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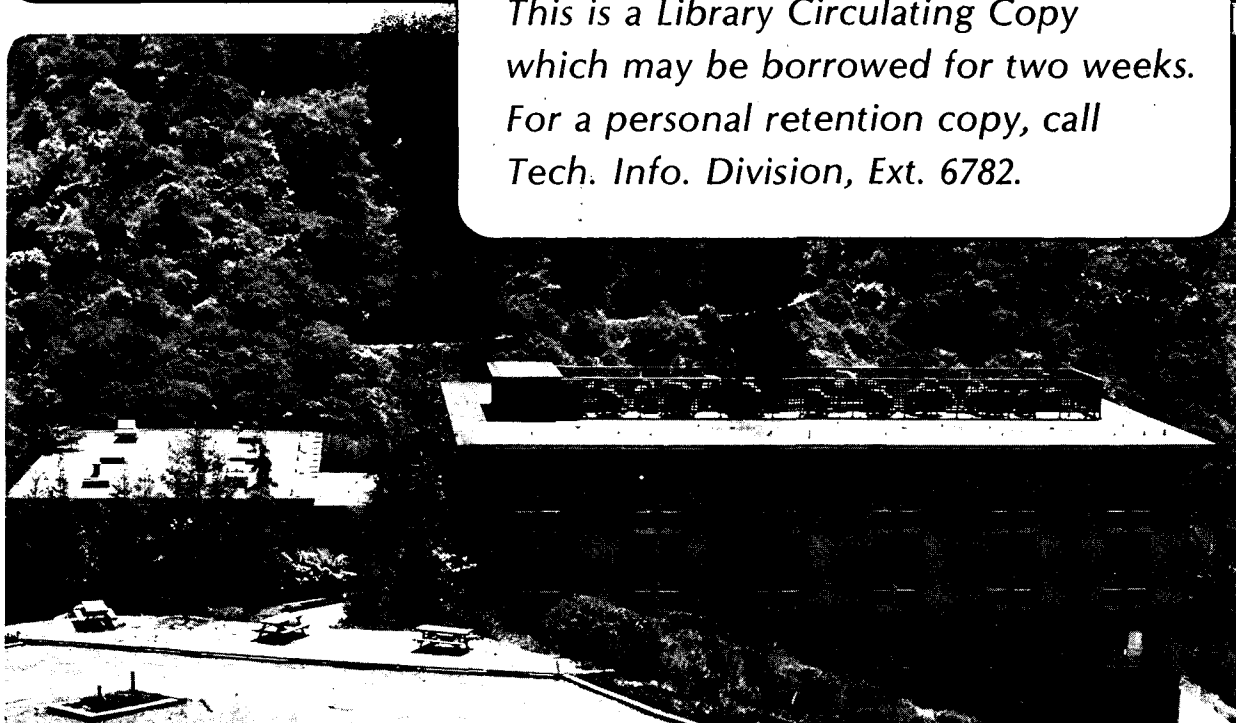
EQUILIBRIUM CHARGE STATES OF URANIUM
AT RELATIVISTIC ENERGIES

H. Crawford, H. Gould, D. Greiner, P. Lindstrom,
and J. Symons

June 1983

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Equilibrium charge states of uranium at relativistic energies

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We have measured the charge fractions of uranium ions at energies of 962 MeV/amu and 430 MeV/amu passing through various thickness targets of mylar ($Z \approx 6.6$), Cu ($Z=29$) and Ta ($Z=73$). From these we determine the equilibrium charge state distributions.

Uranium $68+$ ions from the LBL Bevalac are transported in vacuum through a windowless beam line and pass through targets located upstream of the beam 40 magnetic spectrometer (Fig. 1). The charge states produced by collisions in the targets are spatially separated in the magnets and are detected by a position sensitive ionization chamber located approximately 10 meters downstream from the magnets. At the detector the charge states are separated by roughly 1 cm. The convolution of the instrumental resolution and the beam width is about 0.2 cm (Fig. 2).

