2 + \zeta_2^4}{(\frac{1}{5}\zeta_0^2 + \zeta_2^2)^2}$
J_L [12]	$\frac{1}{2} (J_H + \int_{-1}^1 dx [P_2(x) + \frac{1}{2}] r^5(x))$ $x = \cos \theta$	$\frac{1}{2} \left[J_H + \zeta_0^2 \frac{\frac{3}{7}\zeta_0^2 + \zeta_2^2}{\frac{1}{5}\zeta_0^2 + \zeta_2^2} \right]$
J_{eff}^{-1} [13]	To be calculated from [13A]	
B_{sr1} [14]	[14A] with $\frac{\phi_s}{\phi^2} = \frac{1}{2} \int_0^\pi d\theta \sin \theta r(r^2 + r'^2)^{1/2} \phi_s(\theta)$	[14A] with $\frac{\phi_s}{\phi^2} = \int_0^{\zeta_0} d\zeta \rho(1 + \rho'^2)^{1/2} \phi_s(\zeta)$
B_{sr2} [15]	[15A] with $\frac{\phi_s^2}{\phi^2} = \frac{1}{2} \int_0^\pi d\theta \sin \theta r(r^2 + r'^2)^{1/2} \phi_s^2(\theta)$	[15A] with $\frac{\phi_s^2}{\phi^2} = \int_0^{\zeta_0} d\zeta \rho(1 + \rho'^2)^{1/2} \phi_s^2(\zeta)$

* ϕ_s , the relative Coulomb potential at the surface, is listed in [26B] and [27B]

† ϕ , the relative Coulomb potential in the volume, is listed in [25A] and [26A]

Table A3.e

Two tangent spheres				equal infinitely separated spheres [L] †
	symmetric [I]	asymmetric with ratio of radii μ [J]	slightly asymmetric with $v = \mu - 1$ [K]	
Shape [1]	$\rho^2 = \zeta_0 \zeta - \zeta^2$ $\zeta_0 = 2^{2/3}$	$\rho^2 = \begin{cases} -\zeta(\zeta+2r_1) \\ -\zeta(\zeta-2r_2) \end{cases}$ for $\zeta \leq 0$ with $r_1 = (1+\mu)^{-1/3}$ $r_2 = (1+\mu^{-3})^{-1/3}$		—
B_{Bar} [2]	$0.25992 - 0.21511\zeta$ $+ 0.32748\eta + 0.49281\zeta$ $- 0.06756\chi$ *	see	[2E]	$\frac{(n^{1/3}-1)+2\zeta(n^{-2/3}-1)+\eta(n^{2/3}-n^{1/3})}{-\zeta(2n^{-2/3}+n^{-4/3}-3)-\chi(n^{1/3}-1)^2}$ $\left(0.25992 - 0.74003\zeta + 0.32748\eta\right) \mp$ $+ 1.34323\zeta - 0.06756\chi$
B_{Coul} [3]	$\frac{17}{24} 2^{1/3} = 0.89244$	$\frac{1+\mu^5 + \frac{5}{3} \frac{\mu^3}{1+\mu}}{(1+\mu^3)^{5/3}}$	$\frac{17}{24} 2^{1/3} (1 + \frac{5}{17} v^2) \dots$	$n^{-2/3}$ $(\frac{1}{2} 2^{1/3} = 0.62996)$
B_{surf} [4]	$2^{1/3} = 1.25992$	$\frac{1+\mu^2}{(1+\mu^3)^{2/3}}$	$2^{1/3} (1 - \frac{1}{4} v^2) \dots$	$n^{1/3}$ $(2^{1/3} = 1.25992)$
B_{curv} [5]	$2^{2/3} = 1.58740$	$\frac{1+\mu}{(1+\mu^3)^{1/3}}$	$2^{2/3} (1 - \frac{1}{4} v^2) \dots$	$n^{2/3}$ $(2^{2/3} = 1.58740)$
B_{red} [6]	$\frac{175}{16} 2^{2/3} (\frac{887}{525} - \frac{3}{2} \ln 3)$ $= 0.72236$	$\frac{175}{2} [F(\mu) + F(\frac{1}{\mu}) - \frac{24}{25} B_{\text{Coul}}^2]$ with $F(\mu) = (1+\mu^3)^{-7/3}$ $\cdot \left\{ \frac{34}{35} + \mu^6 [1 - \frac{\mu(\mu+2)}{2(\mu+1)} \ln(1+\frac{2}{\mu})] \right.$ $\left. + \frac{8}{5} \frac{\mu^3}{(1+\mu)} \right\}$	$\frac{175}{16} 2^{2/3} (\frac{887}{525} - \frac{3}{2} \ln 3) \cdot$ $\cdot (1 + \frac{21420 - 18375 \ln 3}{7096 - 6300 \ln 3} v^2) \dots$ $= 0.72236 (1 + 7.05639 v^2) \dots$	$n^{-4/3}$ $(\frac{1}{4} 2^{2/3} = 0.39685)$
B_{comp} [7]	$2^{2/3} = 1.58740$	$\frac{(1+\mu^2)^2}{(1+\mu^3)^{4/3}}$	$2^{2/3} (1 - \frac{1}{2} v^2) \dots$	$n^{2/3}$ $(2^{2/3} = 1.58740)$
ρ_n [8]	$\frac{5}{12} 2^{1/3} \zeta = 0.66142\zeta$	0	0	—
ζ_0 [9]	$2^{2/3} = 1.58740$	$\frac{1+\mu}{(1+\mu^3)^{1/3}}$	$2^{2/3} (1 - \frac{1}{4} v^2) \dots$	—
Q [10]	$\frac{4}{3} \pi 2^{1/3} = 5.27754$	$\frac{8}{3} \pi \frac{1+\mu^5}{(1+\mu^3)^{5/3}}$	$\frac{4}{3} \pi 2^{1/3} (1 + \frac{15}{4} v^2) \dots$	—
$J_{\parallel}$ [11]	$\frac{1}{2} 2^{1/3} = 0.62996$	$\frac{1+\mu^5}{(1+\mu^3)^{5/3}}$	$\frac{1}{2} 2^{1/3} (1 + \frac{15}{4} v^2) \dots$	—
$J_{\perp}$ [12]	$\frac{7}{4} 2^{1/3} = 2.20486$	$\frac{7}{2} \frac{1+\mu^5}{(1+\mu^3)^{5/3}}$	$\frac{7}{4} 2^{1/3} (1 + \frac{15}{4} v^2) \dots$	—
J_{eff}^{-1} [13]	$\frac{5}{7} 2^{2/3} = 1.13386$	$\frac{5}{7} \frac{(1+\mu^3)^{5/3}}{1+\mu^5}$	$\frac{5}{7} 2^{2/3} (1 - \frac{15}{4} v^2) \dots$	—
B_{sri} [14]	$\frac{1}{2} 2^{1/3} = 0.62996$	[14A] with $\bar{\Phi}_S = \bar{\Phi}(\mu) + \bar{C}(\frac{1}{\mu})$ $\bar{C}(\mu) = \frac{1+\mu^3}{(1+\mu)(1+\mu^3)^{4/3}}$	$\frac{1}{2} 2^{1/3} (1 + \frac{13}{4} v^2) \dots$	$n^{-2/3}$ $(\frac{1}{2} 2^{1/3} = 0.62996)$
$B_{\text{sri}2}$ [15]	$\frac{1}{8} (25 \ln 3 - 21)$ $= 0.80816$	[15A] with $\bar{\Psi}_S^2 = \bar{\Psi}(\mu) + \bar{H}(\frac{1}{\mu})$ $\bar{\Psi}(\mu) = (1+\mu^3)^{-2} \cdot \{ 1 + \frac{2\mu^3}{1+\mu} + \frac{\mu^6}{2(1+\mu)} \ln(1+\frac{2}{\mu}) \}$	$\frac{1}{8} (25 \ln 3 - 21) \cdot$ $(1 + \frac{675 \ln 3 - 221}{900 \ln 3 - 756} v^2) \dots$ $= 0.80816 (1 + 2.23657 v^2) \dots$	n^{-1} $(\frac{1}{2} = 0.50000)$

* These expressions have here the meaning of relative energies for tangent spheres, rather than barriers.

† The values in parentheses correspond to $n=2$.

‡ This expression has here the meaning of the relative energy for infinitely separated spheres, rather than barrier.

Table A3.f

Quantity	in ϵ	[A]	in ϵ^2 [B]	in $\alpha_2, \alpha_3, \alpha_4, \alpha_5$	[C]
Stiffness [17]	$C_\epsilon = \frac{8}{15} \epsilon^2 \frac{8}{63} \epsilon^4 (1 - \frac{32}{3} \epsilon + \frac{5}{3} \epsilon^2) \frac{8}{27} \epsilon^6 \dots$		---	$\eta = \zeta = \chi = 0$; $C_{\lambda\lambda} = \frac{\lambda-1}{(2\lambda+1)^2} [(2\lambda+1)(\lambda+2) - 20(1-\nu)] \dots$	
Effective mass [18]	$B_\epsilon = \frac{2}{15} \epsilon^2 (1 + \frac{7}{3} \epsilon^2)$		$B_{\epsilon^2} = \frac{1}{30}$	$B_{\lambda\mu} = \frac{3}{\lambda(2\lambda+1)} + \text{cross terms}$	
Stiffness (ground state) [19]	not existent		$C_{\epsilon^2} = \frac{8}{45}$	$C_{22} = \frac{4}{5} \nu$; $C_{44} = \frac{34}{27} (1 + \frac{10}{7} \nu - \frac{1000}{561} \epsilon)$; $C_{33} = \frac{30}{49} (1 + \frac{4}{3} \nu - \frac{8}{3} \epsilon)$; $C_{55} = \frac{228}{121} (1 + \frac{20}{57} \nu - \frac{10440}{8151} \epsilon)$	
Effective mass (ground state) [20]	---		see [18B]	see [18C]	
Squared frequency (ground state) [21]	---		$\omega_{\epsilon^2}^2 = \frac{8}{3} \nu$	$\eta = \zeta = \chi = 0$; $\omega_{\lambda\lambda}^2 = \frac{\lambda(\lambda-1)}{3(2\lambda+1)} [(2\lambda+1)(\lambda+2) - 20(1-\nu)]$; $\omega_{23}^2 = \frac{8}{3} \nu$; $\omega_{44}^2 = \frac{136}{9} (1 + \frac{10}{7} \nu - \frac{1000}{561} \epsilon)$; $\omega_{33}^2 = \frac{30}{7} (1 + \frac{4}{3} \nu - \frac{8}{3} \epsilon)$; $\omega_{55}^2 = \frac{380}{11} (1 + \frac{20}{57} \nu - \frac{10440}{8151} \epsilon)$	
Stiffness (saddle point) [22]	$\hat{C}_\epsilon = -\frac{112}{45} \nu^2 (1 + \frac{32}{3} \nu + \frac{5}{3} \nu^2 - \frac{2}{3} \epsilon)$		---	$\hat{C}_{22} = \frac{4}{5} \nu (1 - \frac{848}{255} \nu)$; $\hat{C}_{44} = \frac{34}{27} (1 + \frac{10}{7} \nu - \frac{1000}{561} \epsilon)$; $(\hat{C}_{24} = -\frac{32}{15} \nu (1 - \frac{1301}{1020} \nu + \frac{157}{24} \nu^2 - \frac{157}{66} \epsilon))$; $\hat{C}_{33} = \frac{30}{49} (1 - \frac{52}{45} \nu - \frac{8}{3} \epsilon)$	
Effective mass (saddle point) [23]	$\hat{B}_\epsilon = \frac{14}{15} \nu (1 + \frac{46}{3} \nu + \frac{5}{3} \nu^2 - \frac{2}{3} \epsilon)$		---	$\hat{B}_{22} = \frac{3}{10} (1 + 3\nu)$; $\hat{B}_{44} = \frac{1}{12} (1 + \frac{25}{11} \nu)$; $(\hat{B}_{24} = \frac{1}{2} \nu)$; $\hat{B}_{33} = \frac{1}{7} (1 + \frac{112}{45} \nu)$	
Squared frequency (saddle point) [24]	$\hat{\omega}_\epsilon^2 = -\frac{8}{3} \nu (1 - \frac{14}{3} \nu)$		---	$\hat{\omega}_2^2 = -\frac{8}{3} \nu (1 + \frac{304}{255} \nu)$; $\hat{\omega}_4^2 = \frac{136}{9} (1 - \frac{515}{187} \nu - \frac{1000}{561} \epsilon)$; $\hat{\omega}_3^2 = \frac{30}{7} (1 - \frac{164}{45} \nu - \frac{8}{3} \epsilon)$	

Table A3.g

Coulomb potentials:

t12

Cylindrical coordinates:

$$[25A] \quad \phi(\rho, \zeta) = \frac{3}{4\pi} \int_{-\zeta_0}^{+\zeta_0} d\zeta (\rho\rho) \frac{-1/2}{k} \{ [\rho\rho + \rho + \frac{1}{2}(\zeta - \zeta_0)^2] \cdot K(k^2) - 2\rho\rho D(k^2) \} \quad ; \quad P_v = P_v(\cos\theta) \quad *$$

Spherical coordinates:

$$[26A] \quad \phi(r, \theta) = \lambda_0^2 \left\{ \frac{3}{2} + (\lambda_0 r)^2 \left(\frac{3}{5} \alpha_2 P_2 - \frac{1}{2} \right) + \frac{1}{3} (\lambda_0 r)^4 \alpha_4 P_4 + \frac{3}{4} \sum_{k=0}^4 (k-1) (\lambda_0 r)^k P_k \{ -\alpha_2^2 < 22k > -2\alpha_2 \alpha_4 < 24k > + \frac{1}{3} \alpha_2^3 < 222k > \} \dots \right\} +$$

Spherical coordinates, at the surface:

$$[26B] \quad \phi_s(\theta) = \lambda_0^2 \left[1 - \frac{2}{5} \alpha_2 P_2 + \alpha_2^2 \left(\frac{3}{10} \frac{3}{35} P_2 + \frac{7}{10^2} \frac{9}{35} P_2 - \frac{9}{10^2} \frac{3}{35} P_2 + \frac{3}{5} \frac{6}{35} P_2 + \frac{3}{5} \frac{36}{35} P_2 \right) + \alpha_2^3 \left(\frac{3}{35} P_2 - \frac{6}{35} P_2 + \frac{3}{5} \frac{36}{35} P_2 + \alpha_2 \left(\frac{6}{35} P_2 - \frac{3}{35} P_2 + \frac{54}{35} P_4 \right) \right. \right. \\ \left. \left. + \alpha_2 \alpha_4 \left(\frac{6}{35} P_2 + \frac{23}{15} P_4 \right) + \alpha_2^2 \alpha_4 \left(\frac{12}{35} P_2 + \frac{6}{35} P_4 + \frac{16}{5} P_2 P_4 - \frac{36}{35} P_4 \right) - \frac{2}{3} \alpha_4 P_4 + \alpha_2^2 \left(\frac{1}{6} + \frac{5}{6} P_4 \right) \dots \right] \right]$$

Cylindrical coordinates, spheroids:

$$[27A] \quad \phi(\rho, \zeta) = \frac{3}{4} \zeta_0^{-3} \left[2\zeta_0^2 K - \frac{2}{\varepsilon^2} (K-1)^2 \zeta^2 - \frac{1}{\varepsilon^2} (\zeta_0^3 - K) \rho^2 \right] +$$

Cylindrical coordinates, spheroids, at the surface:

$$[27B] \quad \phi_s(\zeta) = \frac{3}{4} \zeta_0^{-3} [\zeta_0^2 L + \varepsilon^2 M \zeta^2] \quad **$$

* $K(k^2)$ and $D(k^2)$ are the usual complete elliptical integrals $[D(k^2) = \{K(k^2) - E(k^2)\}/k^2]$

of the argument $k^2 = \frac{4\rho\rho}{(\zeta - \zeta_0)^2 + (\rho + \bar{\rho})^2} ; \quad \frac{d\rho^2}{d\zeta} = \frac{d\rho^2}{d\zeta}$

+ $\langle \ell m \dots n \rangle = \int_{-1}^{+1} dx P_\ell(x) P_m(x) \dots P_n(x) ; \quad \langle 222 \rangle = \langle 224 \rangle = \frac{2}{35} ; \quad \langle 2222 \rangle = \frac{6}{35} ; \quad \text{Only the relevant terms are kept.}$

+ $K = \frac{1}{2\varepsilon} \ln \frac{1+\varepsilon}{1-\varepsilon}$

** $L = K + \frac{K-1}{\varepsilon^2} ; \quad \varepsilon^2 M = K - 3 \frac{K-1}{\varepsilon^2}$

A4. Listings of the Numerical Results

This appendix consists of the three Tables A4, A5, and A6 with results of generalized spheroids, dumbbells, and Nix-shapes; and α_2 and α_4 and generalized spheroids for heavy nuclei, respectively.

Table A4. Numerical results of saddle point and minimum shapes with the parameterization of generalized spheroids ($\xi \leq 0.9$ except LDM, for $\xi > 0.9$ see Table A6).

Notations:

ETA: η , ZETA: ζ , CHI: χ , XI: ξ , ZO: ζ_0 , Z2: ζ_2 , RNECK: ρ_n , BBAR: B_{Bar} ,

CZ1: C_{ζ_1} , BCOUL: B_{Coul} , BSURF: B_{surf} , BCURV: B_{curv} , BRED: B_{red} ,

BCOMP: B_{comp} , Q: Q , JPARA: $\gamma_{\parallel}$, JPERP: $\gamma_{\perp}$, JEFF-1: γ_{eff}^{-1} , BSR1: B_{sr1} ,

BSR2: B_{sr2} .

a: Liquid drop model $\eta = \zeta = \chi = 0$

b: Droplet model with the reference set in η, ζ, χ

c: Droplet model with various curvature strengths

d: Droplet model with various Coulomb-redistribution strengths

e: Droplet model with various compressibility strengths

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FTA=0	CHI=0	ZETA=0	RAEF	PCOUL	BSURF	BCURV	BRED	BCOMP	Q	JPARA	JPERF	JEFF-1	ESR1	ESR2
1.0000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000	0.0000	1.0000	1.0000
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0007	1.0017	0.2389	0.9547	1.0259	0.0728	0.9992	1.0000
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	0.4890	0.9117	1.0374	0.1511	0.9966	1.0000
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	0.7381	0.8708	1.0949	0.2351	0.9923	0.9998
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	0.9874	0.8314	1.1393	0.3251	0.9860	0.9993
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	1.2328	0.7934	1.1916	0.4212	0.9775	0.9983
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	1.4825	0.7566	1.2333	0.5239	0.9666	0.9963
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	1.7328	0.7208	1.3260	0.6333	0.9628	0.9930
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	1.9825	0.6859	1.4120	0.7427	0.9356	0.9877
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	2.2328	0.6522	1.5132	0.8723	0.9147	0.9797
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	2.4825	0.6187	1.6374	1.0055	0.8885	0.9677
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	2.7328	0.5864	1.7571	1.1456	0.8070	0.9503
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	2.9825	0.5551	1.9730	1.2946	0.8186	0.9255
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	3.2328	0.5250	2.2099	1.4522	0.7720	0.8899
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	3.4825	0.4969	2.5232	1.6161	0.7161	0.8692
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	3.7328	0.4730	2.9333	1.7757	0.6314	0.8373
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	3.9825	0.4594	3.5080	1.8918	0.5901	0.8181
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	4.2328	0.4462	4.2934	1.9884	0.5384	0.8096
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	4.4825	0.4332	4.9366	1.8632	0.5809	0.8083
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	4.7328	0.4204	5.6854	1.7294	0.5842	0.8094
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	4.9825	0.4076	6.4347	1.5971	0.5583	0.8047
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	5.2328	0.3948	7.1840	1.4728	0.5388	0.8000
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	5.4825	0.3820	7.9333	1.3525	0.5200	0.7953
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	5.7328	0.3692	8.6825	1.2325	0.5023	0.7906
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	5.9825	0.3564	9.4317	1.1124	0.4846	0.7859
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	6.2328	0.3436	10.1808	1.0000	0.4664	0.7812
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	6.4825	0.3308	10.9299	0.8875	0.4482	0.7765
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	6.7328	0.3180	11.6790	0.7700	0.4300	0.7718
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	6.9825	0.3052	12.4281	0.6525	0.4118	0.7671
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	7.2328	0.2924	13.1772	0.5350	0.3936	0.7624
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	7.4825	0.2796	13.9263	0.4175	0.3754	0.7577
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	7.7328	0.2668	14.6754	0.3000	0.3572	0.7530
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	7.9825	0.2540	15.4245	0.1825	0.3390	0.7483
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	8.2328	0.2412	16.1736	0.0650	0.3208	0.7436
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	8.4825	0.2284	16.9227	0.0000	0.3026	0.7389
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	8.7328	0.2156	17.6718	0.0000	0.2844	0.7342
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	8.9825	0.2028	18.4209	0.0000	0.2662	0.7295
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	9.2328	0.1900	19.1700	0.0000	0.2480	0.7248
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	9.4825	0.1772	19.9191	0.0000	0.2298	0.7201
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	9.7328	0.1644	20.6682	0.0000	0.2116	0.7154
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	9.9825	0.1516	21.4173	0.0000	0.1934	0.7107
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	10.2328	0.1388	22.1664	0.0000	0.1752	0.7060
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	10.4825	0.1260	22.9155	0.0000	0.1570	0.7013
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	10.7328	0.1132	23.6646	0.0000	0.1388	0.6966
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	10.9825	0.1004	24.4137	0.0000	0.1206	0.6919
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	11.2328	0.0876	25.1628	0.0000	0.1024	0.6872
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	11.4825	0.0748	25.9119	0.0000	0.0842	0.6825
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	11.7328	0.0620	26.6610	0.0000	0.0660	0.6778
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	11.9825	0.0492	27.4101	0.0000	0.0478	0.6731
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	12.2328	0.0364	28.1592	0.0000	0.0296	0.6684
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	12.4825	0.0236	28.9083	0.0000	0.0114	0.6637
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	12.7328	0.0108	29.6574	0.0000	0.0000	0.6590
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	12.9825	0.0000	30.4065	0.0000	0.0000	0.6543
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	13.2328	0.0000	31.1556	0.0000	0.0000	0.6496
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	13.4825	0.0000	31.9047	0.0000	0.0000	0.6449
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	13.7328	0.0000	32.6538	0.0000	0.0000	0.6402
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	13.9825	0.0000	33.4029	0.0000	0.0000	0.6355
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	14.2328	0.0000	34.1520	0.0000	0.0000	0.6308
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	14.4825	0.0000	34.9011	0.0000	0.0000	0.6261
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	14.7328	0.0000	35.6502	0.0000	0.0000	0.6214
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	14.9825	0.0000	36.3993	0.0000	0.0000	0.6167
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	15.2328	0.0000	37.1484	0.0000	0.0000	0.6120
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	15.4825	0.0000	37.8975	0.0000	0.0000	0.6073
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	15.7328	0.0000	38.6466	0.0000	0.0000	0.6026
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	15.9825	0.0000	39.3957	0.0000	0.0000	0.5979
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	16.2328	0.0000	40.1448	0.0000	0.0000	0.5932
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	16.4825	0.0000	40.8939	0.0000	0.0000	0.5885
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	16.7328	0.0000	41.6430	0.0000	0.0000	0.5838
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	16.9825	0.0000	42.3921	0.0000	0.0000	0.5791
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	17.2328	0.0000	43.1412	0.0000	0.0000	0.5744
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	17.4825	0.0000	43.8903	0.0000	0.0000	0.5697
1.0000	0.0000	1.0000	0.9996	1.0000	1.0000	1.0000	1.0032	1.0067	17.7328	0.0000	44.6394	0.0000	0.0000	0.5650
1.0000	0.00													

Table A4.a

ETA=.C517		ZETA=.0113		CHI=.0225		SADDLE PCINTS		ZETA=.0113		CHI=.0225		SADDLE PCINTS	
ETA	ZETA	CHI	SADDLE	ETA	ZETA	CHI	SADDLE	ETA	ZETA	CHI	SADDLE	ETA	ZETA
PCINTS	PCINTS	PCINTS	PCINTS	PCINTS	PCINTS	PCINTS	PCINTS	PCINTS	PCINTS	PCINTS	PCINTS	PCINTS	PCINTS
1.2855	2.4892	0.8592	0.0040	0.9843	1.0290	1.0327	1.0242	1.0588	1.6630	0.7567	1.2530	0.5234	0.9668
1.3513	2.1341	0.8277	0.0318	0.9765	1.0424	1.0491	1.0307	1.0867	1.2126	0.7117	1.3464	0.4623	0.9921
1.3860	1.8426	0.7936	0.0448	0.9665	1.0593	1.0704	1.0338	1.1222	1.2679	0.6665	1.4658	0.8172	0.9844
1.4226	1.6478	0.7555	0.0452	0.9535	1.0805	1.0983	1.0291	1.1675	2.3555	0.6217	1.6231	0.8923	0.9702
1.4600	1.4556	0.7113	0.0671	0.9362	1.1077	1.1357	1.0082	1.2271	4.2428	0.5754	1.8416	1.1948	0.9452
1.4980	1.2664	0.6539	0.0972	0.9117	1.1449	1.1897	0.9522	1.3107	5.5342	0.5265	2.1785	1.4401	0.8984
1.5360	1.0836	0.5586	0.1401	0.8685	1.2073	1.2894	0.7920	1.4575	8.0644	0.4707	2.8772	1.7769	0.8654
1.5740	0.9254	0.4307	0.2124	0.7903	1.3124	1.5180	0.6429	1.7234	14.650	0.4522	4.8241	2.2039	0.8336
1.6120	0.7820	0.3287	0.3287	0.7081	1.3320	1.5546	0.5247	1.7420	18.559	0.4062	5.1792	1.9491	0.8153
1.6500	0.6484	0.2517	0.3853	0.6180	1.3321	1.5736	0.4212	1.7480	15.904	0.4771	5.2230	1.9044	0.8121
1.6880	0.5283	0.1873	0.4733	0.5211	1.3225	1.5873	0.4209	1.7489	16.077	0.4865	5.2840	1.8663	0.8131
1.7260	0.4242	0.1208	0.5616	0.4270	1.3222	1.5991	0.4217	1.7481	16.177	0.4948	5.3222	1.8331	0.8164
1.7640	0.3366	0.0816	0.6500	0.3366	1.3216	1.6102	0.4208	1.7466	16.247	0.5024	5.3507	1.8037	0.8212
1.8020	0.2623	0.0584	0.7384	0.2623	1.3209	1.6216	0.4200	1.7447	16.313	0.5093	5.3774	1.7775	0.8276
1.8400	0.1980	0.0400	0.8268	0.1980	1.3201	1.6344	0.4191	1.7428	16.401	0.5157	5.4100	1.7543	0.8363
1.8780	0.1440	0.0274	0.9152	0.1440	1.3198	1.6420	0.4185	1.7416	16.465	0.5187	5.4321	1.7438	0.8421
1.9160	0.0996	0.0188	1.0040	0.0996	1.3194	1.6510	0.4179	1.7405	16.557	0.5215	5.4623	1.7343	0.8494
1.9540	0.0640	0.0125	1.0936	0.0640	1.3194	1.6556	0.4170	1.7405	16.623	0.5225	5.4835	1.7300	0.8543
1.9920	0.0376	0.0087	1.1840	0.0376	1.3193	1.6585	0.4160	1.7405	16.623	0.5225	5.4835	1.7300	0.8543

Table A4.b

Print 3

ETA=C400	7ETA=)	CHI=0	PCOUL	BSURF	BCURV	BRED	RCOMP	Q	JPARA	JPERF	JEFF-1	BSR1	BSR2		
XI 70	Z2	PAECK	RAE	CZ1	PCOUL	BSURF	BCURV	BRED	RCOMP	Q	JPARA	JPERF	JEFF-1	BSR1	BSR2
SADDLF PCINTS															
C.500	1.2572	2.6892	0.8756	0.0081	0.0028	0.9878	1.0227	1.0252	1.0199	1.0460	1.4324	0.7820	1.2055	0.4520	0.9744
C.500	1.3030	2.3200	0.8457	0.0059	0.0028	0.9822	1.0326	1.0371	1.0261	1.0663	1.7917	0.7635	1.2782	0.5626	0.9619
C.500	1.3576	2.0460	0.8228	0.0100	0.0073	0.9753	1.0444	1.0515	1.0309	1.0908	2.1905	0.7062	1.3599	0.6807	0.9461
C.500	1.4152	1.8317	0.7945	0.0166	0.0166	0.9677	1.0584	1.0692	1.0329	1.1201	2.6435	0.6696	1.4585	0.8078	0.9260
C.500	1.4754	1.6555	0.7648	0.0261	0.0262	0.9572	1.0744	1.0901	1.0300	1.1544	3.1554	0.6344	1.5760	0.9417	0.9014
C.500	1.5402	1.5036	0.7355	0.0401	0.0401	0.9429	1.0932	1.1155	1.0191	1.1951	3.7587	0.5997	1.7214	1.0965	0.8707
C.500	1.6112	1.3462	0.6968	0.0601	0.0601	0.9313	1.1152	1.1463	0.9597	1.2438	4.4844	0.5658	1.9040	1.2422	0.8326
C.500	1.6814	1.2352	0.6557	0.0829	0.0396	0.9199	1.1415	1.1847	0.9529	1.3030	5.3947	0.5326	2.1425	1.4108	0.7850
C.500	1.7514	1.0668	0.6054	0.1125	0.1350	0.8918	1.1739	1.2347	0.8787	1.3781	6.6169	0.5003	2.4748	1.5949	0.7245
C.500	1.8214	0.9392	0.5355	0.1513	0.2142	0.8614	1.2171	1.3073	0.7486	1.4612	8.4800	0.4700	3.0006	1.7943	0.6458
C.500	1.8912	0.7175	0.4255	0.2052	0.3633	0.8202	1.2735	1.4191	0.5507	1.5217	11.563	0.4341	3.9045	1.9463	0.5619
C.500	1.9612	0.5737	0.3614	0.2817	0.6752	0.8010	1.2983	1.4849	0.4690	1.5856	13.350	0.4035	4.4474	1.9327	0.5477
C.500	2.0312	0.5005	0.3139	0.3828	0.4710	0.7842	1.3357	1.5130	0.4477	1.7050	13.998	0.4744	4.6516	1.9929	0.5401
C.500	2.1012	0.4507	0.2883	0.5154	0.4643	0.7022	1.3887	1.5295	0.4397	1.7128	14.252	0.4862	4.7450	1.8547	0.5535
C.500	2.1712	0.4121	0.2692	0.6899	0.4438	0.7008	1.4101	1.5420	0.4364	1.7163	14.437	0.4930	4.8711	1.8271	0.5596
C.500	2.2412	0.3901	0.2513	0.9027	0.4118	0.7000	1.4306	1.5517	0.4351	1.7176	14.503	0.5011	4.8289	1.7887	0.5655
C.500	2.3112	0.3746	0.2343	1.1668	0.3710	0.7897	1.4497	1.5555	0.4349	1.7179	14.523	0.5084	4.8424	1.7509	0.5712
C.500	2.3812	0.3624	0.2208	1.4851	0.3222	0.7895	1.4672	1.5672	0.4353	1.7175	14.515	0.5155	4.8471	1.7334	0.5767
C.500	2.4512	0.3522	0.2098	1.8668	0.2656	0.7896	1.4832	1.5740	0.4360	1.7166	14.495	0.5222	4.8448	1.7384	0.5820
C.500	2.5212	0.3438	0.1978	2.3034	0.2022	0.7897	1.4988	1.5806	0.4368	1.7167	14.449	0.5284	4.8403	1.6950	0.5870
C.500	2.5912	0.3364	0.1861	2.7934	0.1314	0.7889	1.5139	1.5870	0.4377	1.7166	14.414	0.5343	4.8328	1.6646	0.5919
C.500	2.6612	0.3292	0.1746	3.3374	0.0534	0.7900	1.5285	1.5932	0.4387	1.7164	14.355	0.5400	4.8238	1.6446	0.5967
C.500	2.7312	0.3220	0.1633	3.9374	0.0319	0.7902	1.5420	1.5997	0.4397	1.7162	14.303	0.5454	4.8135	1.6259	0.6015
C.500	2.8012	0.3152	0.1513	4.5934	0.0124	0.7904	1.5555	1.6063	0.4407	1.7159	14.251	0.5505	4.8031	1.6083	0.6062
C.500	2.8712	0.3080	0.1403	5.3034	0.0000	0.7906	1.5681	1.6131	0.4416	1.7157	14.200	0.5554	4.7928	1.5917	0.6111
C.500	2.9412	0.3012	0.1284	6.0634	0.0000	0.7908	1.5806	1.6201	0.4426	1.7155	14.150	0.5602	4.7826	1.5761	0.6160
C.500	3.0112	0.2948	0.1158	6.8734	0.0000	0.7910	1.5932	1.6276	0.4434	1.7153	14.103	0.5647	4.7733	1.5614	0.6212
C.500	3.0812	0.2884	0.1034	7.7334	0.0000	0.7911	1.6063	1.6350	0.4442	1.7152	14.064	0.5690	4.7658	1.5476	0.6247
C.500	3.1512	0.2820	0.0910	8.6434	0.0000	0.7913	1.6190	1.6435	0.4449	1.7150	14.024	0.5731	4.7581	1.5346	0.6285
C.500	3.2212	0.2756	0.0783	9.6034	0.0000	0.7914	1.6319	1.6531	0.4455	1.7148	13.993	0.5771	4.7530	1.5224	0.6330
C.500	3.2912	0.2692	0.0659	10.6134	0.0000	0.7914	1.6449	1.6635	0.4459	1.7146	13.974	0.5809	4.7510	1.5110	0.6367
C.500	3.3612	0.2628	0.0535	11.6734	0.0000	0.7915	1.6578	1.6735	0.4463	1.7144	13.954	0.5847	4.7490	1.5000	0.6404

Table A4.c

FIA=.C8C		ZETA=.		RACK		CHI=.0		CZ1		PCOUL		BSURF		BOURV		BRFD		BCOMP		Q		JPARA		JPERF		JEFF=.1		BSPI		BSR2	
XI	Z	PCINIS	Z2	RACK	BBAF	CHI=.0	CZ1	PCOUL	BSURF	BOURV	BRFD	BCOMP	Q	JPARA	JPERF	JEFF=.1	BSPI	BSR2													
0.00	1.2670	2.5474	0.8672	0.0038	0.0038	0.0038	0.0038	0.9861	1.0258	1.0285	1.0220	1.0522	1.5453	0.7694	1.2305	0.4871	0.9707	0.9971													
0.080	1.2236	2.1987	0.8393	0.00161	0.00161	0.00161	0.00161	0.9797	1.0370	1.0424	1.0281	1.0753	1.9406	0.7290	1.3081	0.6073	0.9562	0.9939													
0.060	1.3821	2.1945	0.9105	0.00257	0.00257	0.00257	0.00257	0.9719	1.0502	1.0588	1.0322	1.1030	2.3808	0.6902	1.4066	0.7327	0.9379	0.9884													
0.040	1.4441	1.7361	0.7799	0.00388	0.00388	0.00388	0.00388	0.9624	1.0560	1.0790	1.0321	1.1363	2.8867	0.6522	1.5136	0.8727	0.9145	0.9796													
0.020	1.5178	1.5666	0.7470	0.00560	0.00560	0.00560	0.00560	0.9509	1.0846	1.1037	1.0250	1.1763	3.4796	0.6150	1.6594	1.0212	0.8851	0.9659													
0.000	1.5840	1.4152	0.7105	0.00784	0.00784	0.00784	0.00784	0.9369	1.1066	1.1341	1.0061	1.2246	4.1971	0.5784	1.8309	1.1828	0.8478	0.9447													
0.078	1.6475	1.2735	0.6883	0.01070	0.00939	0.00939	0.00939	0.9193	1.1335	1.1727	0.9578	1.2847	5.1059	0.5420	2.0669	1.3612	0.7998	0.9119													
0.060	1.7072	1.1263	0.6149	0.01437	0.01327	0.01327	0.01327	0.8959	1.1681	1.2254	0.8943	1.3644	6.3886	0.5052	2.4117	1.5647	0.7356	0.8582													
0.040	1.7732	1.0401	0.5789	0.01661	0.01623	0.01623	0.01623	0.8799	1.1911	1.2626	0.8219	1.4817	7.3246	0.4960	2.6718	1.6832	0.6928	0.8157													
0.020	1.8316	0.9256	0.5267	0.01922	0.02408	0.02408	0.02408	0.8649	1.2235	1.3186	0.7593	1.4970	8.7976	0.4655	3.0908	1.8248	0.6351	0.7475													
0.000	1.8706	0.8072	0.4963	0.02262	0.02963	0.02963	0.02963	0.7991	1.3011	1.4868	0.6486	1.6929	13.621	0.4528	4.5175	1.9877	0.5966	0.6577													
0.078	1.9134	0.6740	0.4700	0.02674	0.03506	0.03506	0.03506	0.7807	1.3125	1.5256	0.4984	1.7227	14.686	0.4462	4.8446	1.9573	0.5814	0.6298													
0.060	1.9516	0.5729	0.4417	0.02998	0.04100	0.04100	0.04100	0.7637	1.3162	1.5430	0.4902	1.7323	15.099	0.4691	4.9747	1.9309	0.5644	0.6216													
0.040	2.0192	0.4417	0.3923	0.03259	0.04395	0.04395	0.04395	0.7487	1.3179	1.5544	0.4267	1.7368	15.328	0.4745	5.0691	1.9078	0.5813	0.6180													
0.020	2.0868	0.3538	0.3538	0.03538	0.04626	0.04626	0.04626	0.7828	1.3192	1.5705	0.4243	1.7403	15.577	0.4849	5.1334	1.8674	0.5696	0.6162													
0.000	2.1544	0.2626	0.3257	0.03892	0.05058	0.05058	0.05058	0.7820	1.3194	1.5825	0.4241	1.7438	15.837	0.4936	5.1778	1.8329	0.5689	0.6127													
0.078	2.2220	0.2506	0.3257	0.04138	0.05440	0.05440	0.05440	0.7816	1.3191	1.5927	0.4248	1.7399	15.755	0.5014	5.2029	1.8023	0.5767	0.6207													
0.060	2.2896	0.1911	0.2																												

Print 5

ETA=12%	ZETA=0	CHI=0	PCOUL	BSURF	BCURV	BRAD	BCOMP	Q	JPARA	JPERP	JEFF-1	BSR1	BSR2
SADDLE POINTS													
0.900	1.2860	2.4144	0.8576	0.00106	0.0050	0.9840	1.0294	1.0332	1.0282	1.0596	1.6767	0.7553	1.2557
0.880	1.3465	2.0798	0.8278	0.00184	0.0097	0.9767	1.0420	1.0486	1.0300	1.0858	2.1115	0.7132	1.3433
0.860	1.4132	1.8357	0.7964	0.00295	0.0174	0.9677	1.0573	1.0678	1.0328	1.1178	2.4075	0.6724	1.4505
0.840	1.4782	1.6397	0.7627	0.00446	0.0294	0.9564	1.0755	1.0915	1.0294	1.1567	3.1889	0.6324	1.5840
0.820	1.5534	1.4724	0.7256	0.00646	0.0477	0.9429	1.0973	1.1211	1.0154	1.2041	3.8908	0.5930	1.7541
0.800	1.6394	1.3183	0.6825	0.00908	0.0766	0.9253	1.1243	1.1594	0.9827	1.2641	4.7935	0.5535	1.9839
0.780	1.7492	1.1585	0.6267	0.01252	0.1270	0.9010	1.1606	1.2137	0.9129	1.3469	6.1021	0.5121	2.3331
0.775	1.7840	1.1134	0.6006	0.01355	0.1443	0.8929	1.1724	1.2323	0.8840	1.3745	6.5606	0.5010	2.4588
0.770	1.8258	1.0414	0.5866	0.01447	0.1722	0.8830	1.1864	1.2552	0.8458	1.4080	7.1395	0.4890	2.6193
0.765	1.8726	0.9947	0.5863	0.01590	0.2118	0.8695	1.2038	1.2874	0.7886	1.4541	7.9752	0.4750	2.8549
0.762	1.9437	0.9256	0.5229	0.01672	0.2806	0.8548	1.2263	1.3235	0.7223	1.5039	8.9448	0.4628	3.1321
MINIMA													
0.763	2.0455	0.8557	0.4625	0.01637	0.3599	0.8299	1.2606	1.3891	0.6054	1.5890	10.804	0.4486	3.6728
0.765	2.0838	0.7721	0.4420	0.01567	0.3963	0.8221	1.2711	1.4111	0.5697	1.6158	11.459	0.4458	3.8652
0.770	2.1405	0.7077	0.4062	0.01383	0.4622	0.8094	1.2880	1.4490	0.5149	1.6590	12.413	0.4433	4.2071
0.775	2.1822	0.6543	0.3764	0.01187	0.5180	0.8000	1.3004	1.4798	0.4781	1.6911	13.572	0.4433	4.4935
0.780	2.2275	0.5577	0.3447	0.00983	0.5752	0.7912	1.3116	1.5110	0.4487	1.7202	14.554	0.4452	4.7882
0.783	2.2633	0.5357	0.3126	0.00856	0.6266	0.7840	1.3205	1.5404	0.4289	1.7437	15.468	0.4493	5.0652
SADDLE POINTS													
0.782	2.2883	0.4852	0.2832	0.00900	0.6631	0.7787	1.3264	1.5652	0.4185	1.7593	16.198	0.4551	5.2888
0.780	2.2961	0.4620	0.2708	0.00969	0.6732	0.7770	1.3282	1.5748	0.4159	1.7640	16.462	0.4580	5.3706
0.775	2.3046	0.4274	0.2523	0.01213	0.6804	0.7749	1.3300	1.5883	0.4138	1.7690	16.802	0.4630	5.4749
0.770	2.3085	0.4031	0.2394	0.01439	0.6789	0.7737	1.3309	1.5972	0.4133	1.7712	17.002	0.4669	5.5405
0.760	2.3116	0.3658	0.2194	0.01893	0.6636	0.7724	1.3314	1.6103	0.4135	1.7727	17.258	0.4732	5.6232
0.750	2.3126	0.3350	0.2026	0.02349	0.6375	0.7716	1.3315	1.6207	0.4143	1.7728	17.433	0.4786	5.6810
0.740	2.3136	0.3065	0.1869	0.02804	0.6018	0.7709	1.3312	1.6304	0.4153	1.7721	17.580	0.4834	5.7296
0.730	2.3146	0.2791	0.1711	0.03285	0.5555	0.7703	1.3309	1.6404	0.4163	1.7712	17.726	0.4879	5.7777
0.725	2.3161	0.2646	0.1626	0.03495	0.5270	0.7700	1.3307	1.6459	0.4168	1.7707	17.809	0.4901	5.8047
0.720	2.3181	0.2488	0.1533	0.03725	0.4935	0.7695	1.3305	1.6521	0.4173	1.7702	17.908	0.4922	5.8363
0.718	2.3196	0.2415	0.1488	0.03817	0.4771	0.7693	1.3305	1.6553	0.4175	1.7701	17.963	0.4930	5.8535
MINIMA													
0.710	2.3530	0.1546	0.0960	0.04187	0.2909	0.7657	1.3310	1.6944	0.4182	1.7716	18.616	0.4973	6.1124
0.715	2.3692	0.1324	0.0805	0.03952	0.2573	0.7642	1.3318	1.7066	0.4178	1.7737	19.167	0.4963	6.2159
0.720	2.3823	0.1161	0.0702	0.03715	0.2435	0.7631	1.3325	1.7146	0.4175	1.7755	19.420	0.4951	6.2902
0.725	2.3936	0.1022	0.0614	0.03478	0.2373	0.7621	1.3331	1.7213	0.4171	1.7775	19.640	0.4938	6.3547
0.730	2.4036	0.0892	0.0533	0.03239	0.2356	0.7612	1.3338	1.7271	0.4168	1.7790	19.842	0.4926	6.4137
0.735	2.4123	0.0765	0.0455	0.03000	0.2374	0.7604	1.3344	1.7323	0.4165	1.7807	20.031	0.4913	6.4690
0.740	2.4226	0.0632	0.0374	0.02760	0.2414	0.7597	1.3350	1.7372	0.4162	1.7824	20.214	0.4901	6.5221
0.745	2.4317	0.0484	0.0285	0.02520	0.2476	0.7589	1.3357	1.7417	0.4159	1.7841	20.389	0.4888	6.5732
0.750	2.4406	0.0278	0.0163	0.02278	0.2552	0.7582	1.3363	1.7462	0.4157	1.7857	20.562	0.4875	6.6237

Table A4.c (cont.)

ETA-.160C	ZETA-.0	CHI-.0	BSURF	BCURV	BRED	BCOMP	Q	JPARA	JPERP	JEFF-1	BSR1	BSR2
XI	ZZ	BBAF	BSURF	BCURV	BRED	BCOMP	Q	JPARA	JPERP	JEFF-1	BSR1	BSR2
0.900	1.3076	0.0067	0.0067	0.9815	1.0265	1.0686	1.8301	0.7397	1.2858	0.5742	0.9604	0.9949
0.880	1.3732	0.0814	0.0432	0.9730	1.0483	1.0564	1.0317	0.6955	1.3668	0.7168	0.9406	0.9893
0.860	1.4432	0.1730	0.0342	0.9624	1.0659	1.0790	1.0320	0.6524	1.5131	0.8719	0.9145	0.9795
0.840	1.5157	0.5802	0.0404	0.9492	1.0874	1.1075	1.0231	0.6101	1.8749	1.2422	0.8804	0.9634
0.820	1.6076	0.6984	0.0678	0.9320	1.1142	1.1448	0.9970	0.5673	1.9949	1.2349	0.8362	0.9362
0.800	1.7206	1.3911	0.6416	0.9107	1.1509	1.1988	0.9345	0.5245	2.2243	1.4681	0.7678	0.8867
0.795	1.7587	1.1900	0.6224	0.91168	1.1376	0.8990	0.9063	0.5091	2.2363	1.5415	0.7443	0.8664
0.790	1.8052	1.0916	0.5982	0.91274	1.1663	0.8881	1.1794	0.4946	2.5369	1.6276	0.7149	0.8388
0.785	1.8862	0.9557	0.5565	0.91394	1.2034	0.8691	1.2881	0.4740	2.8617	1.7602	0.6659	0.7864
0.780	1.9544	0.4992	0.4992	0.91361	1.2415	1.3512	0.6741	0.4539	3.3590	1.9052	0.6065	0.7094
0.775	2.0474	0.8340	0.4706	0.8319	1.2579	1.3831	0.6185	0.4470	3.6286	1.9914	0.5820	0.6708
0.770	2.0903	0.7925	0.4473	0.8225	1.2707	1.4092	0.5799	0.4427	3.8588	1.9995	0.5650	0.6402
0.760	2.1237	0.7804	0.4293	0.8154	1.2803	1.4297	0.5450	0.4391	4.0452	2.0249	0.5537	0.6172
0.750	2.1765	0.7611	0.4087	0.8046	1.2947	1.4625	0.5013	0.4370	4.2539	2.0788	0.5396	0.5829
0.740	2.2401	0.7477	0.3860	0.7960	1.3060	1.4901	0.4702	0.4357	4.4236	2.0985	0.5316	0.5568
0.730	2.3264	0.7321	0.3650	0.7830	1.3230	1.5365	0.4315	0.4332	4.5953	2.1017	0.5262	0.5206
0.720	2.3582	0.7292	0.3437	0.7726	1.3359	1.5785	0.4108	0.4367	4.7574	2.1095	0.5301	0.4978
0.710	2.4438	0.7256	0.3256	0.7632	1.3466	1.6248	0.4024	0.4387	4.9195	2.1003	0.5448	0.4862
0.700	2.5204	0.7232	0.3083	0.7518	1.3547	1.7092	0.4092	0.4336	5.0595	2.0585	0.5918	0.5090
0.690	2.6124	0.7209	0.2954	0.7475	1.3583	1.7395	0.4110	0.4312	5.1814	2.0771	0.6052	0.5247
0.680	2.6916	0.7181	0.2831	0.7441	1.3618	1.7605	0.4117	0.4343	5.2974	2.1019	0.6178	0.5359
0.670	2.7688	0.7154	0.2708	0.7410	1.3654	1.7784	0.4121	0.4387	5.4027	2.1267	0.6221	0.5547
0.660	2.8452	0.7128	0.2585	0.7380	1.3692	1.7950	0.4125	0.4380	5.5074	2.1517	0.6257	0.5635
0.650	2.9216	0.7102	0.2462	0.7351	1.3730	1.8107	0.4129	0.4332	5.6127	2.1769	0.6290	0.5723
0.640	2.9980	0.7076	0.2340	0.7322	1.3771	1.8261	0.4133	0.4283	5.7180	2.2021	0.6320	0.5811
0.630	3.0744	0.7050	0.2218	0.7293	1.3813	1.8412	0.4137	0.4234	5.8231	2.2273	0.6348	0.5902
0.620	3.1508	0.7024	0.2096	0								

Table A4.c (cont.)