The equilibrium charge state distributions are shown in Fig. 3. These distributions were obtained from the data as follows: Charge capture and loss cross sections were fit¹ to the curves of charge state population verses target thickness. The fitted capture and loss cross sections were then used to construct the equilibrium distributions.

Fig 3 shows that at 962 MeV/amu the average charge state of the uranium ions is monotonic with target Z . However, at 430 MeV/amu the average charge state first rises and then falls with increasing target Z . The qualitative behavior of the charge state distributions can be understood in terms of the different energy and target Z dependence of the ionization cross section and of the charge exchange, and radiative electron capture cross sections². These will be discussed in detail in a future paper.

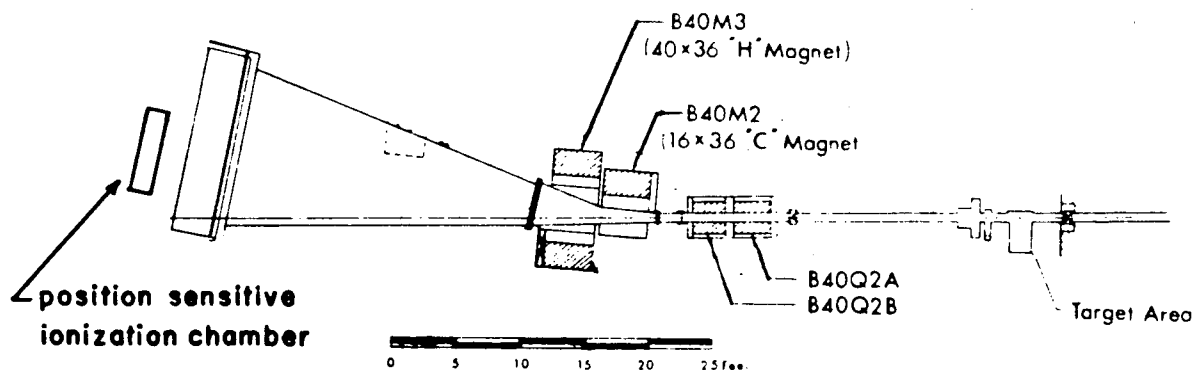


Figure 1. - Schematic diagram of the experimental apparatus

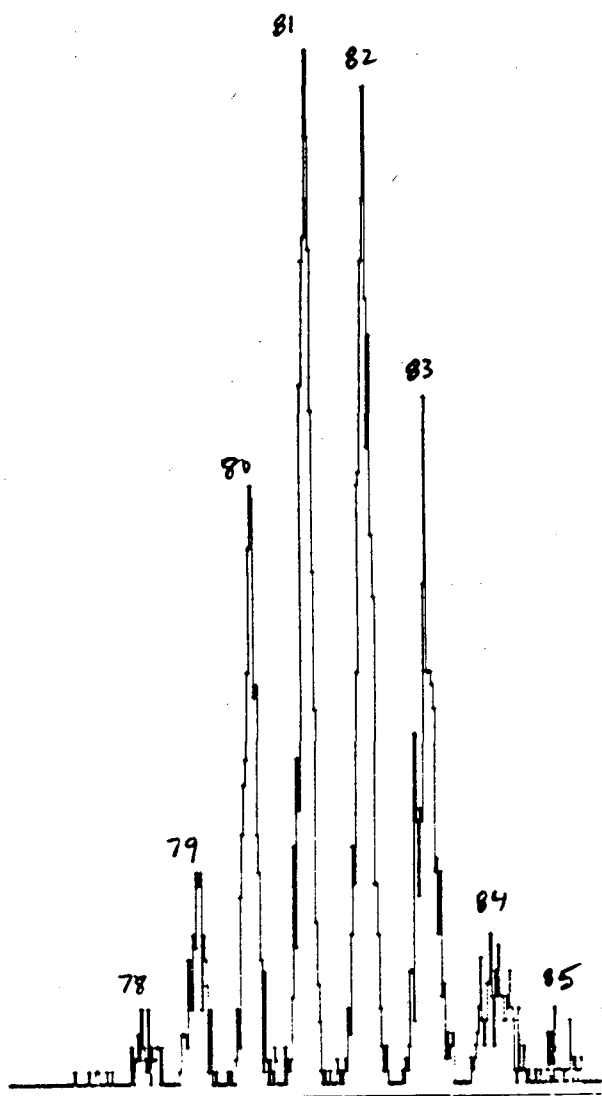
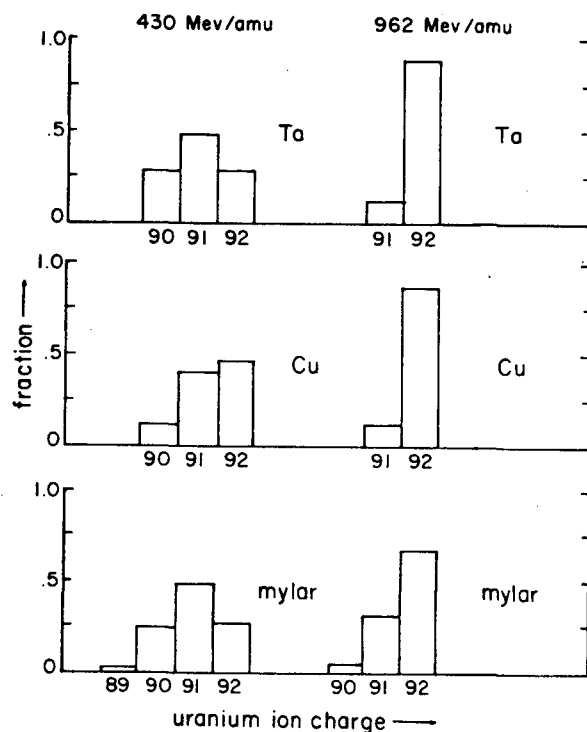


Figure 2. - Charge state fractions of 962 MeV/amu uranium (incident charge state 68+) after passing through 7.1 mg/cm² of mylar.

We thank Dr. Jose Alonso, Mr. Ismael Flores and Mr. Douglas MacDonald for their assistance in analyzing the data and in setting up the experiment. We are especially grateful to the operators and staff of the Bevalac and the Super-HILAC whose skill and dedication