[illegible]

Table A4.d

Print 8

ETA-C	ZETA-0167	CMI-0	BSAF	CZ1	PCOUL	BSURF	BCURV	BRED	BCOMP	Q	JPARA	JPERP	JEFF-1	BSR1	BSR2
XI	ZZ	RNECK													
SADDER POINTS															
C-90C	1.2513	2.8242	0.9769	0.0078	0.0021	0.9879	1.0225	1.0251	1.0200	1.0456	1.4254	0.7828	1.2081	0.4498	0.9748
C-880	1.3101	2.4061	0.9489	0.00138	0.0043	0.9818	1.0333	1.0380	1.0270	1.0678	1.8185	0.7407	1.2834	0.5708	0.9613
C-860	1.3738	2.0955	0.9187	0.00226	0.0079	0.9738	1.0470	1.0548	1.0326	1.0962	2.2782	0.6984	1.3783	0.7062	0.9429
C-840	1.4443	1.8450	0.8855	0.00351	0.0138	0.9636	1.0641	1.0746	1.0345	1.1322	2.8315	0.6556	1.5005	0.8590	0.9183
C-820	1.5241	1.6405	0.8480	0.00522	0.0228	0.9503	1.0856	1.1051	1.0279	1.1785	3.5219	0.6118	1.6627	1.0332	0.8847
C-800	1.6173	1.4515	0.8038	0.00754	0.0367	0.9327	1.1131	1.1433	1.0042	1.2391	4.4290	0.5667	1.8684	1.2351	0.8383
C-780	1.7235	1.2665	0.7687	0.01068	0.0582	0.9087	1.1493	1.1964	0.9460	1.3210	5.7046	0.5206	2.2230	1.4709	0.7731
C-760	1.8491	1.0980	0.7360	0.01496	0.0901	0.8760	1.1866	1.2714	0.8297	1.4319	7.5844	0.4777	2.7440	1.7289	0.6850
C-740	2.0018	0.8717	0.6931	0.02063	0.1221	0.8417	1.2445	1.3570	0.6625	1.5487	9.8932	0.4533	3.4056	1.9124	0.6017
C-720	2.0747	0.7322	0.6301	0.02743	0.1320	0.8207	1.2728	1.4168	0.5958	1.6200	11.533	0.4517	3.8935	1.9569	0.5625
C-700	2.1052	0.6414	0.5881	0.03484	0.1228	0.8101	1.2887	1.4523	0.5041	1.6556	12.653	0.4585	4.1747	1.9417	0.5302
C-680	2.1165	0.5767	0.5376	0.04256	0.1020	0.8043	1.2941	1.4752	0.4779	1.6746	12.978	0.4670	4.3400	1.9107	0.5078
C-660	2.1186	0.5267	0.4938	0.05046	0.0734	0.8010	1.2982	1.4914	0.4636	1.6854	13.288	0.4758	4.4413	1.8764	0.5095
C-640	2.1158	0.4861	0.4541	0.05847	0.0388	0.7989	1.3007	1.5038	0.4554	1.6919	13.471	0.4844	4.5044	1.8425	0.5128
C-620	2.1102	0.4517	0.4272	0.06654	-0.0010	0.7976	1.3022	1.5137	0.4506	1.6957	13.574	0.4926	4.5431	1.8101	0.5168
C-600	2.1031	0.4215	0.4022	0.07465	-0.0453	0.7969	1.3031	1.5221	0.4479	1.6980	13.623	0.5004	4.5657	1.7795	0.5211
C-580	2.0950	0.3953	0.3827	0.08279	-0.0940	0.7964	1.3036	1.5294	0.4465	1.6993	13.636	0.5078	4.5771	1.7508	0.5254
C-560	2.0864	0.3718	0.3583	0.09094	-0.1469	0.7962	1.3038	1.5360	0.4459	1.6999	13.624	0.5149	4.5805	1.7238	0.5298
C-540	2.0775	0.3503	0.3447	0.09909	-0.2038	0.7961	1.3039	1.5420	0.4459	1.7000	13.593	0.5217	4.5781	1.6985	0.5340
C-520	2.0684	0.3304	0.3239	0.10724	-0.2646	0.7962	1.3038	1.5477	0.4462	1.7000	13.549	0.5282	4.5715	1.6746	0.5381
C-500	2.0594	0.3120	0.2236	0.11540	-0.3295	0.7963	1.3037	1.5531	0.4468	1.6997	13.496	0.5344	4.5618	1.6521	0.5421
C-480	2.0504	0.2948	0.2137	0.12354	-0.3983	0.7965	1.3036	1.5583	0.4475	1.6993	13.435	0.5404	4.5497	1.6308	0.5469
C-460	2.0415	0.2785	0.2042	0.13168	-0.4712	0.7967	1.3034	1.5634	0.4484	1.6987	13.370	0.5461	4.5398	1.6106	0.5517
C-440	2.0328	0.2631	0.1937	0.13980	-0.5483	0.7970	1.3031	1.5684	0.4494	1.6982	13.300	0.5517	4.5306	1.5915	0.5566
C-420	2.0242	0.2485	0.1860	0.14792	-0.6296	0.7973	1.3029	1.5733	0.4504	1.6976	13.228	0.5570	4.5205	1.5733	0.5622
C-400	2.0158	0.2344	0.1772	0.15602	-0.7152	0.7976	1.3027	1.5783	0.4514	1.6971	13.155	0.5622	4.4704	1.5560	0.5678
C-380	2.0076	0.2208	0.1685	0.16411	-0.8053	0.7979	1.3025	1.5833	0.4525	1.6965	13.080	0.5672	4.4704	1.5394	0.5736
C-360	1.9995	0.2076	0.1599	0.17219	-0.9000	0.7982	1.3023	1.5883	0.4536	1.6960	13.005	0.5720	4.4528	1.5236	0.5798
C-340	1.9917	0.1948	0.1514	0.18026	-0.9995	0.7985	1.3021	1.5933	0.4546	1.6955	12.929	0.5767	4.4350	1.5085	0.5857
C-320	1.9840	0.1821	0.1428	0.18831	-1.104	0.7988	1.3019	1.5985	0.4557	1.6950	12.854	0.5812	4.4172	1.4941	0.5910
C-300	1.9840	0.1761	0.1382	0.19636	-1.177	0.7986	1.3020	1.6017	0.4556	1.6953	12.871	0.5824	4.4233	1.4910	0.6166

Table A4.d (cont.)

Print 9

ETA-0	ZETA-0240	CHI-0	RECK	BRAP	CHI-0	ECOL	BSURF	BCURV	BRED	SCOMP	Q	JPARA	JPERP	JEFF-1	BSR1	BSR2
XXI	ZZ	ZZ	RECK	BRAP	CHI-0	ECOL	BSURF	BCURV	BRED	SCOMP	Q	JPARA	JPERP	JEFF-1	BSR1	BSR2
SADDLE POINTS																
C.900	1.260E	2.8103	0.8733	0.0001	0.0021	0.9871	1.0239	1.0268	1.0212	1.0485	1.4793	0.7766	1.2181	0.4667	0.9732	0.9978
C.890	1.3259	2.3848	0.8428	0.0046	0.0043	0.9801	1.0362	1.0414	1.0288	1.0736	1.9170	0.7310	1.3031	0.6005	0.9577	0.9947
C.880	1.3957	2.0582	0.9067	0.0044	0.0081	0.9707	1.0523	1.0615	1.0345	1.1074	2.4542	0.6838	1.4162	0.7563	0.9357	0.9886
C.870	1.4661	1.7920	0.9386	0.0145	0.0356	0.9576	1.0739	1.0895	1.0342	1.1533	3.1497	0.6339	1.5738	0.9421	0.9038	0.9764
C.860	1.5934	1.5537	0.7201	0.0591	0.0252	0.9387	1.1040	1.1304	1.0169	1.2187	4.1276	0.5797	1.8115	1.1730	0.8932	0.9517
C.850	1.7387	1.3154	0.6522	0.0590	0.0427	0.9090	1.1490	1.1958	0.9524	1.3202	5.7025	0.5193	2.2210	1.4755	0.7755	0.8965
C.780	1.9291	1.0551	0.5529	0.0341	0.0627	0.8640	1.2138	1.3002	0.7797	1.4794	8.3872	0.4632	2.9660	1.8219	0.6556	0.7779
C.760	2.0525	0.8305	0.4683	0.0160	0.0562	0.8308	1.2593	1.3859	0.6140	1.5859	10.746	0.4464	3.6532	1.9666	0.5801	0.6676
C.740	2.1071	0.7191	0.4173	0.0287	0.0302	0.8156	1.2796	1.4316	0.5393	1.6373	11.993	0.4495	4.2085	1.9762	0.5551	0.6118
C.720	2.1187	0.6346	0.3823	0.0325	0.0037	0.8078	1.2898	1.4594	0.4562	1.6635	12.690	0.4572	4.2440	1.9517	0.5476	0.5821
C.700	2.1247	0.5758	0.3555	0.04204	0.425	0.8032	1.2935	1.4785	0.4748	1.6784	13.104	0.4658	4.3767	1.9184	0.5467	0.5649
C.680	2.1241	0.5288	0.3338	0.04998	0.0853	0.8004	1.2990	1.4927	0.4624	1.6813	13.360	0.4745	4.4612	1.8835	0.5487	0.5545
C.660	2.1158	0.4857	0.3152	0.05800	0.1316	0.7986	1.3011	1.5040	0.4520	1.6928	13.512	0.4839	4.5152	1.8493	0.5321	0.5481
C.640	2.1134	0.4562	0.2990	0.06808	0.1813	0.7975	1.3024	1.5133	0.4506	1.6962	13.598	0.4910	4.5489	1.8167	0.5560	0.5443
C.620	2.1058	0.4267	0.2844	0.07819	0.2344	0.7968	1.3031	1.5212	0.4480	1.6982	13.639	0.4998	4.5687	1.7860	0.5602	0.5423
C.600	2.0973	0.4005	0.2712	0.08233	0.2907	0.7964	1.3036	1.5283	0.4466	1.6993	13.666	0.5062	4.5784	1.7570	0.5645	0.5416
C.580	2.0885	0.3758	0.2589	0.09048	0.3503	0.7962	1.3038	1.5347	0.4460	1.6999	13.681	0.5133	4.5810	1.7298	0.5688	0.5417
C.560	2.0794	0.3552	0.2474	0.09663	0.4133	0.7962	1.3039	1.5406	0.4459	1.7000	13.698	0.5201	4.5781	1.7041	0.5730	0.5426
C.540	2.0702	0.3352	0.2366	0.10578	0.4796	0.7962	1.3038	1.5462	0.4462	1.6999	13.554	0.5267	4.5713	1.6799	0.5771	0.5441
C.520	2.0610	0.3167	0.2263	0.11693	0.5495	0.7963	1.3037	1.5515	0.4467	1.6996	13.500	0.5330	4.5615	1.6571	0.5811	0.5460
C.500	2.0519	0.2993	0.2165	0.12808	0.6230	0.7965	1.3035	1.5567	0.4475	1.6992	13.439	0.5390	4.5453	1.6355	0.5850	0.5484
C.480	2.0429	0.2829	0.2069	0.13121	0.7001	0.7968	1.3033	1.5617	0.4483	1.6987	13.373	0.5448	4.5355	1.6151	0.5888	0.5511
C.460	2.0341	0.2674	0.1977	0.12933	0.7811	0.7970	1.3031	1.5667	0.4493	1.6981	13.303	0.5504	4.5203	1.5957	0.5926	0.5542
C.440	2.0255	0.2526	0.1887	0.14745	0.8660	0.7973	1.3029	1.5716	0.4503	1.6976	13.232	0.5558	4.5043	1.5772	0.5962	0.5576
C.420	2.0170	0.2383	0.1799	0.15955	0.9549	0.7976	1.3027	1.5766	0.4513	1.6970	13.158	0.5610	4.4876	1.5596	0.5988	0.5613
C.400	2.0087	0.2244	0.1712	0.16364	1.048	0.7979	1.3025	1.5815	0.4524	1.6965	13.083	0.5661	4.4704	1.5429	0.6034	0.5653
C.380	2.0006	0.2114	0.1625	0.17172	1.146	0.7982	1.3023	1.5866	0.4535	1.6959	13.008	0.5710	4.4528	1.5269	0.6089	0.5697
C.360	1.9927	0.1984	0.1540	0.17978	1.248	0.7985	1.3021	1.5916	0.4545	1.6954	12.933	0.5757	4.4350	1.5115	0.6105	0.5745
C.340	1.9850	0.1857	0.1454	0.18784	1.355	0.7988	1.3019	1.5967	0.4556	1.6950	12.858	0.5803	4.4173	1.4969	0.6140	0.5796
C.320	1.9774	0.1732	0.1367	0.19588	1.467	0.7992	1.3017	1.6020	0.4567	1.6945	12.783	0.5848	4.3994	1.4828	0.6171	0.5850
C.300	1.9701	0.1607	0.1279	0.20390	1.584	0.7995	1.3016	1.6073	0.4577	1.6941	12.709	0.5891	4.3811	1.4693	0.6215	0.5909

Table A4.d (cont.)

Print 10

ETA=0	ZETA=0.0320	CHI=0	BSAF	CZ1	PCOUL	BSURF	BCURV	BRED	BCOMP	Q	JPARA	JPERP	JEFF-1	ESR1	BSR2
XT	Z0	RNECK	SAF												
SADLE POINTS															
0.907	1.2715	2.8134	0.8692	0.00085	0.0020	0.9862	1.0256	1.0287	1.0225	1.0518	1.5409	0.7697	1.2255	0.4859	0.9713
0.890	1.3452	2.3595	0.8355	0.00156	0.0042	0.9781	1.0397	1.0458	1.0309	1.0810	2.0378	0.7196	1.3277	0.6365	0.9933
0.880	1.4341	2.0046	0.7955	0.00265	0.0084	0.9662	1.0597	1.0710	1.0365	1.1230	2.6955	0.6650	1.4694	0.8231	0.9256
0.840	1.5314	1.7039	0.7436	0.00435	0.0158	0.9475	1.0902	1.1115	1.0296	1.1885	3.6792	0.6021	1.7001	0.8726	0.8790
0.820	1.7408	1.3717	0.6592	0.00708	0.0290	0.9108	1.1465	1.1920	0.9635	1.3144	5.6198	0.5205	2.1972	1.4662	0.9034
0.800	2.0084	0.9731	0.5185	0.01199	0.0171	0.8472	1.2373	1.3417	0.7078	1.5310	9.5620	0.4473	3.3038	1.9326	0.6164
0.780	2.0523	0.7584	0.4487	0.01869	0.0308	0.8225	1.2706	1.4087	0.5777	1.6145	11.446	0.4418	3.8574	2.0040	0.5652
0.760	2.1207	0.6500	0.4077	0.02601	0.0419	0.8118	1.2847	1.4430	0.5204	1.6505	12.361	0.4477	4.1365	1.9919	0.5499
0.740	2.1305	0.6300	0.3778	0.02367	0.0442	0.8058	1.2923	1.4653	0.4899	1.6702	12.895	0.4558	4.3038	1.9615	0.5455
0.720	2.1226	0.5757	0.3539	0.04152	0.0478	0.8021	1.2969	1.4814	0.4721	1.6819	13.225	0.4644	4.4109	1.9264	0.5456
0.700	2.1297	0.5312	0.3338	0.04948	0.0429	0.7998	1.2997	1.4940	0.4613	1.6892	13.431	0.4730	4.4811	1.8909	0.5479
0.680	2.1241	0.4934	0.3163	0.05752	0.0300	0.7983	1.3015	1.5042	0.4504	1.6938	13.557	0.4814	4.5270	1.8564	0.5513
0.660	2.1168	0.4606	0.3007	0.06561	0.0391	0.7973	1.3026	1.5125	0.4504	1.6967	13.626	0.4895	4.5557	1.8235	0.5552
0.640	2.1086	0.4215	0.2865	0.07373	0.0405	0.7967	1.3032	1.5204	0.4480	1.6984	13.656	0.4972	4.5725	1.7925	0.5594
0.620	2.0958	0.4054	0.2755	0.08187	0.0483	0.7964	1.3036	1.5272	0.4466	1.6994	13.658	0.5046	4.5805	1.7633	0.5637
0.600	2.0806	0.3817	0.2614	0.09002	0.0507	0.7962	1.3038	1.5334	0.4459	1.6999	13.640	0.5118	4.5820	1.7357	0.5679
0.580	2.0613	0.3600	0.2501	0.09817	0.0518	0.7962	1.3038	1.5392	0.4459	1.7000	13.605	0.5186	4.5786	1.7098	0.5721
0.560	2.0420	0.3400	0.2393	0.10632	0.0518	0.7962	1.3038	1.5447	0.4462	1.6998	13.559	0.5252	4.5713	1.6853	0.5761
0.540	2.0227	0.3213	0.2290	0.11447	0.0507	0.7964	1.3037	1.5500	0.4467	1.6995	13.504	0.5315	4.5613	1.6622	0.5801
0.520	2.0034	0.3038	0.2192	0.12261	0.0491	0.7966	1.3035	1.5551	0.4474	1.6991	13.443	0.5376	4.5491	1.6403	0.5840
0.500	2.0044	0.2873	0.2096	0.13075	0.0466	0.7966	1.3033	1.5601	0.4483	1.6986	13.377	0.5435	4.5353	1.6196	0.5879
0.480	2.0355	0.2716	0.2004	0.13887	0.0432	0.7970	1.3031	1.5650	0.4492	1.6980	13.307	0.5491	4.5202	1.5999	0.5916
0.460	2.0267	0.2566	0.1914	0.14698	0.0400	0.7973	1.3029	1.5700	0.4502	1.6975	13.235	0.5546	4.5041	1.5812	0.5952
0.440	2.0182	0.2423	0.1825	0.15508	0.0368	0.7976	1.3027	1.5749	0.4512	1.6969	13.162	0.5599	4.4875	1.5633	0.5989
0.420	2.0098	0.2285	0.1738	0.16317	0.0336	0.7979	1.3025	1.5795	0.4523	1.6964	13.087	0.5650	4.4703	1.5463	0.6024
0.400	2.0017	0.2151	0.1651	0.17125	0.0304	0.7982	1.3023	1.5849	0.4534	1.6959	13.012	0.5699	4.4528	1.5301	0.6060
0.380	1.9937	0.2021	0.1566	0.17931	0.0272	0.7986	1.3021	1.5899	0.4545	1.6954	12.936	0.5747	4.4351	1.5146	0.6095
0.360	1.9855	0.1893	0.1479	0.18736	0.0240	0.7989	1.3019	1.5950	0.4555	1.6949	12.861	0.5793	4.4174	1.4997	0.6130
0.340	1.9866	0.1833	0.1434	0.19541	0.0208	0.7987	1.3020	1.5982	0.4564	1.6952	12.879	0.5805	4.4259	1.4906	0.6146
0.320	1.9876	0.1643	0.1305	0.20343	0.0170	0.7995	1.3016	1.6052	0.4577	1.6941	12.711	0.5882	4.4815	1.4718	0.6201
0.300	1.9887	0.1518	0.1216	0.21144	0.0132	0.7998	1.3014	1.6109	0.4587	1.6937	12.638	0.5925	4.4329	1.4586	0.6237

Table A4.d (cont.)

Print 11

EIA=0	ZETA=0	CHI=0.0400	RNECK	BBAF	CZ1	BCOUL	BSURF	BCURV	BRED	BCOMP	Q	JPARA	JPERP	JEFF-1	BSR1	BSR2
0.900	1.2319	2.8726	0.8848	0.0070	0.0021	0.9895	1.0197	1.0217	1.0177	1.0397	1.3122	0.7961	1.1876	0.4142	0.9782	0.9984
0.880	1.2870	2.4767	0.8612	0.0021	0.0041	0.9848	1.0281	1.0316	1.0235	1.0369	1.3305	0.7602	1.2467	0.5134	0.9678	0.9966
0.860	1.3292	2.1866	0.8379	0.0019	0.0071	0.9790	1.0381	1.0437	1.0287	1.0475	1.3482	0.7254	1.3157	0.6185	0.9548	0.9935
0.840	1.3802	1.9615	0.8119	0.0020	0.0117	0.9722	1.0496	1.0581	1.0322	1.0618	1.3623	0.6816	1.3966	0.7298	0.9387	0.9888
0.820	1.4334	1.7791	0.7859	0.0047	0.0182	0.9643	1.0630	1.0751	1.0328	1.1299	1.3794	0.6389	1.4916	0.8473	0.9192	0.9816
0.800	1.4890	1.6250	0.7583	0.0078	0.0272	0.9449	1.0781	1.0951	1.0286	1.1624	1.3975	0.5920	1.6042	0.9715	0.8956	0.9712
0.780	1.5478	1.4901	0.7290	0.0078	0.0396	0.9441	1.0954	1.1185	1.0174	1.1999	1.4174	0.5461	1.7389	1.1027	0.8671	0.9562
0.760	1.6108	1.3677	0.6971	0.0108	0.0565	0.9314	1.1151	1.1460	0.9960	1.2834	1.4484	0.4981	1.9025	1.2410	0.8330	0.9353
0.740	1.6792	1.2521	0.6618	0.0131	0.0795	0.9166	1.1375	1.1789	0.9602	1.2940	1.4808	0.4500	2.1049	1.3663	0.7923	0.9061
0.720	1.7545	1.1380	0.6214	0.0169	0.1113	0.8990	1.1634	1.2182	0.9046	1.3536	1.5161	0.4028	2.3620	1.5375	0.7440	0.8657
0.700	1.8401	1.0192	0.5736	0.0214	0.1563	0.8781	1.1935	1.2668	0.8221	1.4245	1.5518	0.3554	2.6993	1.8271	0.6878	0.8098
0.680	1.9254	0.8986	0.5149	0.0269	0.2200	0.8537	1.2279	1.3270	0.7093	1.5076	1.5969	0.3060	3.1481	2.1871	0.6270	0.7352
0.660	2.0098	0.7717	0.4486	0.0314	0.2971	0.8295	1.2610	1.3928	0.5899	1.5901	1.6438	0.2585	3.6700	2.6700	0.5648	0.6597
0.640	2.0931	0.6413	0.3935	0.04031	0.3543	0.8136	1.2821	1.4527	0.4794	1.6708	1.6945	0.2115	4.3004	3.1882	0.5011	0.5980
0.620	2.1755	0.5124	0.3278	0.0582	0.3832	0.8012	1.2926	1.4731	0.4541	1.6920	1.7144	0.1646	4.9897	3.7540	0.4340	0.5553
0.600	2.2570	0.4377	0.2882	0.07190	0.3522	0.7925	1.3024	1.5181	0.4495	1.6822	1.7361	0.1181	5.7023	4.3820	0.3593	0.5177
0.580	2.3375	0.4028	0.2727	0.08002	0.3235	0.7867	1.3037	1.5270	0.4461	1.6997	1.7603	0.0715	6.5450	5.0577	0.2820	0.4838
0.560	2.4170	0.3766	0.2589	0.08816	0.2881	0.7861	1.3039	1.5346	0.4457	1.7003	1.7879	0.0206	7.4911	5.8111	0.2026	0.4526
0.540	2.4955	0.3533	0.2463	0.09632	0.2466	0.7860	1.3040	1.5475	0.4459	1.7003	1.8077	0.0000	8.5450	6.7026	0.1179	0.4240
0.520	2.5720	0.3322	0.2347	0.10447	0.1996	0.7860	1.3040	1.5610	0.4459	1.7003	1.8322	0.0000	9.7026	7.7577	0.0340	0.3980
0.500	2.6475	0.3122	0.2238	0.11263	0.1473	0.7861	1.3039	1.5753	0.4465	1.7001	1.8577	0.0000	10.9726	8.9779	0.0460	0.3740
0.480	2.7220	0.2948	0.2134	0.12078	0.0899	0.7863	1.3037	1.5898	0.4472	1.6997	1.8832	0.0000	12.3577	10.3727	0.0580	0.3514
0.460	2.7965	0.2775	0.2034	0.12893	0.0275	0.7865	1.3035	1.6041	0.4481	1.6992	1.9082	0.0000	13.8511	11.8820	0.0700	0.3290
0.440	2.8700	0.2620	0.1940	0.13706	-0.0398	0.7868	1.3033	1.6189	0.4490	1.6986	1.9329	0.0000	15.4550	13.4974	0.0820	0.3076
0.420	2.9435	0.2470	0.1848	0.14518	-0.1120	0.7871	1.3031	1.6344	0.4501	1.6980	1.9570	0.0000	17.1726	15.2240	0.0940	0.2862
0.400	3.0170	0.2325	0.1758	0.15329	-0.1892	0.7874	1.3029	1.6505	0.4511	1.6974	1.9818	0.0000	19.0000	17.0624	0.1060	0.2648
0.380	3.0905	0.2181	0.1669	0.16139	-0.2714	0.7877	1.3026	1.6670	0.4522	1.6968	2.0066	0.0000	20.9376	19.0100	0.1180	0.2434
0.360	3.1640	0.2032	0.1581	0.16948	-0.3588	0.7880	1.3024	1.6835	0.4533	1.6963	2.0312	0.0000	22.9852	21.0676	0.1300	0.2220
0.340	3.2375	0.1887	0.1493	0.17755	-0.4513	0.7883	1.3022	1.6996	0.4544	1.6957	2.0558	0.0000	25.1444	23.2320	0.1420	0.2006
0.320	3.3110	0.1742	0.1405	0.18562	-0.5495	0.7886	1.3020	1.7160	0.4554	1.6948	2.0804	0.0000	27.4156	25.5044	0.1540	0.1792
0.300	3.3845	0.1597	0.1317	0.19370	-0.6533	0.7889	1.3018	1.7324	0.4564	1.6939	2.1050	0.0000	29.7990	27.8880	0.1660	0.1578

Table A4.e

Print 12

ETA=C	MI	ZO	ZETA=C	RNECK	CHI=.080C	RCOUL	BSURF	BSURV	BRFD	BCOMP	Q	JPARA	JPERP	JEFF-1	ESR1	BSR2
SADDLF	PCINTS	ZZ			RBAF	CZ1										
C.900	1.2287	2.9C54	0.8864	0.0C069	0.0020	0.9898	1.0191	1.0211	1.0173	1.0386	1.2912	0.7986	1.1839	0.4076	0.9788	0.9985
C.880	1.2753	2.5094	0.8635	0.00118	0.0038	0.9852	1.0272	1.0306	1.0230	1.0551	1.5987	0.7636	1.2406	0.5036	0.9689	0.9968
C.860	1.3230	2.2192	0.8401	0.0C188	0.0067	0.9798	1.0367	1.0420	1.0281	1.0747	1.9322	0.7298	1.3064	0.6048	0.9566	0.9940
C.840	1.3720	1.9935	0.8167	0.0C281	0.0108	0.9734	1.0477	1.0554	1.0318	1.0976	2.2983	0.6970	1.3828	0.7116	0.9415	0.9897
C.820	1.4226	1.8125	0.7911	0.0C402	0.0166	0.9659	1.0602	1.0715	1.0330	1.1239	2.7010	0.6653	1.4714	0.8234	0.9234	0.9833
C.800	1.4753	1.6601	0.7651	0.0C555	0.0247	0.9573	1.0743	1.0900	1.0301	1.1541	3.1522	0.6346	1.5753	0.9410	0.9017	0.9740
C.780	1.5306	1.5271	0.7376	0.0C745	0.0354	0.9473	1.0902	1.1114	1.0214	1.1886	3.6628	0.6048	1.6978	1.0645	0.8758	0.9610
C.760	1.5892	1.4076	0.7081	0.00978	0.0498	0.9359	1.1082	1.1362	1.0045	1.2281	4.2492	0.5760	1.8440	1.1939	0.8451	0.9431
C.740	1.6520	1.2965	0.6763	0.01261	0.0693	0.9226	1.1284	1.1654	0.9761	1.2734	4.9347	0.5483	2.0209	1.3291	0.8099	0.9186
C.720	1.7201	1.1892	0.6402	0.01600	0.0946	0.9073	1.1514	1.1996	0.9324	1.3257	5.7539	0.5215	2.2390	1.4694	0.7665	0.8854
C.700	1.7952	1.0810	0.5992	0.02006	0.1294	0.8893	1.1776	1.2404	0.8681	1.3866	6.7594	0.4975	2.5146	1.6122	0.7175	0.8406
C.680	1.8782	0.9665	0.5506	0.02490	0.1772	0.8683	1.2074	1.2904	0.7785	1.4578	8.0254	0.4765	2.8714	1.7505	0.6626	0.7809
C.660	1.9685	0.8413	0.4924	0.03063	0.2412	0.8449	1.2399	1.3498	0.6665	1.5373	9.5966	0.4620	3.3258	1.8638	0.6075	0.7065
C.640	2.0454	0.7166	0.4312	0.03727	0.3097	0.8239	1.2684	1.4092	0.5631	1.6088	11.206	0.4588	3.8027	1.9166	0.5680	0.6345
C.620	2.0881	0.6185	0.3823	0.04460	0.3950	0.8109	1.2856	1.4521	0.5027	1.6527	12.327	0.4649	4.1634	1.9096	0.5526	0.5887
C.600	2.1048	0.5456	0.3475	0.05231	0.3730	0.8041	1.2943	1.4792	0.4739	1.6752	12.956	0.4740	4.3503	1.8795	0.5501	0.5651
C.580	2.1068	0.4575	0.3215	0.06023	0.3722	0.8005	1.2988	1.4973	0.4598	1.6870	13.301	0.4833	4.4524	1.8447	0.5525	0.5528
C.560	2.1064	0.4565	0.2932	0.06826	0.3596	0.7984	1.3013	1.5106	0.4525	1.6971	13.583	0.5006	4.5173	1.8104	0.5565	0.5463
C.520	2.0523	0.3936	0.2679	0.08447	0.3045	0.7965	1.3035	1.5294	0.4467	1.6990	13.620	0.5086	4.5731	1.7476	0.5658	0.5419
C.480	2.0755	0.3445	0.2417	0.10078	0.2234	0.7960	1.3040	1.5432	0.4458	1.7001	13.623	0.5161	4.5814	1.7195	0.5705	0.5420
C.460	2.0667	0.3240	0.2301	0.10894	0.1742	0.7961	1.3039	1.5499	0.4461	1.7003	13.552	0.5300	4.5742	1.6681	0.5795	0.5448
C.440	2.0574	0.3047	0.2192	0.11709	0.1197	0.7962	1.3038	1.5557	0.4466	1.6999	13.497	0.5365	4.5643	1.6448	0.5837	0.5471
C.420	2.0481	0.2868	0.2088	0.12524	0.0600	0.7964	1.3036	1.5613	0.4476	1.6995	13.434	0.5427	4.5516	1.6229	0.5878	0.5498
C.400	2.0385	0.2700	0.1989	0.12338	-0.0048	0.7966	1.3034	1.5667	0.4485	1.6989	13.365	0.5486	4.5369	1.6022	0.5918	0.5530
C.380	2.0285	0.2542	0.1892	0.14151	-0.0746	0.7969	1.3032	1.5719	0.4496	1.6983	13.291	0.5544	4.5206	1.5827	0.5957	0.5565
C.360	2.0219	0.2391	0.1799	0.14962	-0.1495	0.7972	1.3030	1.5772	0.4506	1.6977	13.215	0.5599	4.5034	1.5641	0.5996	0.5604
C.340	2.0122	0.2246	0.1707	0.15773	-0.2294	0.7975	1.3027	1.5824	0.4518	1.6971	13.137	0.5651	4.4855	1.5465	0.6033	0.5647
C.320	2.0038	0.2106	0.1616	0.16582	-0.3147	0.7979	1.3025	1.5876	0.4529	1.6965	13.059	0.5703	4.4671	1.5297	0.6071	0.5693
C.300	1.9955	0.1971	0.1527	0.17390	-0.4052	0.7982	1.3023	1.5929	0.4540	1.6959	12.979	0.5752	4.4484	1.5137	0.6108	0.5743

Table A4.e (cont.)

Print 13

ETA-C	ZC	ZETA=0	RNECK	CHI=1200	ECOL	BSURF	BCURV	BRED	BCOMP	Q	JPARA	JPERP	JEFF-1	ESR1	BSR2
XT	SADDLE POINTS	Z2		PPAP	CZ1										
0.900	1.225	2.9376	0.8880	0.0067	0.0019	0.9900	1.0186	1.0206	1.0376	1.2712	0.8010	1.1803	0.4012	0.9794	0.9985
0.880	1.275	2.5410	0.8656	0.0115	0.0036	0.9857	1.0254	1.0284	1.0535	1.5690	0.7668	1.2350	0.4944	0.9699	0.9970
0.860	1.317	2.2502	0.8430	0.0183	0.0062	0.9805	1.0355	1.0405	1.0722	1.8896	0.7338	1.2977	0.5921	0.9583	0.9944
0.840	1.364	2.0264	0.8198	0.0272	0.0107	0.9745	1.0458	1.0533	1.0936	2.2381	0.7021	1.3700	0.6944	0.9441	0.9903
0.820	1.417	1.8451	0.7960	0.0388	0.0153	0.9675	1.0576	1.0683	1.1186	2.6203	0.6713	1.4533	0.8015	0.9272	0.9847
0.800	1.465	1.6933	0.7712	0.0534	0.0225	0.9594	1.0709	1.0855	1.1468	3.0433	0.6416	1.5498	0.9133	0.9070	0.9765
0.780	1.513	1.5615	0.7453	0.0714	0.0319	0.9502	1.0857	1.1052	1.1788	3.5167	0.6129	1.6523	1.0302	0.8833	0.9650
0.760	1.572	1.4446	0.7177	0.0934	0.0444	0.9397	1.1022	1.1280	1.2149	4.0528	0.5850	1.7545	1.1520	0.8554	0.9494
0.740	1.623	1.3367	0.6892	0.1198	0.0607	0.9277	1.1207	1.1541	1.2560	4.6690	0.5583	1.9316	1.2787	0.8229	0.9285
0.720	1.696	1.2342	0.6558	0.1514	0.0819	0.9140	1.1414	1.1845	1.3027	5.3895	0.5328	2.1411	1.4097	0.7852	0.9006
0.700	1.791	1.1334	0.6197	0.1889	0.1099	0.8983	1.1646	1.2200	1.3562	6.2495	0.5089	2.3739	1.5437	0.7419	0.8637
0.680	1.832	1.0295	0.5781	0.2332	0.1470	0.8801	1.1907	1.2621	1.4172	7.2999	0.4874	2.6358	1.6767	0.6930	0.8154
0.660	1.913	0.9193	0.5292	0.2852	0.1965	0.8594	1.2199	1.3124	1.4881	8.6096	0.4696	3.0364	1.7991	0.6407	0.7535
0.640	2.052	0.8000	0.4724	0.3458	0.2585	0.8376	1.2500	1.3697	1.5624	10.136	0.4596	3.4844	1.8887	0.5922	0.6817
0.620	2.265	0.6868	0.4163	0.4146	0.3176	0.8196	1.2742	1.4228	1.6236	11.570	0.4599	3.9125	1.9190	0.5618	0.6191
0.580	2.452	0.5989	0.3723	0.04891	0.3531	0.8088	1.2884	1.4602	1.6599	12.526	0.4671	4.2251	1.9030	0.5512	0.5811
0.560	2.692	0.5347	0.3400	0.05669	0.3650	0.8029	1.2958	1.4846	1.6790	13.027	0.4764	4.3758	1.8705	0.5505	0.5611
0.540	2.984	0.4856	0.3153	0.06464	0.3802	0.7998	1.2997	1.5014	1.6892	13.365	0.4858	4.4741	1.8350	0.5535	0.5506
0.520	3.334	0.4461	0.2952	0.07269	0.3937	0.7979	1.3018	1.5135	1.6948	13.524	0.4947	4.5305	1.8005	0.5579	0.5451
0.500	3.752	0.4130	0.2781	0.08080	0.4080	0.7969	1.3036	1.5239	1.6978	13.600	0.5032	4.5617	1.7680	0.5626	0.5426
0.480	4.244	0.3844	0.2630	0.08893	0.4248	0.7964	1.3036	1.5323	1.6995	13.624	0.5112	4.5768	1.7376	0.5675	0.5418
0.460	4.812	0.3592	0.2495	0.09708	0.4430	0.7961	1.3039	1.5396	1.7002	13.613	0.5188	4.5810	1.7093	0.5722	0.5423
0.440	5.462	0.3364	0.2370	0.10524	0.4620	0.7960	1.3040	1.5463	1.7003	13.590	0.5260	4.5783	1.6828	0.5768	0.5437
0.420	6.192	0.3156	0.2254	0.11340	0.4810	0.7961	1.3039	1.5524	1.7001	13.570	0.5328	4.5704	1.6581	0.5813	0.5457
0.400	7.012	0.2965	0.2145	0.12155	0.0910	0.7963	1.3037	1.5583	1.6998	13.470	0.5393	4.5589	1.6348	0.5856	0.5482
0.380	7.922	0.2787	0.2040	0.12969	0.0290	0.7965	1.3035	1.5639	1.6992	13.402	0.5456	4.5488	1.6129	0.5898	0.5513
0.360	8.922	0.2615	0.1940	0.13783	-0.0303	0.7968	1.3033	1.5693	1.6980	13.328	0.5515	4.5488	1.5923	0.5938	0.5547
0.340	10.012	0.2461	0.1843	0.14595	-0.1107	0.7971	1.3031	1.5747	1.6961	13.251	0.5573	4.5488	1.5727	0.5978	0.5586
0.320	11.192	0.2310	0.1749	0.15405	-0.1864	0.7974	1.3028	1.5801	1.6944	13.172	0.5628	4.5488	1.5542	0.6017	0.5628
0.300	12.462	0.2164	0.1654	0.16216	-0.2714	0.7977	1.3026	1.5854	1.6928	13.091	0.5681	4.5488	1.5366	0.6055	0.5673
0.280	13.832	0.2024	0.1562	0.17024	-0.3598	0.7981	1.3024	1.5908	1.6912	13.010	0.5733	4.5488	1.5199	0.6093	0.5723

Table A4.e (cont.)

Print 14

ETA-C	CHI-1600	BRAF	CZ1	PCOUL	BSURF	BOUVR	BRED	BCOMP	Q	JPARA	JPERP	JEFF-1	BSR1	BSR2
SI	ZZ	RNECK	SADDLE POINTS											
C.900	1.2226	2.9491	0.0066	0.0018	C.9903	1.0182	1.020C	1.0165	1.0367	1.2523	0.8033	1.1770	0.3953	0.9800
C.980	1.2268	2.5712	0.00113	0.0034	0.9861	1.0256	1.0287	1.0219	1.0519	1.5410	0.7698	1.2297	0.4858	0.9709
C.960	1.3115	2.2814	0.0058	0.0058	0.9812	1.0343	1.0391	1.0270	1.0698	1.8500	0.7377	1.2898	0.5802	0.9598
C.940	1.3570	2.0570	0.0093	0.0093	0.9755	1.0442	1.0513	1.0309	1.0903	2.1836	0.7068	1.3584	0.6787	0.9464
C.920	1.4037	1.9761	0.0093	0.0093	0.9698	1.0553	1.0653	1.0329	1.1138	2.5468	0.6769	1.4369	0.7813	0.9303
C.900	1.4516	1.7245	0.0093	0.0093	0.9613	1.0678	1.0814	1.0320	1.1402	2.9455	0.6491	1.5271	0.8881	0.9118
C.780	1.5017	1.5947	0.00515	0.0206	0.9527	1.0817	1.0998	1.0269	1.1700	3.3873	0.6203	1.6311	0.9991	0.8899
C.760	1.5531	1.4791	0.00894	0.0399	0.9430	1.0970	1.1207	1.0159	1.2034	3.8821	0.5934	1.7519	1.1144	0.8644
C.740	1.6075	1.3737	0.0088	0.01144	0.9321	1.1140	1.1445	0.9974	1.2410	4.4428	0.5676	1.8933	1.2338	0.8348
C.720	1.6652	1.2748	0.0088	0.01439	0.9197	1.1328	1.1718	0.9687	1.2833	5.0872	0.5428	2.0609	1.3569	0.8009
C.700	1.7268	1.1791	0.0088	0.01788	0.9057	1.1537	1.2032	0.9272	1.3311	5.8401	0.5195	2.2623	1.4828	0.7622
C.680	1.7935	1.0839	0.0071	0.02197	0.8917	1.1770	1.2397	0.8697	1.3853	6.7363	0.4980	2.5082	1.6093	0.7186
C.660	1.8661	0.9838	0.02673	0.1636	0.8716	1.2028	1.2826	0.7932	1.4468	7.8222	0.4792	2.8135	1.7312	0.6778
C.640	1.9437	0.8765	0.03227	0.2135	0.8515	1.2309	1.3326	0.6986	1.5191	9.1368	0.4651	3.1916	1.8370	0.6220
C.620	2.0125	0.7641	0.03861	0.2717	0.8315	1.2583	1.3859	0.5998	1.5832	10.603	0.4586	3.6227	1.9045	0.5806
C.600	2.0727	0.6604	0.04307	0.3474	0.8160	1.2790	1.4364	0.5254	1.6651	12.696	0.4494	4.0071	1.9181	0.5573
C.580	2.1385	0.5866	0.05325	0.4391	0.8009	1.2908	1.4874	0.4854	1.7524	14.882	0.4413	4.3582	1.8954	0.5376
C.560	2.2080	0.5215	0.06108	0.5357	0.8019	1.2970	1.5390	0.4472	1.8498	17.661	0.4342	4.6789	1.8611	0.5311
C.540	2.2822	0.4737	0.06906	0.6474	0.7991	1.3004	1.5933	0.4551	1.9511	21.421	0.4284	4.9733	1.8251	0.5247
C.520	2.3602	0.4355	0.07713	0.7779	0.7976	1.3023	1.6472	0.4498	2.0699	25.554	0.4222	5.2582	1.7904	0.5293
C.500	2.4420	0.4032	0.08525	0.9298	0.7967	1.3038	1.7033	0.4460	2.1998	30.613	0.4163	5.5681	1.7578	0.5441
C.480	2.5274	0.3751	0.09339	0.10970	0.7962	1.3040	1.7603	0.4437	2.3467	37.623	0.4099	5.8581	1.7274	0.5427
C.460	2.6140	0.3502	0.10154	0.12223	0.7961	1.3040	1.8172	0.4437	2.5033	45.613	0.4033	6.1581	1.6990	0.5427
C.440	2.7018	0.3277	0.10970	0.13544	0.7961	1.3040	1.8740	0.4437	2.6703	54.613	0.3966	6.4637	1.6726	0.5444
C.420	2.7902	0.3072	0.11786	0.14963	0.7962	1.3038	1.9350	0.4467	2.8477	64.613	0.3905	6.7657	1.6478	0.5467
C.400	2.8792	0.2891	0.12601	0.16437	0.7964	1.3037	1.9999	0.4475	3.0333	75.613	0.3839	7.0657	1.6246	0.5496
C.380	2.9691	0.2724	0.13415	0.17932	0.7966	1.3034	2.0699	0.4485	3.2283	87.613	0.3776	7.3657	1.6027	0.5529
C.360	3.0599	0.2573	0.14228	0.19484	0.7969	1.3032	2.1472	0.4496	3.4333	100.613	0.3716	7.6657	1.5811	0.5567
C.340	3.1512	0.2426	0.15039	0.21084	0.7973	1.3029	2.2283	0.4507	3.6477	114.613	0.3655	7.9657	1.5626	0.5608
C.320	3.2437	0.2284	0.15850	0.22729	0.7976	1.3027	2.3140	0.4519	3.8703	129.613	0.3595	8.2657	1.5441	0.5653
C.300	3.3372	0.2146	0.16658	0.24484	0.7979	1.3025	2.4040	0.4531	4.1033	145.613	0.3533	8.5657	1.5265	0.5703

Table A4.e (cont.)

Table A5. Numerical results of saddle point and minimum shapes with the parameterization of dumbbells and with the Nix-parameterization

Notations:

S0: σ_0 , S2: σ_2 , U: u , for the other notations see capture of Table A4.

a: Heavy and superheavy nuclei with $\eta = 0.16$, $\zeta = \chi = 0$ (dumbbells).

b: Liquid drop model for light nuclei with $\xi \leq 0.4$ (dumbbells).

c: Droplet model for heavy nuclei $\xi \geq 0.7$ (Nix-parameterization).

Print 15

ETA=.1600	ZETA=.0	CHI=.0										
XI	S0	S2	U	Z0	RAECK	BEAR	BCOUL	BSURF	BCURV	BRED	BCOMP	
SADDLE POINTS (DUMBBELLS)												
1.000	0.0000	0.0000	1.0000	1.0000	1.0000	0.00000	1.0000	1.0000	1.0000	1.0000	1.0000	
0.980	0.0030	0.0007	0.9602	1.0432	0.9602	0.00039	0.9994	1.0016	1.0017	1.0015	1.0033	
0.960	0.0118	0.0014	0.9253	1.0871	0.9253	0.00111	0.9975	1.0055	1.0062	1.0056	1.0118	
0.940	0.0237	0.0021	0.8942	1.1318	0.8942	0.00189	0.9945	1.0121	1.0130	1.0102	1.0243	
0.920	0.0312	0.0029	0.8654	1.1786	0.8654	0.00264	0.9904	1.0200	1.0220	1.0149	1.0404	
0.900	0.0384	0.0035	0.8402	1.2244	0.8402	0.00335	0.9856	1.0288	1.0323	1.0189	1.0583	
0.880	0.0469	0.0043	0.8121	1.2815	0.8121	0.00417	0.9787	1.0407	1.0468	1.0209	1.0831	
0.860	0.0532	0.0051	0.7866	1.3398	0.7865	0.00514	0.9708	1.0538	1.0632	1.0214	1.1105	
0.840	0.0616	0.0056	0.7616	1.4032	0.7616	0.00646	0.9616	1.0687	1.0824	1.0177	1.1421	
0.830	0.7128	0.0059	0.7429	1.4557	0.7429	0.00731	0.9537	1.0814	1.0993	1.0136	1.1694	
0.820	0.8054	0.0062	0.7202	1.5255	0.7201	0.00842	0.9426	1.0986	1.1229	1.0042	1.2070	
0.815	0.8730	0.0066	0.7046	1.5776	0.7046	0.00917	0.9342	1.1116	1.1411	0.9954	1.2357	
MINIMA (DUMBBELLS)												
0.815	1.0595	0.0068	0.6661	1.7246	0.6661	0.00974	0.9101	1.1488	1.1954	0.9628	1.3196	
0.820	1.1733	0.0070	0.6449	1.8182	0.6448	0.00934	0.8948	1.1725	1.2315	0.9377	1.3747	
0.830	1.2612	0.0073	0.6298	1.8910	0.6297	0.00762	0.8829	1.1908	1.2604	0.9177	1.4181	
0.840	1.3142	0.0075	0.6211	1.9253	0.6211	0.00548	0.8758	1.2020	1.2782	0.9059	1.4448	
0.850	1.3744	0.0078	0.6117	1.9861	0.6116	0.00320	0.8677	1.2147	1.2889	0.8897	1.4755	
0.860	1.4222	0.0080	0.6044	2.0266	0.6044	0.00068	0.8612	1.2248	1.3155	0.8789	1.5002	
0.870	1.4619	0.0083	0.5986	2.0604	0.5985	-0.00202	0.8559	1.2333	1.3295	0.8682	1.5209	
0.880	1.5012	0.0087	0.5929	2.0941	0.5929	-0.00487	0.8507	1.2416	1.3435	0.8570	1.5416	
0.890	1.5216	0.0125	0.5901	2.1117	0.5900	-0.00787	0.8480	1.2460	1.3509	0.8511	1.5525	
0.895	1.5365	0.0150	0.5881	2.1246	0.5879	-0.00941	0.8460	1.2492	1.3563	0.8498	1.5604	
SADDLE POINTS (DUMBBELLS)												
0.895	1.5031	0.0437	0.5938	2.0569	0.5922	-0.00929	0.8501	1.2427	1.3454	0.8596	1.5443	
0.890	1.5090	0.0752	0.5951	2.1041	0.5903	-0.00761	0.8485	1.2453	1.3498	0.8502	1.5508	
0.885	1.5151	0.1006	0.5968	2.1119	0.5883	-0.00601	0.8467	1.2483	1.3548	0.8586	1.5582	
0.880	1.5211	0.1812	0.6082	2.1293	0.5806	-0.00359	0.8410	1.2580	1.3715	0.8220	1.5826	
MINIMA (DUMBBELLS)												
0.880	1.5280	0.3255	0.6418	2.1697	0.5531	-0.00219	0.8240	1.2859	1.4214	0.7057	1.6535	
0.890	1.5640	0.3811	0.6545	2.2185	0.5321	-0.00551	0.8104	1.3073	1.4617	0.6143	1.7089	
0.900	1.6024	0.4277	0.6660	2.2683	0.5105	-0.00911	0.7972	1.3280	1.5030	0.5970	1.7636	
0.920	1.6516	0.4401	0.6661	2.3177	0.5000	-0.01697	0.7882	1.3425	1.5315	0.5344	1.8023	
0.940	1.6985	0.4622	0.6702	2.3691	0.4853	-0.02567	0.7777	1.3591	1.5661	0.4899	1.8473	
0.960	1.7571	0.4824	0.6735	2.4206	0.4700	-0.03485	0.7662	1.3776	1.6056	0.4304	1.8979	
0.980	1.8126	0.4964	0.6752	2.4878	0.4578	-0.04459	0.7562	1.3937	1.6407	0.3804	1.9424	
1.000	1.8713	0.5091	0.6768	2.5480	0.4459	-0.05517	0.7461	1.4099	1.6771	0.3474	1.9879	
1.020	1.9226	0.5206	0.6786	2.6011	0.4353	-0.06647	0.7371	1.4240	1.7098	0.3371	2.0278	
1.040	1.9860	0.5312	0.6798	2.6658	0.4242	-0.07637	0.7279	1.4403	1.7482	0.3365	2.0744	
1.060	2.0352	0.5357	0.6811	2.7163	0.4154	-0.08702	0.7208	1.4527	1.7785	0.2928	2.1104	
1.080	2.0848	0.5514	0.6843	2.7689	0.4047	-0.09821	0.7132	1.4657	1.8124	0.2682	2.1483	
1.100	2.1409	0.5595	0.6853	2.8262	0.3957	-0.11020	0.7055	1.4790	1.8465	0.2622	2.1873	
SADDLE POINTS (DUMBBELLS)												
1.100	1.7513	0.7223	0.7658	2.5571	0.2545	-0.09882	0.7349	1.4117	1.8658	0.4556	1.9929	
1.080	1.7630	0.7227	0.7665	2.5295	0.2552	-0.08772	0.7380	1.4069	1.8522	0.4134	1.9793	
1.060	1.7365	0.7232	0.7671	2.5039	0.2558	-0.07750	0.7406	1.4024	1.8397	0.4062	1.9668	
1.040	1.7019	0.7235	0.7680	2.4698	0.2563	-0.06897	0.7435	1.3964	1.8232	0.4455	1.9498	
1.020	1.6719	0.7245	0.7687	2.4406	0.2569	-0.05714	0.7475	1.3912	1.8089	0.4370	1.9354	
1.000	1.6405	0.7247	0.7693	2.4099	0.2583	-0.04648	0.7512	1.3855	1.7933	0.3996	1.9206	
0.980	1.6056	0.7250	0.7700	2.3796	0.2593	-0.03742	0.7543	1.3805	1.7782	0.4100	1.9059	
0.960	1.5757	0.7260	0.7710	2.3467	0.2594	-0.02799	0.7580	1.3746	1.7626	0.4581	1.8894	
0.940	1.5412	0.7265	0.7718	2.3130	0.2605	-0.01729	0.7627	1.3686	1.7458	0.4009	1.8729	
0.920	1.5165	0.7269	0.7724	2.2888	0.2612	-0.00811	0.7655	1.3642	1.7340	0.4006	1.8611	
0.900	1.4884	0.7270	0.7730	2.2614	0.2625	-0.00000	0.7683	1.3592	1.7200	0.4402	1.8478	
0.880	1.4567	0.7275	0.7737	2.2304	0.2635	0.01022	0.7729	1.3537	1.7046	0.4201	1.8326	
0.860	1.4224	0.7278	0.7745	2.1969	0.2651	0.01947	0.7775	1.3477	1.6877	0.4028	1.8163	
0.840	1.3927	0.7283	0.7753	2.1680	0.2659	0.02704	0.7807	1.3424	1.6735	0.4463	1.8020	
0.820	1.3603	0.7295	0.7763	2.1366	0.2656	0.03468	0.7857	1.3365	1.6590	0.4222	1.7863	
0.800	1.3311	0.7302	0.7772	2.1082	0.2660	0.04229	0.7898	1.3313	1.6454	0.4154	1.7723	