made this experiment possible. This work was supported by the Director, Office of Energy Research; Office of Basic Energy Sciences, Chemical Sciences Division, and Office of High Energy and Nuclear Physics, Nuclear Science Division, of U.S. Department of Energy, under Contract No. DE-AC-03-76SF00098.

equilibrium charge state distributions of uranium at 430 Mev/amu and 962 Mev/amu in mylar ($Z \approx 6.6$) Cu ($Z = 29$) and Ta ($Z = 73$)



XBL 835-9640

Figure 3. - Equilibrium charge state distributions

References

(a) also University of California Space Sciences Laboratory, Berkeley Ca. 94720.

(1) The method used to fit the cross sections to the data is described in S. Datz, H.O. Lutz, L.B. Bridwell, C. D. Moak, H.D. Betz, and L.D. Ellsworth, *Phys. Rev. A2*, 430 (1970).

(2) see for example, H. Bethe, *Ann. Phys. (Leipzig)* 5, 325 (1930); P.H. Fowler, V.M. Clapham, V.G. Cowen, J.M. Kidd, and R.T. Moses, *Proc. Roy. Soc. (London)* A318, 1 (1970); C. Raisbeck and F. Yiou, *Phys. Rev. A4*, 1858 (1971); C.M. Lee, *Phys. Rev. A17*, 566 (1978); L. Wilson, Lawrence Berkeley Laboratory report No LBL-7723; H. Crawford, Lawrence Berkeley Laboratory report No LBL-8807; R. Shakeshaft, *Phys. Rev. A20*, 779 (1979); B.L. Moiseiwitsch and S.G. Stockman, *J. Phys. B13*, 2975 (1980). D.H. Jakuba β -Amundsen and P.A. Amundsen, *Z. Physik A298*, 13 (1980).

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