Table A5.a

Print 16

ETA=C	SO	ZETA=0	CHI=0	RAECK	BEAR	BCOUL	BSURF	BCURV	BRED	BCOMP
SI	POINTS (DUMBELLS)	U	ZO							
0.0	0.7537	0.7937	0.7937	1.5874	0.0000	0.25992	0.8924	1.2595	1.5874	0.7224
0.10	0.7934	0.7934	0.7937	1.5871	0.0210	0.25755	0.8928	1.2597	1.5709	0.7068
0.20	0.877	0.7936	0.7937	1.6014	0.0141	0.25553	0.8879	1.2600	1.5834	0.6969
0.30	0.8121	0.7934	0.7937	1.6058	0.0213	0.25326	0.8863	1.2601	1.5800	0.7004
0.40	0.8182	0.7932	0.7937	1.6125	0.0275	0.25093	0.8839	1.2602	1.5785	0.7115
0.50	0.8245	0.7930	0.7937	1.6185	0.0341	0.24861	0.8823	1.2604	1.5765	0.6897
0.60	0.8307	0.7927	0.7937	1.6243	0.0398	0.24626	0.8808	1.2606	1.5751	0.6661
0.70	0.8375	0.7924	0.7937	1.6312	0.0450	0.24387	0.8790	1.2608	1.5745	0.6454
0.80	0.8427	0.7920	0.7936	1.6363	0.0511	0.24144	0.8775	1.2610	1.5725	0.6338
0.90	0.8484	0.7914	0.7936	1.6321	0.0601	0.23890	0.8788	1.2607	1.5714	0.6425
1.00	0.8533	0.7907	0.7936	1.6329	0.0677	0.23635	0.8786	1.2606	1.5623	0.6402
1.10	0.8582	0.7907	0.7936	1.6398	0.0678	0.23386	0.8724	1.2615	1.5687	0.6287
1.20	0.8632	0.7901	0.7935	1.6593	0.0736	0.23120	0.8706	1.2623	1.5671	0.6379
1.30	0.8682	0.7895	0.7935	1.6417	0.0799	0.22853	0.8698	1.2624	1.5636	0.6453
1.40	0.8771	0.7889	0.7935	1.6705	0.0853	0.22595	0.8676	1.2630	1.5640	0.6279
1.50	0.8850	0.7882	0.7934	1.6784	0.0905	0.22337	0.8659	1.2636	1.5641	0.6003
1.60	0.8925	0.7876	0.7933	1.6859	0.0955	0.22072	0.8641	1.2642	1.5641	0.5831
1.70	0.8965	0.7865	0.7933	1.6502	0.1005	0.21800	0.8631	1.2645	1.5626	0.5773
1.80	0.9020	0.7862	0.7932	1.6952	0.1055	0.21523	0.8618	1.2650	1.5614	0.5749
1.90	0.9115	0.7854	0.7931	1.7003	0.1104	0.21241	0.8605	1.2654	1.5605	0.5763
2.00	0.9144	0.7845	0.7930	1.7050	0.1158	0.20954	0.8592	1.2658	1.5588	0.5823
2.10	0.9144	0.7835	0.7929	1.7093	0.1221	0.20660	0.8580	1.2662	1.5564	0.5925
2.20	0.9226	0.7824	0.7928	1.7135	0.1284	0.20362	0.8568	1.2666	1.5539	0.6062
2.30	0.9256	0.7813	0.7927	1.7177	0.1342	0.20080	0.8561	1.2670	1.5519	0.5992
2.40	0.9291	0.7804	0.7926	1.7217	0.1384	0.19798	0.8554	1.2674	1.5508	0.5827
2.50	0.9356	0.7794	0.7925	1.7280	0.1432	0.19516	0.8542	1.2681	1.5506	0.5621
2.60	0.9417	0.7785	0.7923	1.7340	0.1475	0.19228	0.8530	1.2687	1.5504	0.5490
2.70	0.9442	0.7771	0.7922	1.7364	0.1541	0.18931	0.8526	1.2689	1.5469	0.5454
2.80	0.9515	0.7765	0.7921	1.7439	0.1564	0.18633	0.8509	1.2698	1.5490	0.5407
2.90	0.9566	0.7754	0.7919	1.7485	0.1611	0.18326	0.8499	1.2703	1.5479	0.5432
3.00	0.9632	0.7740	0.7917	1.7549	0.1666	0.18009	0.8483	1.2711	1.5472	0.5530
3.10	0.9657	0.7721	0.7914	1.7612	0.1740	0.17678	0.8467	1.2718	1.5450	0.5718
3.20	0.9757	0.7706	0.7912	1.7669	0.1795	0.17374	0.8457	1.2725	1.5439	0.5706
3.30	0.9771	0.7688	0.7910	1.7680	0.1859	0.17069	0.8457	1.2725	1.5400	0.5617
3.40	0.9827	0.7683	0.7909	1.7736	0.1874	0.16774	0.8448	1.2733	1.5416	0.5437
3.50	0.9856	0.7665	0.7906	1.7763	0.1924	0.16469	0.8445	1.2735	1.5394	0.5346
3.60	0.9884	0.7651	0.7904	1.7788	0.1984	0.16159	0.8442	1.2738	1.5365	0.5276
3.70	0.9964	0.7641	0.7902	1.7865	0.2014	0.15845	0.8427	1.2749	1.5381	0.5182
3.80	1.0047	0.7625	0.7898	1.7945	0.2060	0.15521	0.8411	1.2760	1.5388	0.5180
3.90	1.0140	0.7603	0.7894	1.8034	0.2122	0.15176	0.8392	1.2772	1.5388	0.5316
4.00	1.0240	0.7584	0.7890	1.8129	0.2175	0.14821	0.8370	1.2786	1.5397	0.5627

Table A5.b

Print 16a

FTA=.1600		ZETA#.0		CHI#.0							
XI	S1	S2	S3	U	Z0	RNECK	BBAR	RCOUL	RSURF	RCURV	
SADDLE POINTS (NIX-PARAMETRIZATION)											
1.000	0.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.00000	1.0000	1.0000	1.0000	
0.990	0.0184	0.9134	0.9283	0.9828	1.0306	0.9848	0.00000	0.9996	1.0007	1.0007	
0.980	0.0369	0.8267	0.8566	0.9657	1.0612	0.9696	0.00000	0.9993	1.0015	1.0015	
0.970	0.0840	0.7447	0.8063	0.9459	1.0931	0.9539	0.00002	0.9983	1.0033	1.0034	
0.960	0.1473	0.6675	0.7679	0.9257	1.1246	0.9385	0.00007	0.9970	1.0058	1.0062	
0.950	0.2249	0.5959	0.7382	0.9057	1.1560	0.9232	0.00015	0.9953	1.0090	1.0096	
0.940	0.3153	0.5285	0.7150	0.8859	1.1873	0.9079	0.00026	0.9933	1.0127	1.0138	
0.930	0.4167	0.4651	0.6970	0.8668	1.2188	0.8927	0.00042	0.9909	1.0171	1.0188	
0.920	0.5280	0.4052	0.6828	0.8483	1.2506	0.8773	0.00063	0.9881	1.0221	1.0246	
0.910	0.6479	0.3485	0.6718	0.8308	1.2827	0.8618	0.00090	0.9850	1.0277	1.0312	
0.900	0.7757	0.2949	0.6633	0.8142	1.3154	0.8460	0.00124	0.9814	1.0339	1.0386	
0.890	0.9106	0.2439	0.6568	0.7985	1.3488	0.8300	0.00165	0.9775	1.0407	1.0470	
0.880	1.0522	0.1955	0.6520	0.7838	1.3830	0.8135	0.00214	0.9730	1.0483	1.0564	
0.870	1.2004	0.1494	0.6485	0.7700	1.4183	0.7965	0.00273	0.9681	1.0566	1.0669	
0.860	1.3553	0.1055	0.6462	0.7572	1.4550	0.7788	0.00342	0.9626	1.0657	1.0787	
0.850	1.5173	0.0635	0.6450	0.7453	1.4935	0.7602	0.00423	0.9564	1.0758	1.0919	
0.840	1.6875	0.0232	0.6446	0.7343	1.5341	0.7406	0.00518	0.9494	1.0869	1.1069	
0.830	1.8675	-.0154	0.6451	0.7241	1.5778	0.7194	0.00627	0.9415	1.0994	1.1240	
0.820	2.0604	-.0528	0.6464	0.7148	1.6255	0.6961	0.00753	0.9323	1.1136	1.1440	
0.810	2.2722	-.0894	0.6487	0.7064	1.6795	0.6696	0.00899	0.9214	1.1302	1.1681	
0.800	2.5163	-.1261	0.6522	0.6987	1.7442	0.6376	0.01069	0.9077	1.1507	1.1989	
0.790	2.8398	-.1659	0.6582	0.6917	1.8348	0.5922	0.01273	0.8874	1.1802	1.2453	
0.788	2.9323	-.1755	0.6601	0.6904	1.8620	0.5784	0.01319	0.8812	1.1891	1.2599	
0.786	3.0602	-.1875	0.6629	0.6890	1.9004	0.5588	0.01369	0.8724	1.2016	1.2810	
0.785	3.2772	-.2043	0.6680	0.6878	1.9685	0.5238	0.01395	0.8566	1.2237	1.3198	
MINIMA (NIX-PARAMETRIZATION)											
0.786	3.3986	-.2117	0.6710	0.6877	2.0082	0.5031	0.01366	0.8475	1.2363	1.3432	
0.788	3.5072	-.2173	0.6736	0.6880	2.0447	0.4840	0.01303	0.8391	1.2478	1.3650	
0.790	3.5804	-.2204	0.6754	0.6883	2.0699	0.4706	0.01238	0.8335	1.2555	1.3804	
0.800	3.8078	-.2271	0.6807	0.6903	2.1511	0.4270	0.00886	0.8157	1.2795	1.4308	
0.810	3.9563	-.2295	0.6838	0.6923	2.2067	0.3963	0.00506	0.8042	1.2949	1.4664	
0.820	4.0734	-.2306	0.6859	0.6943	2.2524	0.3701	0.00106	0.7951	1.3067	1.4963	
0.830	4.1727	-.2316	0.6875	0.6964	2.2929	0.3454	-.00311	0.7875	1.3165	1.5236	
0.840	4.2610	-.2339	0.6890	0.6992	2.3319	0.3184	-.00743	0.7804	1.3253	1.5514	
0.845	4.3040	-.2373	0.6901	0.7015	2.3540	0.2995	-.00964	0.7765	1.3298	1.5689	
0.847	4.3264	-.2431	0.6916	0.7032	2.3658	0.2868	-.01054	0.7744	1.3320	1.5796	
0.848	4.3347	-.2453	0.6918	0.7073	2.3849	0.2581	-.01100	0.7710	1.3349	1.6006	
SADDLE POINTS (NIX-PARAMETRIZATION)											
0.846	4.3252	-.2469	0.6926	0.7056	2.3738	0.2721	-.01008	0.7728	1.3333	1.5898	
0.844	4.3194	-.2517	0.6939	0.7072	2.3764	0.2631	-.00917	0.7721	1.3336	1.5952	
0.842	4.3123	-.2553	0.6949	0.7083	2.3770	0.2574	-.00826	0.7719	1.3335	1.5982	
0.840	4.3047	-.2584	0.6958	0.7092	2.3768	0.2529	-.00735	0.7718	1.3334	1.6004	
0.820	4.2285	-.2823	0.7034	0.7153	2.3652	0.2256	0.00177	0.7724	1.3304	1.6099	
0.800	4.1578	-.3024	0.7107	0.7197	2.3497	0.2076	0.01084	0.7737	1.3270	1.6137	
0.780	4.0929	-.3210	0.7181	0.7234	2.3339	0.1926	0.01986	0.7752	1.3237	1.6160	
0.760	4.0330	-.3388	0.7256	0.7267	2.3184	0.1791	0.02882	0.7767	1.3207	1.6179	
0.740	3.9776	-.3560	0.7333	0.7297	2.3034	0.1664	0.03771	0.7782	1.3177	1.6196	
0.720	3.9263	-.3727	0.7410	0.7325	2.2890	0.1542	0.04656	0.7795	1.3150	1.6215	
0.700	3.8786	-.3889	0.7489	0.7352	2.2753	0.1420	0.05535	0.7809	1.3123	1.6236	

Table A5.c

Table A6. Numerical and analytical results of saddle point shapes with the parameterization of generalized spheroids and expansions into α_2 and α_4 , respectively (heavy nuclei, $\xi > 0.9$)

Notations:

BBAR(N) B_{Bar} calculated numerically with generalized spheroids

BBAR(E) B_{Bar} calculated with the exact Eqs. (5.4) and (5.6)

BBAR(L) B_{Bar} calculated with the linear expansions Eqs. (5.7) and (5.8)

a: Liquid drop model with the reference set of η, ζ, χ

b: Droplet model with various curvature strengths

c: Droplet model with various Coulomb redistribution strengths. Note that the barriers BBAR(L) are decreasing with increasing ζ , while the barriers BBAR(E) and BBAR(N) are always increasing with increasing ζ .

d: Droplet model with various compressibility strengths

Print 17

ETA=.0	ZETA=.0	BBAR(N)	BBAR(E)	BBAR(L)	BCCUL	BSURF	BCURV	BRED	BCCMP	BSR1	BSR2
XI	Z2										
0.910	1.2111	3.0991	.0005212	.000476C	.0005075	0.99126	1.01642	1.01801	1.01513	1.03311	0.98204
0.920	1.1871	3.4215	.0003655	.0003401	.0003581	0.99312	1.01302	1.01414	1.01226	1.02621	0.98598
0.930	1.1624	3.8315	.0002445	.0002315	.0002411	0.99475	1.01002	1.01077	1.00957	1.02013	0.98937
0.940	1.1398	4.3774	.0001538	.0001480	.0001525	0.99614	1.00740	1.00788	1.00713	1.01486	0.99226
0.950	1.1164	5.1390	.0000889	.0000868	.0000887	0.99732	1.00517	1.00546	1.00498	1.01038	0.99467
0.960	1.0931	5.2755	.0000453	.0000450	.0000456	0.99828	1.00334	1.00348	1.00316	1.00669	0.99661
0.970	1.0698	8.1801	.0000188	.0000192	.0000193	0.99903	1.00190	1.00196	1.00172	1.00379	0.99812
0.980	1.0466	12.021	.0000052	.0000057	.0000057	0.99957	1.00085	1.00087	1.00067	1.00170	0.99919
0.990	1.0233	23.478	.0000001	.0000007	.0000007	0.99989	1.00022	1.00022	1.00004	1.00043	0.99983
ETA=.0917	ZETA=.0113		CHI=.0229								
XI	Z2	BBAR(N)	BBAR(E)	BBAR(L)	BCCUL	BSURF	BCURV	BRED	BCCMP	BSR1	BSR2
0.910	1.2548	2.7190	.0007401	.0006437	.0006613	0.98743	1.02333	1.02603	1.02049	1.04721	0.97378
0.920	1.2244	3.0006	.0005170	.0004614	.0004662	0.99020	1.01835	1.02024	1.01674	1.03705	0.97978
0.930	1.1951	3.3607	.0003451	.0003150	.0003134	0.99257	1.01404	1.01530	1.01317	1.02828	0.98482
0.940	1.1663	3.8342	.0002172	.0002018	.0001981	0.99458	1.01032	1.01111	1.00987	1.02075	0.98904
0.950	1.1379	4.4912	.0001261	.0001186	.0001150	0.99626	1.00719	1.00765	1.00693	1.01443	0.99250
0.960	1.1100	5.4696	.0000654	.0000616	.0000591	0.99761	1.00462	1.00486	1.00444	1.00927	0.99526
0.970	1.0824	7.0879	.0000285	.0000263	.0000250	0.99866	1.00262	1.00273	1.00245	1.00526	0.99736
0.980	1.0546	10.393	.0000096	.0000079	.0000074	0.99940	1.00118	1.00121	1.00100	1.00236	0.99885
0.990	1.0279	19.888	.0000025	.0000010	.0000009	0.99984	1.00031	1.00031	1.00013	1.00062	0.99974

Table A6.a

ETA=.0400			ZETA=.0			CHI=.0			BBAR(N)			BBAR(E)			BBAR(L)			BCCUL			BSURF			BCURV			BRED			ECCMP			BSR1			BSR2		
XI	Z0	Z2	ZETA=.0	CHI=.0	BBAR(N)	BBAR(E)	BBAR(L)	BCCUL	BSURF	BCURV	BRED	ECCMP	BSR1	BSR2																								
0.910	1.2245	2.9339			.0005908	.0005326	.0005781	0.99012	1.01849	1.02039	1.01678	1.03733	0.57958	0.99856																								
0.920	1.1990	3.2352			.0004146	.0003817	.0004077	0.99222	1.01468	1.01602	1.01367	1.02958	0.98406	0.99912																								
0.930	1.1738	3.6173			.0002777	.0002607	.0002743	0.99405	1.01131	1.01222	1.01073	1.02275	0.98752	0.99950																								
0.940	1.1488	4.1248			.0001749	.0001671	.0001734	0.99563	1.00837	1.00895	1.00804	1.01681	0.99120	0.99976																								
0.950	1.1240	4.8315			.0001012	.0000983	.0001008	0.99696	1.00586	1.00620	1.00564	1.01176	0.99393	0.99991																								
0.960	1.0992	5.8873			.0000517	.0000511	.0000518	0.99805	1.00379	1.00396	1.00361	1.00759	0.99614	0.99999																								
0.970	1.0745	7.6465			.0000216	.0000218	.0000219	0.99890	1.00216	1.00223	1.00198	1.00432	0.99785	1.00000																								
0.980	1.0498	11.149			.0000060	.0000065	.0000065	0.99951	1.00097	1.00099	1.00079	1.00194	0.99907	1.00000																								
0.990	1.0250	21.661			.0000003	.0000008	.0000008	0.99988	1.00025	1.00025	1.00007	1.00049	0.99980	1.00000																								
ETA=.0800																																						
XI	Z0	Z2	ZETA=.0	CHI=.0	BBAR(N)	BBAR(E)	BBAR(L)	BCCUL	BSURF	BCURV	BRED	ECCMP	BSR1	BSR2																								
0.910	1.2395	2.7729			.0006743	.0005988	.0006486	0.98875	1.02096	1.02325	1.01864	1.04236	0.97661	0.99811																								
0.920	1.2123	3.0537			.0004737	.0004307	.0004573	0.99114	1.01665	1.01827	1.01529	1.03358	0.98176	0.99884																								
0.930	1.1856	3.4078			.0003176	.0002952	.0003075	0.99321	1.01285	1.01395	1.01209	1.02587	0.98616	0.99934																								
0.940	1.1590	3.8781			.0002003	.0001899	.0001943	0.99501	1.00953	1.01023	1.00911	1.01915	0.98991	0.99966																								
0.950	1.1325	4.5320			.0001161	.0001121	.0001125	0.99652	1.00659	1.00710	1.00644	1.01342	0.99304	0.99986																								
0.960	1.1062	5.5081			.0000595	.0000585	.0000580	0.99777	1.00433	1.00455	1.00415	1.00868	0.99556	0.99997																								
0.970	1.0798	7.1297			.0000249	.0000251	.0000246	0.99873	1.00247	1.00256	1.00230	1.00495	0.99752	1.00000																								
0.980	1.0533	10.468			.0000070	.0000075	.0000073	0.99944	1.00111	1.00114	1.00093	1.00222	0.99892	1.00000																								
0.990	1.0268	23.068			.0000004	.0000010	.0000009	0.99986	1.00028	1.00029	1.00011	1.00057	0.99976	1.00000																								
ETA=.1200																																						
XI	Z0	Z2	ZETA=.0	CHI=.0	BBAR(N)	BBAR(E)	BBAR(L)	BCCUL	BSURF	BCURV	BRED	ECCMP	BSR1	BSR2																								
0.910	1.2565	2.6151			.0007757	.0006764	.0007192	0.98710	1.02392	1.02672	1.02072	1.04841	0.97298	0.99750																								
0.920	1.2275	2.8743			.0005455	.0004885	.0005068	0.98982	1.01904	1.02102	1.01717	1.03844	0.97892	0.99845																								
0.930	1.1989	3.2034			.0003663	.0003362	.0003407	0.99220	1.01471	1.01605	1.01367	1.02963	0.98402	0.99910																								
0.940	1.1705	3.6374			.0002314	.0002173	.0002152	0.99426	1.01093	1.01179	1.01038	1.02197	0.98834	0.99953																								
0.950	1.1423	4.2398			.0001344	.0001288	.0001250	0.99599	1.00769	1.00819	1.00739	1.01543	0.99194	0.99980																								
0.960	1.1141	5.1375			.0000690	.0000675	.0000642	0.99742	1.00500	1.00526	1.00480	1.01002	0.99486	0.99995																								
0.970	1.0859	6.6288			.0000290	.0000291	.0000272	0.99853	1.00286	1.00297	1.00269	1.00573	0.99711	1.00000																								
0.980	1.0576	9.6143			.0000083	.0000088	.0000081	0.99934	1.00130	1.00133	1.00112	1.00260	0.99873	1.00000																								
0.990	1.0290	18.546			.0000005	.0000011	.0000010	0.99983	1.00033	1.00034	1.00016	1.00066	0.99972	1.00000																								
ETA=.1600																																						
XI	Z0	Z2	ZETA=.0	CHI=.0	BBAR(N)	BBAR(E)	BBAR(L)	BCCUL	BSURF	BCURV	BRED	ECCMP	BSR1	BSR2																								
0.910	1.2759	2.4609			.0009001	.0007679	.0007898	0.98508	1.02751	1.03096	1.02303	1.05577	0.96848	0.99664																								
0.920	1.2448	2.7007			.0006337	.0005573	.0005564	0.98822	1.02192	1.02437	1.01930	1.04432	0.97542	0.99790																								
0.930	1.2141	3.0039			.0004262	.0003854	.0003739	0.99096	1.01697	1.01863	1.01552	1.03422	0.98137	0.99878																								
0.940	1.1836	3.4027			.0002698	.0002503	.0002361	0.99333	1.01263	1.01370	1.01188	1.02542	0.98641	0.99935																								
0.950	1.1534	3.9550			.0001571	.0001492	.0001371	0.99534	1.00891	1.00955	1.00853	1.01791	0.99059	0.99971																								
0.960	1.1232	4.7760			.0000809	.0000786	.0000704	0.99699	1.00581	1.00615	1.00559	1.01166	0.99358	0.99991																								
0.970	1.0929	6.1361			.0000342	.0000341	.0000258	0.99828	1.00334	1.00349	1.00316	1.00669	0.99661	1.00000																								
0.980	1.0624	8.8434			.0000099	.0000103	.0000088	0.99922	1.00152	1.00157	1.00135	1.00305	0.99850	1.00000																								
0.990	1.0315	16.944			.0000008	.0000013	.0000011	0.99980	1.00039	1.00040	1.00021	1.00079	0.99965	1.00000																								

Print 18

Table A6.b

Print 19

ETA=.C		ZETA=.08C		CHI=.C		BCCUL		BSURF		BCURV		BRED		BCCMP		BSR1		BSR2	
XI	ZO	ZI	BBAR(N)	BBAR(E)	BBAR(L)	BCCUL	BSURF	BCURV	BRED	BCCMP	BSR1	BSR2							
0.910	1.2170	3.0969	.0005406	.0004890	.0005019	0.95084	1.01719	1.01890	1.01582	1.03468	0.98116	0.99881							
0.920	1.1916	3.4272	.0003778	.0003482	.0003542	0.95284	1.01355	1.01474	1.01275	1.02728	0.98535	0.99929							
0.930	1.1667	3.8462	.0002522	.0002362	.0002384	0.95456	1.01036	1.01116	1.00990	1.02083	0.98900	0.99961							
0.940	1.1421	4.4028	.0001586	.0001504	.0001508	0.95603	1.00761	1.00811	1.00734	1.01528	0.99204	0.99982							
0.950	1.1179	5.1789	.0000919	.0000879	.0000877	0.95726	1.00529	1.00558	1.00510	1.01061	0.99454	0.99994							
0.960	1.0940	6.3356	.0000474	.0000453	.0000451	0.95825	1.00340	1.00355	1.00322	1.00681	0.99655	1.00000							
0.970	1.0704	8.2712	.0000205	.0000192	.0000191	0.95902	1.00192	1.00198	1.00175	1.00385	0.99809	1.00000							
0.980	1.0469	12.054	.0000067	.0000057	.0000057	0.95956	1.00086	1.00088	1.00068	1.00173	0.99918	1.00000							
0.990	1.0238	23.155	.0000016	.0000007	.0000007	0.95989	1.00022	1.00023	1.00005	1.00045	0.99982	1.00000							
ETA=.0		ZETA=.0160		CHI=.C		BCCUL		BSURF		BCURV		BRED		BCCMP		BSR1		BSR2	
XI	ZO	ZI	BBAR(N)	BBAR(E)	BBAR(L)	BCCUL	BSURF	BCURV	BRED	BCCMP	BSR1	BSR2							
0.910	1.2235	3.0971	.0005613	.0005028	.0004962	0.99037	1.01805	1.01989	1.01658	1.03642	0.98019	0.99873							
0.920	1.1964	3.4363	.0003908	.0003567	.0003502	0.99252	1.01412	1.01539	1.01329	1.02844	0.98476	0.99925							
0.930	1.1702	3.8646	.0002601	.0002411	.0002357	0.95436	1.01073	1.01157	1.01026	1.02157	0.98860	0.99959							
0.940	1.1446	4.4335	.0001634	.0001529	.0001492	0.95592	1.00783	1.00836	1.00756	1.01572	0.99180	0.99981							
0.950	1.1195	5.2251	.0000949	.0000889	.0000867	0.95720	1.00541	1.00571	1.00522	1.01086	0.99442	0.99994							
0.960	1.0950	6.4048	.0000456	.0000457	.0000446	0.95822	1.00346	1.00361	1.00329	1.00693	0.99649	1.00000							
0.970	1.0709	8.3528	.0000222	.0000193	.0000185	0.95901	1.00195	1.00201	1.00177	1.00390	0.99806	1.00000							
0.980	1.0473	12.179	.0000082	.0000057	.0000056	0.95956	1.00088	1.00090	1.00070	1.00175	0.99916	1.00000							
0.990	1.0243	22.916	.0000030	.0000007	.0000007	0.95988	1.00023	1.00024	1.00006	1.00047	0.99982	1.00000							
ETA=.0		ZETA=.0240		CHI=.C		BCCUL		BSURF		BCURV		BRED		BCCMP		BSR1		BSR2	
XI	ZO	ZI	BBAR(N)	BBAR(E)	BBAR(L)	BCCUL	BSURF	BCURV	BRED	BCCMP	BSR1	BSR2							
0.910	1.2306	3.0996	.0005836	.0005174	.0004906	0.98984	1.01900	1.02100	1.01743	1.03837	0.97910	0.99863							
0.920	1.2015	3.4316	.0004044	.0003657	.0003462	0.99219	1.01473	1.01608	1.01386	1.02967	0.98409	0.99921							
0.930	1.1738	3.8930	.0002683	.0002461	.0002331	0.99416	1.01110	1.01199	1.01064	1.02233	0.98819	0.99958							
0.940	1.1471	4.4705	.0001683	.0001554	.0001475	0.99579	1.00806	1.00861	1.00779	1.01619	0.99156	0.99981							
0.950	1.1208	5.3085	.0000980	.0000900	.0000858	0.99715	1.00550	1.00581	1.00531	1.01103	0.99433	0.99994							
0.960	1.0960	6.4848	.0000517	.0000460	.0000441	0.99819	1.00352	1.00367	1.00335	1.00705	0.99643	1.00000							
0.970	1.0713	8.5207	.0000240	.0000194	.0000187	0.99900	1.00196	1.00203	1.00179	1.00393	0.99805	1.00000							
0.980	1.0477	12.320	.0000058	.0000057	.0000056	0.99955	1.00088	1.00091	1.00071	1.00178	0.99915	1.00000							
0.990	1.0248	22.746	.0000044	.0000007	.0000007	0.99988	1.00024	1.00025	1.00007	1.00049	0.99981	1.00000							
ETA=.0		ZETA=.0320		CHI=.C		BCCUL		BSURF		BCURV		BRED		BCCMP		BSR1		BSR2	
XI	ZO	ZI	BBAR(N)	BBAR(E)	BBAR(L)	BCCUL	BSURF	BCURV	BRED	BCCMP	BSR1	BSR2							
0.910	1.2385	3.1049	.0006077	.0005330	.0004849	0.98924	1.02008	1.02225	1.01838	1.04057	0.97787	0.99853							
0.920	1.2074	3.4631	.0004189	.0003751	.0003423	0.99180	1.01544	1.01690	1.01454	1.03112	0.98329	0.99916							
0.930	1.1779	3.9174	.0002768	.0002513	.0002304	0.99392	1.01154	1.01249	1.01107	1.02322	0.98772	0.99956							
0.940	1.1498	4.5161	.0001733	.0001580	.0001458	0.99566	1.00831	1.00888	1.00804	1.01668	0.99130	0.99980							
0.950	1.1229	5.3456	.0001011	.0000911	.0000848	0.99706	1.00567	1.00599	1.00548	1.01137	0.99415	0.99994							
0.960	1.0970	6.5773	.0000538	.0000464	.0000436	0.99816	1.00374	1.00374	1.00341	1.00717	0.99637	1.00000							
0.970	1.0718	8.6629	.0000257	.0000194	.0000185	0.99859	1.00199	1.00205	1.00182	1.00398	0.99803	1.00000							
0.980	1.0480	12.539	.0000113	.0000057	.0000055	0.99934	1.00090	1.00092	1.00072	1.00180	0.99914	1.00000							
0.990	1.0252	22.638	.0000058	.0000007	.0000007	0.99987	1.00025	1.00025	1.00008	1.00050	0.99980	1.00000							

Table A6.c

Print 20

ETA=0	ZETA=0	BBAR(N)	BBAR(E)	BBAR(I)	BCCUL	BSURF	BCURV	BRED	BCCMP	BSR1	BSR2
XI	Z2										
0.910	1.2083	.0005107	.0004673	.0005075	0.99149	1.01600	1.01753	1.01479	1.03226	0.98253	0.99895
0.920	1.1849	.0003585	.0003344	.0003581	0.99328	1.01272	1.01381	1.01200	1.02561	0.98632	0.99936
0.930	1.1616	.0002406	.0002280	.0002411	0.99486	1.00981	1.01055	1.00938	1.01972	0.98960	0.99965
0.940	1.1385	.0001517	.0001460	.0001525	0.99621	1.00727	1.00774	1.00700	1.01459	0.99240	0.99983
0.950	1.1155	.0000878	.0000858	.0000887	0.99736	1.00510	1.00537	1.00490	1.01022	0.99475	0.99995
0.960	1.0925	.0000449	.0000446	.0000456	0.99831	1.00330	1.00344	1.00312	1.00660	0.99666	1.00000
0.970	1.0695	.0000187	.0000190	.0000193	0.99904	1.00188	1.00194	1.00170	1.00376	0.99814	1.00000
0.980	1.0464	.0000052	.0000057	.0000057	0.99957	1.00085	1.00086	1.00067	1.00169	0.99919	1.00000
0.990	1.0233	.0000001	.0000007	.0000007	0.99989	1.00021	1.00022	1.00004	1.00043	0.99983	1.00000
ETA=0	ZETA=0										
XI	Z2										
0.910	1.2057	.0005007	.0004591	.0005075	0.99171	1.01561	1.01708	1.01446	1.03146	0.98299	0.99900
0.920	1.1828	.0003525	.0003290	.0003581	0.99344	1.01244	1.01349	1.01175	1.02504	0.98664	0.99939
0.930	1.1600	.0002368	.0002247	.0002411	0.99496	1.00962	1.01033	1.00920	1.01933	0.98982	0.99966
0.940	1.1373	.0001456	.0001441	.0001525	0.99628	1.00714	1.00760	1.00688	1.01434	0.99254	0.99984
0.950	1.1146	.0000868	.0000848	.0000887	0.99740	1.00502	1.00529	1.00483	1.01007	0.99483	0.99995
0.960	1.0919	.0000444	.0000441	.0000456	0.99833	1.00326	1.00340	1.00308	1.00652	0.99670	1.00000
0.970	1.0691	.0000185	.0000189	.0000193	0.99905	1.00186	1.00192	1.00168	1.00372	0.99816	1.00000
0.980	1.0463	.0000051	.0000057	.0000057	0.99957	1.00084	1.00086	1.00066	1.00168	0.99920	1.00000
0.990	1.0232	.0000001	.0000007	.0000007	0.99989	1.00021	1.00022	1.00004	1.00043	0.99984	1.00000
ETA=0	ZETA=0										
XI	Z2										
0.910	1.2031	.0004912	.0004512	.0005075	0.99191	1.01524	1.01666	1.01415	1.03071	0.98342	0.99905
0.920	1.1807	.0003465	.0003238	.0003581	0.99358	1.01217	1.01319	1.01151	1.02449	0.98694	0.99942
0.930	1.1584	.0002332	.0002214	.0002411	0.99506	1.00943	1.01012	1.00903	1.01895	0.99002	0.99968
0.940	1.1361	.0001476	.0001422	.0001525	0.99635	1.00702	1.00747	1.00676	1.01409	0.99267	0.99985
0.950	1.1137	.0000858	.0000839	.0000887	0.99744	1.00495	1.00521	1.00475	1.00992	0.99491	0.99995
0.960	1.0913	.0000440	.0000437	.0000456	0.99835	1.00322	1.00336	1.00304	1.00645	0.99674	1.00000
0.970	1.0688	.0000184	.0000188	.0000193	0.99906	1.00184	1.00190	1.00167	1.00369	0.99817	1.00000
0.980	1.0461	.0000051	.0000056	.0000057	0.99958	1.00083	1.00085	1.00066	1.00167	0.99921	1.00000
0.990	1.0232	.0000001	.0000007	.0000007	0.99989	1.00021	1.00022	1.00004	1.00043	0.99984	1.00000
ETA=0	ZETA=0										
XI	Z2										
0.910	1.2006	.0004821	.0004437	.0005075	0.99210	1.01489	1.01626	1.01366	1.03000	0.98382	0.99910
0.920	1.1787	.0003407	.0003188	.0003581	0.99372	1.01192	1.01290	1.01129	1.02398	0.98723	0.99945
0.930	1.1568	.0002297	.0002183	.0002411	0.99515	1.00926	1.00993	1.00887	1.01860	0.99022	0.99965
0.940	1.1349	.0001456	.0001405	.0001525	0.99641	1.00691	1.00734	1.00665	1.01366	0.99280	0.99985
0.950	1.1129	.0000848	.0000830	.0000887	0.99748	1.00488	1.00513	1.00469	1.00978	0.99499	0.99995
0.960	1.0908	.0000436	.0000433	.0000456	0.99837	1.00318	1.00331	1.00301	1.00637	0.99678	1.00000
0.970	1.0695	.0000183	.0000186	.0000193	0.99907	1.00182	1.00188	1.00165	1.00365	0.99819	1.00000
0.980	1.0460	.0000051	.0000056	.0000057	0.99958	1.00083	1.00085	1.00065	1.00166	0.99921	1.00000
0.990	1.0232	.0000001	.0000007	.0000007	0.99989	1.00021	1.00021	1.00004	1.00042	0.99984	1.00000

Table A6.d

A5. Listing of the Relative Strengths of the Droplet Model Parameters

Table A7 of this appendix lists the relative strengths of the droplet model energies together with the energy unit according to Eqs. (3.4), (3.6), and (3.7).

Notations:

ENORM: E° , XBW: $x_{\text{Bohr and Wheeler}} = Z^2/50A$, ZM: z_{Myers} , ZS: $z_{\text{Swiatecki}}$

W: $w = E_{\text{comp}}^{\circ}/E^{\circ}$.

a: Tungsten Osmium

b: Indium Gold

c: Mercury Lead

d: Bismuth Radon

e: Francium Actinium

f: Thorium Uranium

g: Neptunium Americium

h: Curium Californium

i: Einsteinium Mendelevium

j: Nobelium Kurchatovium

k: Superheavy nuclei $105 \leq Z \leq 108$

l: Superheavy nuclei $Z = 109, 110, 114, \text{ and } 126$

Print 21

Z	N	A	EAQRM	XI	ETA	ZETA	CHI	XBM	X	Y	ZM	ZS	W
74 W	104	178	546.17	0.6522	.09620	.00834	.02407	0.6365	0.6763	.10105	.01296	.00876	.02529
74 W	105	179	546.60	0.6505	.09630	.00835	.02410	0.6352	0.6746	.10117	.01300	.00877	.02531
74 W	106	180	547.07	0.6489	.09641	.00836	.02412	0.6336	0.6729	.10129	.01305	.00878	.02534
74 W	107	181	547.36	0.6472	.09652	.00837	.02415	0.6321	0.6712	.10141	.01310	.00879	.02537
74 W	108	182	547.69	0.6457	.09664	.00838	.02418	0.6306	0.6696	.10155	.01315	.00881	.02541
74 W	109	183	547.97	0.6442	.09677	.00839	.02421	0.6291	0.6681	.10169	.01320	.00882	.02544
74 W	110	184	548.22	0.6428	.09690	.00840	.02425	0.6278	0.6666	.10183	.01325	.00883	.02548
74 W	111	185	548.43	0.6414	.09704	.00841	.02428	0.6264	0.6652	.10198	.01329	.00884	.02552
74 W	112	186	548.61	0.6401	.09718	.00843	.02432	0.6251	0.6639	.10214	.01334	.00886	.02556
74 W	113	187	548.76	0.6388	.09733	.00844	.02435	0.6239	0.6626	.10230	.01339	.00887	.02560
74 W	114	188	548.87	0.6376	.09748	.00845	.02439	0.6227	0.6613	.10247	.01344	.00889	.02564
75 RE	107	182	551.63	0.6585	.09595	.00855	.02401	0.6425	0.6827	.10078	.01315	.00898	.02522
75 RE	108	183	552.01	0.6569	.09606	.00856	.02404	0.6413	0.6810	.10090	.01320	.00899	.02525
75 RE	109	184	552.35	0.6553	.09618	.00857	.02406	0.6398	0.6794	.10103	.01325	.00900	.02528
75 RE	110	185	552.65	0.6538	.09630	.00858	.02410	0.6383	0.6779	.10117	.01329	.00901	.02531
75 RE	111	186	552.91	0.6524	.09643	.00859	.02413	0.6369	0.6764	.10131	.01334	.00902	.02535
75 RE	112	187	553.14	0.6510	.09656	.00860	.02416	0.6356	0.6749	.10145	.01339	.00904	.02538
75 RE	113	188	553.34	0.6496	.09670	.00861	.02419	0.6342	0.6735	.10160	.01344	.00905	.02542
75 RE	114	189	553.50	0.6483	.09684	.00863	.02423	0.6330	0.6722	.10176	.01348	.00906	.02546
75 RE	115	190	553.63	0.6470	.09699	.00864	.02427	0.6318	0.6709	.10193	.01353	.00908	.02550
75 RE	116	191	553.72	0.6458	.09714	.00865	.02431	0.6306	0.6697	.10209	.01358	.00909	.02555
76 OS	107	183	555.81	0.6659	.09540	.00873	.02387	0.6538	0.6943	.10018	.01320	.00916	.02507
76 OS	108	184	556.24	0.6642	.09550	.00874	.02390	0.6521	0.6925	.10029	.01325	.00917	.02509
76 OS	109	185	556.63	0.6626	.09561	.00875	.02392	0.6505	0.6908	.10041	.01329	.00918	.02512
76 OS	110	186	556.98	0.6610	.09572	.00876	.02395	0.6490	0.6892	.10053	.01334	.00919	.02515
76 OS	111	187	557.30	0.6625	.09584	.00877	.02398	0.6475	0.6876	.10066	.01339	.00921	.02519
76 OS	112	188	557.58	0.6620	.09596	.00878	.02401	0.6461	0.6861	.10079	.01344	.00922	.02522
76 OS	113	189	557.82	0.6605	.09609	.00879	.02404	0.6447	0.6846	.10093	.01348	.00923	.02526
76 OS	114	190	558.03	0.6592	.09622	.00880	.02408	0.6434	0.6832	.10108	.01353	.00925	.02529
76 OS	115	191	558.21	0.6578	.09636	.00881	.02411	0.6421	0.6818	.10123	.01358	.00926	.02533
76 OS	116	192	558.35	0.6566	.09650	.00883	.02415	0.6408	0.6805	.10139	.01363	.00927	.02537
76 OS	117	193	558.47	0.6553	.09665	.00884	.02418	0.6397	0.6793	.10155	.01367	.00929	.02541
76 OS	118	194	558.55	0.6541	.09680	.00885	.02422	0.6385	0.6781	.10172	.01372	.00930	.02545
76 OS	119	195	558.60	0.6530	.09696	.00887	.02426	0.6374	0.6769	.10190	.01377	.00932	.02550

Table A7.a

Print 22

Z	N	A	ENCRW	XI	EYA	ZETA	CHI	XBW	X	Y	ZM	ZS	M
77 IR	111	188	561.59	0.6747	.05528	.00895	.02384	0.6582	0.6990	.10004	.01344	.00939	.02503
77 IR	112	189	561.92	0.6731	.05539	.00896	.02387	0.6567	0.6974	.10016	.01348	.00940	.02506
77 IR	113	190	562.21	0.6716	.05551	.00897	.02390	0.6552	0.6958	.10029	.01353	.00942	.02509
77 IR	114	191	562.47	0.6701	.05563	.00898	.02393	0.6538	0.6943	.10042	.01358	.00943	.02513
77 IR	115	192	562.70	0.6687	.05576	.00899	.02396	0.6525	0.6929	.10057	.01363	.00944	.02516
77 IR	116	193	562.89	0.6674	.05589	.00900	.02399	0.6512	0.6915	.10072	.01367	.00946	.02520
77 IR	117	194	563.05	0.6661	.05603	.00902	.02403	0.6499	0.6902	.10087	.01372	.00947	.02524
77 IR	118	195	563.18	0.6648	.05617	.00903	.02406	0.6487	0.6889	.10102	.01377	.00948	.02528
77 IR	119	196	563.28	0.6636	.05632	.00904	.02410	0.6475	0.6877	.10119	.01382	.00950	.02532
77 IR	120	197	563.34	0.6624	.05647	.00906	.02414	0.6464	0.6865	.10136	.01386	.00952	.02536
77 IR	121	198	563.38	0.6613	.05663	.00907	.02418	0.6453	0.6853	.10153	.01391	.00953	.02540
78 PT	111	185	565.79	0.6860	.05474	.00913	.02370	0.6690	0.7105	.09944	.01348	.00958	.02488
78 PT	112	186	566.17	0.6843	.05484	.00914	.02373	0.6674	0.7088	.09956	.01353	.00959	.02491
78 PT	113	187	566.51	0.6828	.05495	.00915	.02376	0.6659	0.7072	.09968	.01358	.00960	.02494
78 PT	114	188	566.82	0.6812	.05506	.00916	.02379	0.6644	0.7056	.09980	.01363	.00961	.02497
78 PT	115	189	567.17	0.6798	.05518	.00917	.02382	0.6630	0.7041	.09993	.01367	.00963	.02500
78 PT	116	190	567.34	0.6783	.05530	.00918	.02385	0.6616	0.7026	.10007	.01372	.00964	.02504
78 PT	117	191	567.54	0.6770	.05543	.00919	.02388	0.6603	0.7012	.10021	.01377	.00965	.02507
78 PT	118	192	567.72	0.6756	.05556	.00921	.02391	0.6590	0.6998	.10036	.01382	.00967	.02511
78 PT	119	193	567.86	0.6743	.05570	.00922	.02395	0.6578	0.6985	.10051	.01386	.00968	.02515
78 PT	120	194	567.99	0.6731	.05585	.00923	.02398	0.6566	0.6973	.10067	.01391	.00970	.02519
78 PT	121	195	568.06	0.6719	.05599	.00925	.02402	0.6554	0.6960	.10082	.01396	.00971	.02523
78 PT	122	200	568.11	0.6708	.05614	.00926	.02406	0.6543	0.6949	.10100	.01400	.00973	.02527
79 AU	115	154	571.40	0.6909	.05462	.00935	.02368	0.6736	0.7154	.09932	.01372	.00982	.02485
79 AU	116	155	571.69	0.6894	.05474	.00936	.02371	0.6722	0.7138	.09945	.01377	.00983	.02488
79 AU	117	156	571.95	0.6879	.05486	.00937	.02373	0.6708	0.7123	.09958	.01382	.00984	.02492
79 AU	118	157	572.17	0.6865	.05498	.00939	.02377	0.6694	0.7109	.09971	.01386	.00985	.02495
79 AU	119	158	572.36	0.6852	.05511	.00940	.02380	0.6681	0.7095	.09986	.01391	.00987	.02499
79 AU	120	159	572.52	0.6839	.05524	.00941	.02383	0.6668	0.7082	.10000	.01396	.00988	.02502
79 AU	121	200	572.65	0.6826	.05538	.00943	.02387	0.6656	0.7069	.10016	.01400	.00990	.02506
79 AU	122	201	572.75	0.6814	.05553	.00944	.02390	0.6645	0.7056	.10031	.01405	.00991	.02510
79 AU	123	202	572.81	0.6802	.05567	.00945	.02394	0.6633	0.7044	.10047	.01410	.00993	.02514
79 AU	124	203	572.85	0.6791	.05582	.00947	.02398	0.6623	0.7033	.10064	.01414	.00995	.02518

Table A7.b

Print 23

Z	N	A	FAORP	XI	ETA	ZETA	CHI	XBW	X	Y	ZM	ZS	M
80	HG	115	155	0.7021	.05409	.00954	.02354	0.6844	0.7268	.09873	.01377	.01001	.02470
80	HG	116	156	0.7006	.05427	.00955	.02357	0.6828	0.7251	.09885	.01382	.01002	.02473
80	HG	117	157	0.6950	.05431	.00956	.02360	0.6814	0.7236	.09897	.01386	.01003	.02476
80	HG	118	158	0.6976	.05442	.00957	.02363	0.6795	0.7220	.09910	.01391	.01004	.02480
80	HG	119	159	0.6961	.05454	.00958	.02366	0.6785	0.7206	.09923	.01396	.01006	.02483
80	HG	120	200	0.6948	.05467	.00959	.02369	0.6772	0.7192	.09937	.01400	.01007	.02486
80	HG	121	201	0.6924	.05480	.00961	.02372	0.6759	0.7178	.09951	.01405	.01008	.02490
80	HG	122	202	0.6921	.05493	.00962	.02375	0.6747	0.7165	.09966	.01410	.01010	.02494
80	HG	123	203	0.6909	.05507	.00963	.02379	0.6735	0.7152	.09981	.01414	.01011	.02497
80	HG	124	204	0.6897	.05521	.00965	.02382	0.6724	0.7140	.09996	.01419	.01013	.02501
80	HG	125	205	0.6885	.05536	.00966	.02386	0.6712	0.7128	.10013	.01424	.01015	.02505
80	HG	126	206	0.6874	.05551	.00968	.02390	0.6702	0.7117	.10029	.01428	.01016	.02509
81	TL	120	201	0.7057	.05411	.00978	.02355	0.6877	0.7303	.09876	.01405	.01026	.02471
81	TL	121	202	0.7043	.05423	.00979	.02358	0.6863	0.7289	.09889	.01410	.01027	.02474
81	TL	122	203	0.7030	.05436	.00980	.02361	0.6850	0.7275	.09903	.01414	.01029	.02478
81	TL	123	204	0.7017	.05449	.00982	.02364	0.6838	0.7261	.09917	.01419	.01030	.02481
81	TL	124	205	0.7004	.05462	.00983	.02368	0.6826	0.7248	.09931	.01424	.01032	.02485
81	TL	125	206	0.6992	.05476	.00984	.02371	0.6814	0.7236	.09947	.01428	.01033	.02489
81	TL	126	207	0.6980	.05490	.00986	.02375	0.6803	0.7224	.09962	.01433	.01035	.02493
81	TL	127	208	0.6969	.05504	.00987	.02378	0.6792	0.7212	.09978	.01437	.01037	.02497
81	TL	128	209	0.6958	.05519	.00989	.02382	0.6781	0.7201	.09995	.01442	.01038	.02501
81	TL	129	210	0.6947	.05535	.00991	.02386	0.6771	0.7191	.10012	.01447	.01040	.02505
82	PH	120	202	0.7168	.05358	.00996	.02341	0.6983	0.7415	.09817	.01410	.01045	.02456
82	PH	121	203	0.7154	.05369	.00998	.02344	0.6969	0.7400	.09829	.01414	.01047	.02459
82	PH	122	204	0.7139	.05381	.00999	.02347	0.6955	0.7386	.09842	.01419	.01048	.02463
82	PH	123	205	0.7126	.05393	.01000	.02350	0.6941	0.7371	.09855	.01424	.01049	.02466
82	PH	124	206	0.7112	.05405	.01001	.02353	0.6929	0.7358	.09869	.01428	.01051	.02469
82	PH	125	207	0.7099	.05418	.01003	.02357	0.6916	0.7345	.09883	.01433	.01052	.02473
82	PH	126	208	0.7087	.05431	.01004	.02360	0.6904	0.7332	.09898	.01437	.01054	.02477
82	PH	127	209	0.7075	.05445	.01006	.02363	0.6893	0.7320	.09913	.01442	.01055	.02480
82	PH	128	210	0.7063	.05459	.01007	.02367	0.6882	0.7308	.09929	.01447	.01057	.02484
82	PH	129	211	0.7052	.05474	.01009	.02370	0.6871	0.7297	.09944	.01451	.01059	.02488
82	PH	130	212	0.7041	.05489	.01010	.02374	0.6861	0.7286	.09961	.01456	.01061	.02492
82	PH	131	213	0.7031	.05504	.01012	.02378	0.6851	0.7275	.09978	.01460	.01062	.02497
82	PH	132	214	0.7021	.05520	.01014	.02382	0.6841	0.7265	.09995	.01465	.01064	.02501

Table A7.c

Print 24

Z	N	A	ENORM	XI	ETA	ZETA	CHI	XBM	X	Y	ZM	ZS	M
82	81	124	207	0.7212	.09351	.01020	.02340	0.7032	0.7468	.09809	.01433	.01070	.02454
83	81	125	208	0.7208	.09363	.01021	.02343	0.7020	0.7455	.09822	.01437	.01071	.02458
83	81	126	209	0.7195	.09375	.01023	.02346	0.7007	0.7441	.09836	.01442	.01073	.02461
83	81	127	210	0.7182	.09388	.01024	.02349	0.6995	0.7428	.09850	.01447	.01075	.02465
83	81	128	211	0.7170	.09401	.01026	.02352	0.6983	0.7416	.09865	.01451	.01076	.02468
83	81	129	212	0.7158	.09415	.01027	.02356	0.6972	0.7404	.09880	.01456	.01078	.02472
83	81	130	213	0.7147	.09429	.01029	.02359	0.6961	0.7392	.09895	.01460	.01079	.02476
83	81	131	214	0.7136	.09444	.01030	.02363	0.6950	0.7381	.09911	.01465	.01081	.02480
83	81	132	215	0.7125	.09458	.01032	.02367	0.6940	0.7370	.09928	.01469	.01083	.02484
84	80	124	208	0.7332	.09298	.01039	.02327	0.7138	0.7580	.09751	.01437	.01090	.02440
84	80	125	209	0.7318	.09309	.01040	.02329	0.7124	0.7565	.09764	.01442	.01091	.02443
84	80	126	210	0.7304	.09321	.01041	.02332	0.7111	0.7551	.09776	.01447	.01092	.02446
84	80	127	211	0.7290	.09333	.01043	.02335	0.7098	0.7538	.09790	.01451	.01094	.02450
84	80	128	212	0.7278	.09346	.01044	.02338	0.7086	0.7524	.09803	.01456	.01095	.02453
84	80	129	213	0.7265	.09359	.01046	.02342	0.7074	0.7512	.09818	.01460	.01097	.02457
84	80	130	214	0.7253	.09372	.01047	.02345	0.7062	0.7499	.09832	.01465	.01099	.02460
84	80	131	215	0.7241	.09385	.01049	.02348	0.7051	0.7488	.09847	.01469	.01100	.02464
84	80	132	216	0.7230	.09400	.01050	.02352	0.7040	0.7476	.09863	.01474	.01102	.02468
84	80	133	217	0.7219	.09414	.01052	.02355	0.7030	0.7465	.09878	.01479	.01104	.02472
84	80	134	218	0.7209	.09429	.01053	.02359	0.7020	0.7455	.09895	.01483	.01106	.02476
85	80	123	208	0.7458	.09238	.01057	.02311	0.7259	0.7708	.09684	.01437	.01108	.02423
85	80	124	209	0.7443	.09248	.01058	.02314	0.7244	0.7693	.09696	.01442	.01109	.02426
85	80	125	210	0.7428	.09258	.01059	.02317	0.7230	0.7677	.09707	.01447	.01111	.02429
85	80	126	211	0.7414	.09269	.01060	.02319	0.7216	0.7663	.09719	.01451	.01112	.02432
85	80	127	212	0.7400	.09280	.01062	.02322	0.7202	0.7648	.09732	.01456	.01113	.02435
85	80	128	213	0.7386	.09292	.01063	.02325	0.7189	0.7634	.09744	.01460	.01115	.02438
85	80	129	214	0.7373	.09304	.01064	.02328	0.7176	0.7621	.09758	.01465	.01116	.02442
85	80	130	215	0.7360	.09317	.01066	.02331	0.7164	0.7608	.09771	.01469	.01118	.02445
85	80	131	216	0.7348	.09329	.01067	.02334	0.7152	0.7595	.09786	.01474	.01120	.02448
85	80	132	217	0.7336	.09343	.01069	.02338	0.7141	0.7583	.09800	.01479	.01121	.02452
85	80	133	218	0.7325	.09356	.01070	.02341	0.7130	0.7572	.09815	.01483	.01123	.02456
85	80	134	219	0.7314	.09370	.01072	.02345	0.7119	0.7560	.09830	.01488	.01125	.02460
86	80	129	215	0.7482	.09252	.01084	.02315	0.7280	0.7731	.09700	.01469	.01136	.02427
86	80	130	216	0.7469	.09263	.01085	.02318	0.7267	0.7717	.09713	.01474	.01138	.02430
86	80	131	217	0.7456	.09275	.01086	.02321	0.7255	0.7704	.09726	.01479	.01139	.02434
86	80	132	218	0.7443	.09288	.01088	.02324	0.7243	0.7691	.09740	.01483	.01141	.02437
86	80	133	219	0.7431	.09301	.01089	.02327	0.7231	0.7679	.09754	.01488	.01142	.02441
86	80	134	220	0.7420	.09314	.01091	.02330	0.7220	0.7667	.09769	.01492	.01144	.02444
86	80	135	221	0.7408	.09328	.01092	.02334	0.7209	0.7656	.09783	.01497	.01146	.02448
86	80	136	222	0.7397	.09341	.01094	.02337	0.7199	0.7645	.09799	.01501	.01148	.02452

Table A7.d

Print 25

Z	N	A	ENORM	XI	ETA	ZETA	CHI	XBM	X	Y	ZM	ZS	W
87	FR	130	217	0.7578	.09212	.01104	.02305	0.7371	0.7828	.09657	.01479	.01157	.02416
87	FR	131	218	0.7565	.09223	.01105	.02308	0.7358	0.7814	.09669	.01483	.01159	.02419
87	FR	132	219	0.7551	.09235	.01107	.02311	0.7346	0.7801	.09682	.01488	.01160	.02423
87	FR	133	220	0.7539	.09247	.01108	.02314	0.7333	0.7788	.09695	.01492	.01162	.02426
87	FR	134	221	0.7526	.09260	.01110	.02317	0.7322	0.7775	.09709	.01497	.01164	.02429
87	FR	135	222	0.7515	.09273	.01111	.02320	0.7310	0.7763	.09723	.01501	.01165	.02433
87	FR	136	223	0.7503	.09286	.01113	.02323	0.7299	0.7751	.09737	.01506	.01167	.02436
88	RA	131	215	0.7614	.09173	.01125	.02295	0.7463	0.7925	.09614	.01488	.01179	.02406
88	RA	132	220	0.7661	.09184	.01126	.02298	0.7449	0.7913	.09626	.01492	.01180	.02409
88	RA	133	221	0.7647	.09196	.01128	.02301	0.7437	0.7897	.09638	.01497	.01182	.02412
88	RA	134	222	0.7634	.09207	.01129	.02304	0.7424	0.7884	.09651	.01501	.01184	.02415
88	RA	135	223	0.7622	.09219	.01131	.02307	0.7412	0.7871	.09665	.01506	.01185	.02418
88	RA	136	224	0.7610	.09232	.01132	.02310	0.7400	0.7859	.09678	.01510	.01187	.02422
88	RA	137	225	0.7598	.09245	.01134	.02313	0.7389	0.7847	.09692	.01515	.01189	.02425
88	RA	138	226	0.7587	.09258	.01135	.02316	0.7378	0.7835	.09707	.01519	.01190	.02429
88	RA	139	227	0.7576	.09271	.01137	.02320	0.7368	0.7824	.09721	.01524	.01192	.02432
88	RA	140	228	0.7565	.09285	.01139	.02323	0.7358	0.7814	.09737	.01528	.01194	.02436
88	RA	141	229	0.7555	.09299	.01140	.02327	0.7348	0.7803	.09752	.01533	.01196	.02440
88	RA	142	230	0.7545	.09313	.01142	.02330	0.7339	0.7793	.09768	.01537	.01198	.02444
89	AC	132	221	0.7771	.09135	.01146	.02286	0.7554	0.8022	.09572	.01497	.01201	.02355
89	AC	133	222	0.7757	.09146	.01147	.02288	0.7541	0.8008	.09584	.01501	.01202	.02358
89	AC	134	223	0.7743	.09157	.01149	.02291	0.7528	0.7994	.09596	.01506	.01204	.02401
89	AC	135	224	0.7730	.09168	.01150	.02294	0.7515	0.7980	.09608	.01510	.01205	.02404
89	AC	136	225	0.7717	.09180	.01151	.02297	0.7503	0.7967	.09621	.01515	.01207	.02407
89	AC	137	226	0.7705	.09192	.01153	.02300	0.7491	0.7955	.09634	.01519	.01208	.02411
89	AC	138	227	0.7693	.09204	.01155	.02303	0.7479	0.7943	.09648	.01524	.01210	.02414
89	AC	139	228	0.7681	.09217	.01156	.02306	0.7468	0.7931	.09662	.01528	.01212	.02418
89	AC	140	229	0.7670	.09230	.01158	.02310	0.7458	0.7920	.09676	.01533	.01214	.02421
89	AC	141	230	0.7659	.09244	.01159	.02313	0.7447	0.7909	.09691	.01537	.01216	.02425
89	AC	142	231	0.7649	.09257	.01161	.02316	0.7437	0.7898	.09706	.01541	.01217	.02429

Table A7.e

Print 26

Z	N	A	ENDRM	XI	ETA	ZETA	CHI	XDW	X	Y	ZM	ZS	W
90 TM	133	223	622.55	0.7867	0.9098	0.1167	0.2276	0.7646	0.8119	0.9591	0.1506	0.1222	0.2385
90 TM	134	224	622.77	0.7853	0.9108	0.1168	0.2279	0.7632	0.8105	0.9542	0.1510	0.1224	0.2388
90 TM	135	225	622.97	0.7839	0.9119	0.1170	0.2282	0.7619	0.8091	0.9554	0.1515	0.1225	0.2391
90 TM	136	226	623.14	0.7826	0.9130	0.1171	0.2284	0.7606	0.8077	0.9566	0.1519	0.1227	0.2394
90 TM	137	227	623.28	0.7813	0.9141	0.1173	0.2287	0.7593	0.8064	0.9579	0.1524	0.1229	0.2397
90 TM	138	228	623.39	0.7800	0.9153	0.1174	0.2290	0.7581	0.8051	0.9592	0.1528	0.1230	0.2400
90 TM	139	229	623.48	0.7788	0.9165	0.1176	0.2293	0.7570	0.8039	0.9605	0.1533	0.1232	0.2403
90 TM	140	230	623.55	0.7776	0.9177	0.1177	0.2296	0.7558	0.8027	0.9618	0.1537	0.1234	0.2407
90 TM	141	231	623.59	0.7765	0.9190	0.1179	0.2299	0.7547	0.8015	0.9632	0.1541	0.1235	0.2410
90 TM	142	232	623.60	0.7754	0.9203	0.1180	0.2303	0.7537	0.8004	0.9647	0.1546	0.1237	0.2414
90 TM	143	233	623.60	0.7743	0.9216	0.1182	0.2306	0.7527	0.7993	0.9661	0.1550	0.1239	0.2417
90 TM	144	234	623.57	0.7733	0.9230	0.1184	0.2309	0.7517	0.7983	0.9676	0.1555	0.1241	0.2421
90 TM	145	235	623.51	0.7723	0.9244	0.1186	0.2313	0.7507	0.7972	0.9691	0.1559	0.1243	0.2425
91 PA	133	224	626.68	0.7978	0.9051	0.1187	0.2265	0.7752	0.8232	0.9480	0.1510	0.1243	0.2372
91 PA	134	225	626.94	0.7964	0.9061	0.1188	0.2267	0.7737	0.8217	0.9491	0.1515	0.1245	0.2375
91 PA	135	226	627.17	0.7949	0.9071	0.1190	0.2270	0.7723	0.8202	0.9502	0.1519	0.1246	0.2377
91 PA	136	227	627.38	0.7935	0.9082	0.1191	0.2272	0.7710	0.8188	0.9513	0.1524	0.1247	0.2380
91 PA	137	228	627.56	0.7922	0.9092	0.1192	0.2275	0.7697	0.8174	0.9525	0.1528	0.1249	0.2383
91 PA	138	229	627.71	0.7908	0.9103	0.1194	0.2278	0.7684	0.8160	0.9537	0.1533	0.1251	0.2386
91 PA	139	230	627.84	0.7896	0.9115	0.1195	0.2281	0.7672	0.8147	0.9550	0.1537	0.1252	0.2389
91 PA	140	231	627.94	0.7883	0.9126	0.1197	0.2284	0.7660	0.8135	0.9562	0.1541	0.1254	0.2393
91 PA	141	232	628.02	0.7871	0.9138	0.1198	0.2287	0.7649	0.8122	0.9576	0.1546	0.1256	0.2396
91 PA	142	233	628.07	0.7860	0.9151	0.1200	0.2290	0.7637	0.8111	0.9589	0.1550	0.1257	0.2399
91 PA	143	234	628.10	0.7849	0.9163	0.1202	0.2293	0.7627	0.8099	0.9603	0.1555	0.1259	0.2403
91 PA	144	235	628.11	0.7838	0.9176	0.1203	0.2296	0.7616	0.8088	0.9617	0.1559	0.1261	0.2406
91 PA	145	236	628.09	0.7827	0.9190	0.1205	0.2299	0.7604	0.8077	0.9632	0.1564	0.1263	0.2410
91 PA	146	237	628.05	0.7817	0.9203	0.1207	0.2303	0.7597	0.8067	0.9647	0.1568	0.1265	0.2414
92 U	135	227	631.30	0.8060	0.9025	0.1210	0.2258	0.7829	0.8314	0.9491	0.1524	0.1267	0.2365
92 U	136	228	631.54	0.8046	0.9035	0.1211	0.2261	0.7815	0.8299	0.9462	0.1528	0.1268	0.2368
92 U	137	229	631.76	0.8031	0.9045	0.1212	0.2263	0.7801	0.8285	0.9473	0.1533	0.1270	0.2370
92 U	138	230	631.95	0.8018	0.9055	0.1214	0.2266	0.7788	0.8270	0.9484	0.1537	0.1271	0.2373
92 U	139	231	632.12	0.8004	0.9066	0.1215	0.2268	0.7775	0.8257	0.9496	0.1541	0.1273	0.2376
92 U	140	232	632.26	0.7991	0.9077	0.1217	0.2271	0.7763	0.8244	0.9508	0.1546	0.1274	0.2379
92 U	141	233	632.38	0.7979	0.9088	0.1218	0.2274	0.7751	0.8231	0.9521	0.1550	0.1276	0.2382
92 U	142	234	632.47	0.7967	0.9100	0.1220	0.2277	0.7739	0.8218	0.9534	0.1555	0.1278	0.2385
92 U	143	235	632.53	0.7955	0.9112	0.1221	0.2280	0.7728	0.8206	0.9547	0.1559	0.1280	0.2389
92 U	144	236	632.58	0.7943	0.9124	0.1223	0.2283	0.7717	0.8195	0.9560	0.1564	0.1281	0.2392
92 U	145	237	632.59	0.7932	0.9137	0.1225	0.2286	0.7706	0.8183	0.9574	0.1568	0.1283	0.2396
92 U	146	238	632.59	0.7922	0.9150	0.1226	0.2289	0.7696	0.8173	0.9588	0.1572	0.1285	0.2399
92 U	147	239	632.56	0.7911	0.9163	0.1228	0.2293	0.7684	0.8162	0.9603	0.1577	0.1287	0.2403
92 U	148	240	632.52	0.7901	0.9177	0.1230	0.2296	0.7676	0.8152	0.9617	0.1581	0.1289	0.2406

Table A7.f

Print 27

Z	N	A	ENORM	XI	ETA	ZETA	CHI	XBM	X	Y	ZM	ZS	W
92 NP	138	231	626.13	0.8128	0.9009	0.1234	0.2254	0.7893	0.8382	0.9434	0.1541	0.1292	0.2360
92 NP	139	232	626.33	0.8114	0.9019	0.1235	0.2257	0.7879	0.8367	0.9445	0.1546	0.1294	0.2363
92 NP	140	233	626.51	0.8100	0.9029	0.1238	0.2259	0.7866	0.8353	0.9456	0.1550	0.1295	0.2366
92 NP	141	234	626.66	0.8087	0.9040	0.1238	0.2262	0.7854	0.8340	0.9468	0.1555	0.1297	0.2369
92 NP	142	235	626.79	0.8074	0.9051	0.1240	0.2265	0.7841	0.8327	0.9480	0.1559	0.1298	0.2372
92 NP	143	236	626.89	0.8062	0.9063	0.1241	0.2268	0.7829	0.8314	0.9492	0.1564	0.1300	0.2375
92 NP	144	237	626.97	0.8050	0.9074	0.1243	0.2271	0.7818	0.8302	0.9505	0.1568	0.1302	0.2378
92 NP	145	238	627.03	0.8038	0.9086	0.1244	0.2273	0.7807	0.8290	0.9518	0.1572	0.1304	0.2382
92 NP	146	239	627.06	0.8027	0.9098	0.1246	0.2277	0.7796	0.8279	0.9532	0.1577	0.1305	0.2385
92 NP	147	240	627.07	0.8016	0.9111	0.1248	0.2280	0.7785	0.8268	0.9545	0.1581	0.1307	0.2388
92 NP	148	241	627.05	0.8006	0.9124	0.1250	0.2283	0.7775	0.8257	0.9560	0.1586	0.1309	0.2392
94 PU	138	232	640.22	0.8239	0.8964	0.1254	0.2243	0.7998	0.8494	0.9384	0.1546	0.1313	0.2348
94 PU	139	233	640.47	0.8224	0.8974	0.1256	0.2245	0.7984	0.8479	0.9395	0.1550	0.1315	0.2351
94 PU	140	234	640.68	0.8210	0.8983	0.1257	0.2248	0.7971	0.8464	0.9406	0.1555	0.1316	0.2353
94 PU	141	235	640.87	0.8196	0.8994	0.1258	0.2250	0.7957	0.8450	0.9417	0.1559	0.1318	0.2356
94 PU	142	236	641.04	0.8183	0.9004	0.1260	0.2253	0.7944	0.8437	0.9428	0.1564	0.1319	0.2359
94 PU	143	237	641.19	0.8170	0.9015	0.1261	0.2256	0.7932	0.8423	0.9440	0.1568	0.1321	0.2362
94 PU	144	238	641.29	0.8158	0.9026	0.1263	0.2258	0.7920	0.8410	0.9452	0.1572	0.1323	0.2365
94 PU	145	239	641.39	0.8145	0.9037	0.1264	0.2261	0.7908	0.8398	0.9464	0.1577	0.1324	0.2368
94 PU	146	240	641.45	0.8134	0.9049	0.1266	0.2264	0.7897	0.8386	0.9477	0.1581	0.1326	0.2371
94 PU	147	241	641.50	0.8122	0.9061	0.1268	0.2267	0.7886	0.8374	0.9490	0.1586	0.1328	0.2375
94 PU	148	242	641.52	0.8111	0.9073	0.1269	0.2270	0.7875	0.8363	0.9504	0.1590	0.1330	0.2378
94 PU	149	243	641.52	0.8100	0.9085	0.1271	0.2273	0.7865	0.8352	0.9517	0.1594	0.1332	0.2381
94 PU	150	244	641.50	0.8090	0.9098	0.1273	0.2276	0.7855	0.8341	0.9531	0.1599	0.1334	0.2385
94 PU	151	245	641.45	0.8080	0.9111	0.1275	0.2280	0.7845	0.8331	0.9546	0.1603	0.1336	0.2388
94 PU	152	246	641.39	0.8070	0.9124	0.1277	0.2283	0.7836	0.8321	0.9560	0.1607	0.1338	0.2392
95 AM	142	237	645.22	0.8293	0.8958	0.1280	0.2241	0.8045	0.8547	0.9378	0.1568	0.1340	0.2347
95 AM	143	238	645.39	0.8279	0.8968	0.1282	0.2244	0.8035	0.8533	0.9389	0.1572	0.1342	0.2349
95 AM	144	239	645.54	0.8266	0.8979	0.1283	0.2247	0.8023	0.8520	0.9400	0.1577	0.1343	0.2352
95 AM	145	240	645.67	0.8253	0.8990	0.1285	0.2249	0.8011	0.8507	0.9412	0.1581	0.1345	0.2355
95 AM	146	241	645.78	0.8241	0.9001	0.1286	0.2252	0.7999	0.8494	0.9424	0.1586	0.1347	0.2358
95 AM	147	242	645.85	0.8229	0.9012	0.1288	0.2255	0.7987	0.8482	0.9437	0.1590	0.1349	0.2361
95 AM	148	243	645.91	0.8217	0.9023	0.1290	0.2258	0.7976	0.8470	0.9449	0.1594	0.1350	0.2364
95 AM	149	244	645.95	0.8206	0.9035	0.1291	0.2261	0.7965	0.8458	0.9462	0.1599	0.1352	0.2368
95 AM	150	245	645.96	0.8195	0.9048	0.1293	0.2264	0.7955	0.8447	0.9476	0.1603	0.1354	0.2371
95 AM	151	246	645.95	0.8184	0.9060	0.1295	0.2267	0.7944	0.8436	0.9489	0.1607	0.1356	0.2374

Table A7.g

Print 28

Z	N	A	FACRM	XI	ETA	ZETA	CHI	XBM	X	Y	ZM	ZS	M
56 CM	142	228	649.33	0.8403	0.8914	0.1301	0.2230	0.8154	0.8659	0.9330	0.1572	0.1362	0.2334
56 CM	143	235	649.54	0.8389	0.8924	0.1302	0.2233	0.8140	0.8644	0.9340	0.1577	0.1363	0.2337
54 CM	144	240	649.73	0.8375	0.8933	0.1304	0.2235	0.8127	0.8630	0.9351	0.1581	0.1365	0.2340
56 CM	145	241	649.89	0.8362	0.8944	0.1305	0.2238	0.8114	0.8616	0.9362	0.1586	0.1366	0.2342
56 CM	146	242	650.03	0.8349	0.8954	0.1307	0.2240	0.8101	0.8603	0.9373	0.1590	0.1368	0.2345
56 CM	147	243	650.15	0.8336	0.8965	0.1308	0.2243	0.8089	0.8590	0.9385	0.1594	0.1370	0.2348
56 CM	148	244	650.24	0.8324	0.8976	0.1310	0.2246	0.8077	0.8578	0.9397	0.1599	0.1371	0.2351
56 CM	149	245	650.31	0.8312	0.8987	0.1312	0.2249	0.8066	0.8566	0.9409	0.1603	0.1373	0.2354
56 CM	150	246	650.35	0.8301	0.8999	0.1313	0.2252	0.8055	0.8554	0.9422	0.1607	0.1375	0.2358
56 CM	151	247	650.38	0.8290	0.9010	0.1315	0.2255	0.8044	0.8543	0.9435	0.1612	0.1377	0.2361
56 CM	152	248	650.39	0.8279	0.9023	0.1317	0.2258	0.8034	0.8532	0.9448	0.1616	0.1379	0.2364
56 CM	153	249	650.36	0.8268	0.9035	0.1319	0.2261	0.8024	0.8521	0.9462	0.1621	0.1381	0.2368
56 CM	154	250	650.32	0.8258	0.9048	0.1320	0.2264	0.8014	0.8511	0.9476	0.1625	0.1383	0.2371
57 BK	146	243	654.22	0.8458	0.8909	0.1327	0.2229	0.8205	0.8713	0.9324	0.1594	0.1385	0.2333
57 BK	147	244	654.37	0.8445	0.8919	0.1329	0.2232	0.8192	0.8700	0.9335	0.1599	0.1391	0.2336
57 BK	148	245	654.49	0.8432	0.8930	0.1330	0.2234	0.8180	0.8687	0.9347	0.1603	0.1393	0.2339
57 BK	149	246	654.61	0.8420	0.8940	0.1332	0.2237	0.8168	0.8674	0.9358	0.1607	0.1394	0.2342
57 BK	150	247	654.68	0.8408	0.8951	0.1334	0.2240	0.8156	0.8662	0.9370	0.1612	0.1396	0.2345
57 BK	151	248	654.74	0.8396	0.8963	0.1335	0.2243	0.8145	0.8650	0.9383	0.1616	0.1398	0.2348
57 BK	152	249	654.78	0.8384	0.8974	0.1337	0.2245	0.8134	0.8638	0.9395	0.1621	0.1400	0.2351
57 BK	153	250	654.79	0.8373	0.8986	0.1339	0.2248	0.8124	0.8627	0.9408	0.1625	0.1402	0.2354
58 CF	146	244	658.33	0.8568	0.8865	0.1348	0.2218	0.8309	0.8824	0.9276	0.1559	0.1411	0.2321
58 CF	147	245	658.52	0.8554	0.8875	0.1350	0.2221	0.8296	0.8810	0.9287	0.1603	0.1412	0.2324
58 CF	148	246	658.68	0.8541	0.8885	0.1351	0.2223	0.8283	0.8796	0.9298	0.1607	0.1414	0.2326
58 CF	149	247	658.82	0.8528	0.8895	0.1353	0.2226	0.8271	0.8783	0.9309	0.1612	0.1416	0.2329
58 CF	150	248	658.94	0.8515	0.8905	0.1354	0.2228	0.8258	0.8770	0.9320	0.1616	0.1417	0.2332
58 CF	151	249	659.03	0.8503	0.8916	0.1356	0.2231	0.8247	0.8757	0.9332	0.1621	0.1419	0.2335
58 CF	152	250	659.10	0.8491	0.8927	0.1358	0.2234	0.8235	0.8745	0.9344	0.1625	0.1421	0.2338
58 CF	153	251	659.15	0.8480	0.8938	0.1359	0.2236	0.8224	0.8734	0.9356	0.1629	0.1423	0.2341
58 CF	154	252	659.18	0.8468	0.8950	0.1361	0.2239	0.8213	0.8722	0.9369	0.1634	0.1425	0.2344
58 CF	155	253	659.19	0.8457	0.8962	0.1363	0.2242	0.8202	0.8711	0.9382	0.1638	0.1427	0.2347
59 CF	156	254	659.17	0.8447	0.8974	0.1365	0.2245	0.8193	0.8700	0.9395	0.1642	0.1429	0.2351

Table A7.h

Print 29

Z	N	A	FAORW	XI	ETA	ZETA	CHI	XBW	X	Y	ZM	ZS	W
99 ES	147	246	662.60	0.8664	.08832	.01371	.02210	0.8401	0.8921	.09240	.01607	.01434	.02312
99 ES	148	247	662.80	0.8651	.08842	.01372	.02212	0.8387	0.8907	.09250	.01612	.01436	.02315
99 ES	149	248	662.98	0.8637	.08851	.01374	.02215	0.8374	0.8893	.09261	.01616	.01437	.02317
99 ES	150	249	663.13	0.8624	.08861	.01375	.02217	0.8361	0.8879	.09271	.01621	.01439	.02320
99 ES	151	250	663.25	0.8611	.08871	.01377	.02220	0.8345	0.8866	.09283	.01625	.01441	.02323
99 ES	152	251	663.35	0.8599	.08882	.01378	.02222	0.8337	0.8854	.09294	.01629	.01442	.02325
99 ES	153	252	663.44	0.8586	.08892	.01380	.02225	0.8326	0.8841	.09306	.01634	.01444	.02328
99 ES	154	253	663.50	0.8575	.08903	.01382	.02228	0.8314	0.8829	.09318	.01638	.01446	.02331
99 ES	155	254	663.54	0.8563	.08914	.01384	.02231	0.8303	0.8818	.09330	.01642	.01448	.02334
99 ES	156	255	663.56	0.8552	.08926	.01385	.02233	0.8293	0.8806	.09342	.01646	.01450	.02338
99 ES	157	256	663.55	0.8542	.08938	.01387	.02236	0.8282	0.8796	.09355	.01651	.01452	.02341
100 FM	148	248	666.85	0.8761	.08800	.01393	.02202	0.8492	0.9018	.09204	.01616	.01458	.02303
100 FM	149	249	667.06	0.8747	.08809	.01395	.02204	0.8478	0.9004	.09214	.01621	.01459	.02306
100 FM	150	250	667.25	0.8733	.08818	.01396	.02206	0.8465	0.8990	.09224	.01625	.01461	.02308
100 FM	151	251	667.41	0.8720	.08828	.01398	.02209	0.8452	0.8976	.09235	.01629	.01462	.02311
100 FM	152	252	667.55	0.8707	.08838	.01399	.02211	0.8440	0.8963	.09246	.01634	.01464	.02313
100 FM	153	253	667.67	0.8694	.08848	.01401	.02214	0.8428	0.8950	.09257	.01638	.01466	.02316
100 FM	154	254	667.76	0.8682	.08858	.01403	.02216	0.8416	0.8937	.09268	.01642	.01468	.02319
100 FM	155	255	667.83	0.8670	.08869	.01404	.02219	0.8404	0.8925	.09280	.01646	.01469	.02322
100 FM	156	256	667.88	0.8658	.08880	.01406	.02222	0.8393	0.8913	.09292	.01651	.01471	.02325
101 MD	149	250	671.09	0.8858	.08768	.01416	.02194	0.8584	0.9115	.09165	.01625	.01481	.02294
101 MD	150	251	671.31	0.8844	.08776	.01418	.02196	0.8570	0.9101	.09179	.01629	.01483	.02297
101 MD	151	252	671.57	0.8830	.08785	.01419	.02198	0.8556	0.9087	.09189	.01634	.01484	.02299
101 MD	152	253	671.68	0.8816	.08795	.01421	.02201	0.8543	0.9073	.09199	.01638	.01486	.02302
101 MD	153	254	671.82	0.8803	.08804	.01422	.02203	0.8531	0.9059	.09210	.01642	.01488	.02304
101 MD	154	255	671.95	0.8790	.08814	.01424	.02205	0.8518	0.9046	.09220	.01646	.01489	.02307
101 MD	155	256	672.06	0.8778	.08824	.01425	.02208	0.8506	0.9033	.09231	.01651	.01491	.02310
101 MD	156	257	672.14	0.8766	.08835	.01427	.02211	0.8495	0.9021	.09243	.01655	.01493	.02313
101 MD	157	258	672.27	0.8754	.08845	.01429	.02213	0.8483	0.9009	.09254	.01659	.01495	.02316

Table A7.1

Print 30

Z	N	A	EAORW	XI	ETA	ZETA	CHI	XBW	X	Y	ZM	ZS	W
102 NO	150	252	675.30	0.8955	.08736	.01439	.02186	0.8675	0.5213	.09135	.01634	.01505	.02286
102 NO	151	253	675.53	0.8940	.08745	.01441	.02188	0.8661	0.5198	.09144	.01638	.01506	.02288
102 NO	152	254	675.74	0.8926	.08753	.01442	.02190	0.8648	0.5183	.09154	.01642	.01508	.02250
102 NO	153	255	675.92	0.8912	.08763	.01444	.02193	0.8635	0.5169	.09164	.01646	.01510	.02253
102 NO	154	256	676.09	0.8899	.08772	.01445	.02195	0.8622	0.5156	.09174	.01651	.01511	.02295
102 NO	155	257	676.22	0.8886	.08782	.01447	.02197	0.8609	0.5142	.09184	.01655	.01513	.02258
102 NO	156	258	676.33	0.8873	.08791	.01448	.02200	0.8597	0.5130	.09195	.01659	.01515	.02301
102 NO	157	259	676.43	0.8861	.08802	.01450	.02202	0.8585	0.5117	.09206	.01664	.01517	.02304
102 NO	158	260	676.51	0.8849	.08812	.01452	.02205	0.8574	0.5105	.09218	.01668	.01515	.02306
103 LA	151	254	679.53	0.9052	.08705	.01462	.02178	0.8767	0.5210	.09101	.01642	.01529	.02277
103 LA	152	255	679.74	0.9037	.08713	.01464	.02180	0.8753	0.5295	.09110	.01646	.01530	.02279
103 LA	153	256	679.95	0.9023	.08722	.01465	.02182	0.8739	0.5281	.09119	.01651	.01532	.02282
103 LA	154	257	680.15	0.9009	.08731	.01467	.02185	0.8726	0.5266	.09129	.01655	.01534	.02284
103 LA	155	258	680.32	0.8995	.08740	.01468	.02187	0.8713	0.5252	.09139	.01659	.01535	.02287
103 LA	156	259	680.47	0.8982	.08749	.01470	.02189	0.8700	0.5239	.09149	.01664	.01537	.02289
103 LA	157	260	680.59	0.8969	.08759	.01471	.02192	0.8688	0.5226	.09160	.01668	.01539	.02292
103 LA	158	261	680.70	0.8957	.08769	.01473	.02194	0.8676	0.5213	.09171	.01672	.01541	.02295
103 LA	159	262	680.78	0.8945	.08779	.01475	.02197	0.8664	0.5201	.09182	.01676	.01542	.02297
104 KU	152	256	683.67	0.9149	.08675	.01486	.02170	0.8855	0.5408	.09067	.01651	.01553	.02269
104 KU	153	257	683.92	0.9134	.08683	.01487	.02173	0.8845	0.5393	.09076	.01655	.01555	.02271
104 KU	154	258	684.15	0.9119	.08691	.01489	.02175	0.8831	0.5378	.09085	.01659	.01556	.02273
104 KU	155	259	684.35	0.9105	.08700	.01491	.02177	0.8817	0.5363	.09095	.01664	.01558	.02276
104 KU	156	260	684.53	0.9092	.08708	.01492	.02179	0.8804	0.5349	.09105	.01668	.01559	.02278
104 KU	157	261	684.69	0.9078	.08718	.01493	.02181	0.8791	0.5336	.09115	.01672	.01561	.02281
104 KU	158	262	684.83	0.9065	.08727	.01495	.02184	0.8778	0.5322	.09125	.01676	.01563	.02283
104 KU	159	263	684.95	0.9053	.08737	.01496	.02186	0.8766	0.5309	.09135	.01681	.01565	.02286
104 KU	160	264	685.04	0.9040	.08746	.01498	.02188	0.8754	0.5297	.09146	.01685	.01566	.02288

Table A7.j

Print 31

Z	N	A	ENDRM	XI	ETA	ZETA	CHI	XBM	X	Y	ZM	ZS	B
105	--	153 255	687.83	0.9246	.08644	.01509	.02163	0.8951	0.5505	.09035	.01659	.01577	.02261
105	--	154 255	688.09	0.9231	.08652	.01511	.02165	0.8936	0.5490	.09043	.01664	.01579	.02263
105	--	155 260	688.33	0.9216	.08661	.01512	.02167	0.8922	0.5475	.09052	.01668	.01580	.02265
105	--	156 261	688.54	0.9202	.08669	.01513	.02169	0.8908	0.5460	.09061	.01672	.01582	.02267
105	--	157 262	688.73	0.9188	.08678	.01515	.02171	0.8895	0.5446	.09071	.01676	.01584	.02270
105	--	158 263	688.90	0.9175	.08686	.01516	.02173	0.8882	0.5432	.09080	.01681	.01585	.02272
105	--	159 264	689.05	0.9161	.08696	.01518	.02176	0.8869	0.5419	.09090	.01685	.01587	.02275
105	--	160 265	689.18	0.9149	.08705	.01520	.02178	0.8857	0.5406	.09101	.01689	.01589	.02277
105	--	161 266	689.29	0.9136	.08715	.01521	.02180	0.8845	0.5393	.09111	.01693	.01591	.02280
106	--	154 260	651.97	0.9343	.08615	.01533	.02156	0.9043	0.5603	.09002	.01668	.01602	.02253
106	--	155 261	652.24	0.9328	.08623	.01534	.02157	0.9028	0.5588	.09011	.01672	.01603	.02255
106	--	156 262	652.49	0.9313	.08631	.01536	.02159	0.9014	0.5572	.09019	.01676	.01605	.02257
106	--	157 263	652.71	0.9299	.08639	.01537	.02162	0.9000	0.5558	.09028	.01681	.01606	.02259
106	--	158 264	652.91	0.9285	.08647	.01539	.02164	0.8986	0.5543	.09038	.01685	.01608	.02261
106	--	159 265	653.09	0.9271	.08656	.01540	.02166	0.8973	0.5529	.09047	.01689	.01610	.02264
106	--	160 266	653.25	0.9258	.08665	.01542	.02168	0.8960	0.5515	.09057	.01693	.01611	.02266
106	--	161 267	653.39	0.9245	.08674	.01543	.02170	0.8948	0.5502	.09067	.01698	.01613	.02269
106	--	162 268	653.50	0.9232	.08683	.01545	.02173	0.8936	0.5489	.09077	.01702	.01615	.02271
107	--	155 262	656.09	0.9441	.08586	.01557	.02148	0.9135	0.5701	.08971	.01676	.01626	.02245
107	--	156 263	656.37	0.9425	.08593	.01558	.02150	0.9120	0.5685	.08979	.01681	.01628	.02247
107	--	157 264	656.63	0.9410	.08601	.01559	.02152	0.9106	0.5670	.08987	.01685	.01629	.02249
107	--	158 265	656.86	0.9396	.08609	.01561	.02154	0.9092	0.5655	.08996	.01689	.01631	.02251
107	--	159 266	657.07	0.9381	.08617	.01562	.02156	0.9078	0.5640	.09005	.01693	.01633	.02253
107	--	160 267	657.26	0.9367	.08626	.01564	.02158	0.9064	0.5626	.09014	.01698	.01634	.02255
107	--	161 268	657.43	0.9354	.08634	.01565	.02160	0.9051	0.5612	.09023	.01702	.01636	.02258
107	--	162 269	657.58	0.9341	.08643	.01567	.02163	0.9039	0.5599	.09033	.01706	.01638	.02260
107	--	163 270	657.70	0.9328	.08652	.01569	.02165	0.9026	0.5585	.09043	.01710	.01639	.02263
108	--	156 264	700.20	0.9538	.08557	.01581	.02141	0.9227	0.5799	.08939	.01685	.01651	.02237
108	--	157 265	700.49	0.9523	.08564	.01582	.02143	0.9212	0.5783	.08947	.01689	.01653	.02239
108	--	158 266	700.75	0.9507	.08572	.01583	.02145	0.9198	0.5767	.08955	.01693	.01654	.02241
108	--	159 267	700.99	0.9493	.08580	.01585	.02147	0.9183	0.5752	.08964	.01698	.01656	.02243
108	--	160 268	701.22	0.9478	.08588	.01586	.02149	0.9169	0.5737	.08973	.01702	.01657	.02245
108	--	161 269	701.42	0.9464	.08596	.01588	.02151	0.9156	0.5723	.08982	.01706	.01659	.02247
108	--	162 270	701.59	0.9450	.08604	.01589	.02153	0.9142	0.5709	.08991	.01710	.01661	.02250
108	--	163 271	701.75	0.9437	.08613	.01591	.02155	0.9130	0.5695	.09000	.01715	.01662	.02252
108	--	164 272	701.89	0.9424	.08622	.01592	.02157	0.9117	0.5682	.09010	.01719	.01664	.02254

Table A7.k

Print 32

Z	N	A	ENORM	XI	ETA	ZETA	CHI	XBW	X	Y	ZW	ZS	W
109	--	157 266	704.29	0.9636	.08529	.01605	.02134	0.9320	0.5897	.08908	.01693	.01676	.02229
109	--	158 267	704.58	0.9620	.08536	.01606	.02136	0.9304	0.5881	.08916	.01698	.01677	.02231
109	--	159 268	704.86	0.9605	.08543	.01607	.02138	0.9289	0.5865	.08924	.01702	.01679	.02233
109	--	160 269	705.11	0.9590	.08551	.01609	.02140	0.9273	0.5850	.08932	.01706	.01681	.02235
109	--	161 270	705.34	0.9575	.08559	.01610	.02141	0.9261	0.5835	.08941	.01710	.01682	.02237
109	--	162 271	705.55	0.9561	.08567	.01612	.02143	0.9247	0.5820	.08950	.01715	.01684	.02239
109	--	163 272	705.74	0.9547	.08575	.01613	.02146	0.9234	0.5806	.08959	.01719	.01685	.02242
109	--	164 273	705.91	0.9533	.08583	.01615	.02148	0.9221	0.5792	.08968	.01723	.01687	.02244
109	--	165 274	706.05	0.9520	.08592	.01616	.02150	0.9208	0.5778	.08977	.01727	.01689	.02246
110	--	158 266	708.36	0.9733	.08501	.01629	.02127	0.9412	0.5995	.08878	.01702	.01701	.02221
110	--	159 267	708.66	0.9717	.08508	.01630	.02129	0.9396	0.5979	.08886	.01706	.01703	.02223
110	--	160 270	708.95	0.9702	.08515	.01632	.02131	0.9381	0.5963	.08893	.01710	.01704	.02225
110	--	161 271	709.21	0.9687	.08522	.01633	.02132	0.9367	0.5947	.08901	.01715	.01706	.02227
110	--	162 272	709.45	0.9672	.08530	.01634	.02134	0.9353	0.5932	.08910	.01719	.01707	.02229
110	--	163 273	709.67	0.9658	.08538	.01636	.02136	0.9339	0.5917	.08918	.01723	.01709	.02231
110	--	164 274	709.87	0.9644	.08546	.01637	.02138	0.9325	0.5903	.08927	.01727	.01710	.02234
110	--	165 275	710.04	0.9630	.08554	.01639	.02140	0.9312	0.5889	.08936	.01731	.01712	.02236
110	--	166 276	710.20	0.9617	.08563	.01641	.02142	0.9299	0.5875	.08945	.01736	.01714	.02238
114	--	175 293	727.49	0.9891	.08527	.01755	.02134	0.9556	1.0148	.08907	.01806	.01833	.02229
114	--	180 294	727.57	0.9880	.08537	.01757	.02136	0.9545	1.0137	.08917	.01810	.01835	.02231
114	--	181 295	727.49	0.9869	.08547	.01759	.02138	0.9535	1.0126	.08928	.01814	.01837	.02234
114	--	182 296	727.47	0.9859	.08557	.01761	.02141	0.9525	1.0115	.08939	.01819	.01840	.02237
114	--	183 297	727.42	0.9849	.08567	.01763	.02143	0.9516	1.0105	.08950	.01823	.01842	.02239
114	--	184 298	727.36	0.9839	.08577	.01765	.02146	0.9506	1.0095	.08961	.01827	.01844	.02242
114	--	185 299	727.29	0.9830	.08587	.01767	.02149	0.9497	1.0086	.08972	.01831	.01846	.02245
114	--	186 300	727.20	0.9820	.08598	.01769	.02151	0.9488	1.0076	.08984	.01835	.01849	.02248
114	--	187 301	727.09	0.9811	.08609	.01772	.02154	0.9480	1.0067	.08996	.01839	.01851	.02251
114	--	188 302	726.96	0.9802	.08620	.01774	.02157	0.9471	1.0058	.09008	.01843	.01854	.02254
114	--	189 303	726.83	0.9794	.08631	.01776	.02160	0.9463	1.0050	.09020	.01847	.01856	.02257
126	--	179 305	773.30	1.1220	.08129	.02044	.02034	1.0812	1.1482	.08473	.01855	.02130	.02120
126	--	180 306	773.72	1.1204	.08135	.02045	.02035	1.0796	1.1465	.08479	.01859	.02132	.02122
126	--	181 307	774.03	1.1187	.08140	.02046	.02037	1.0781	1.1448	.08485	.01863	.02133	.02123
126	--	182 308	774.32	1.1172	.08146	.02048	.02038	1.0765	1.1432	.08492	.01867	.02135	.02125
126	--	183 309	774.59	1.1156	.08152	.02049	.02040	1.0750	1.1416	.08498	.01871	.02136	.02126
126	--	184 310	774.85	1.1141	.08158	.02051	.02041	1.0735	1.1400	.08505	.01875	.02138	.02128
126	--	185 311	775.09	1.1126	.08164	.02052	.02043	1.0721	1.1385	.08511	.01879	.02140	.02130
126	--	186 312	775.31	1.1111	.08171	.02054	.02044	1.0707	1.1370	.08518	.01883	.02142	.02131
126	--	187 313	775.51	1.1097	.08177	.02056	.02046	1.0693	1.1355	.08526	.01888	.02143	.02133
126	--	188 314	775.69	1.1083	.08184	.02057	.02048	1.0679	1.1341	.08533	.01892	.02145	.02135
126	--	189 315	775.86	1.1069	.08191	.02059	.02050	1.0666	1.1327	.08540	.01896	.02147	.02137

Table A7.1

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