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Authors

Gilat, Jacob
Alexander, John M.

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University of California

Ernest O. Lawrence Radiation Laboratory

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The determination of recoil ranges of heavy ion reaction products provides a convenient means for distinguishing between compound nucleus (i.e. total momentum transfer) and direct interaction reaction mechanisms.[1] Once the compound nucleus nature of a given reaction is established, measurement of the range straggling and angular distribution of the recoils can be used to obtain further insight into the details of the evaporation cascade. Simonoff and Alexander[2] have shown that both the range straggling parameter ρ^2, and the mean square angle, are proportional to the average kinetic energy of the evaporated particles and have applied angular distribution measurements to the study of angular momentum effects on the relative roles of neutron and photon emission in the deexcitation process. However, their results are subject to systematic errors due to uncertainties in the angular distributio of the evaporated neutrons. This difficulty can be overcome by using both range straggling and angular distribution of recoils in which case the average neutron energy can be determined independent of their angular distribution.

The measured range straggling is a composite of straggling due to several different causes: (a) nuclear or reaction straggling (b) finite target thickness (c) experimental effects, such as inhomogeneity of the stopping medium (d) inherent straggling of the stopping process. Recoil range measurements of Dy and Tb nuclei in Al foils[1,2] have shown that the contribution of the latter three effects is predominant, and the values of the purely nuclear straggling parameter obtained by subtraction, are not accurate enough for any quantitative evaluation.

Measurement of range straggling in gas rather than solid should have at least two advantages: (a) it eliminates the problem of inhomogeneity of the medium (b) the inherent straggling can be greatly reduced through the use of light gases (hydrogen or helium). On the other hand, apparent straggling can be caused during the collection of the stopped ions.

In the present paper results of preliminary experiments on range straggling of rare earth recoils in helium are reported. The apparatus, essentially similar to that used by Ghiosso and Sikkeland,[3] consists of two parallel flat electrodes, approximately 1" apart. The electrodes are placed, together with an appropriate target, and parallel to the bombarding beam, inside a helium filled chamber, and an electrostatic field of 100-200 Volts/cm is maintained between them. Special care was taken in the design to make this field as uniform and homogenous as possible. The surfaces of the electrodes facing the beam (and the recoils) are covered with aluminum foil, which is removed after bombardment, cut into strips, and counted for the collected recoil activity.

The following results were obtained using Nd^{144} targets bombarded with about 110 MeV C^{12} ions at the Berkeley HILAC and counting the 4.1 hr alpha activity of Tb^{149} that results from the decay of Dy^{149} recoils produced by the $Nd^{144}(C^{12}{}_{7}n)Dy^{149}$ reaction.

1) In agreement with previous observations[4] the respective amounts of activity collected on the negatively and positively charged plates are similar, i.e. a large fraction (30-70%) of the recoils become negatively charged towards the end of their range.

2) The total collection efficiency (positive and negative) is 70-90%.

3) The range distributions of the positive and negative ions are almost identical and can be closely approximated by a Gaussian function with a straggling parameter $\rho = 0.160 \pm .005$. This value is much smaller than the value of 0.24 obtained for the same reaction by using aluminum foils. It seems, therefore, that the effect of non nuclear straggling processes is less important in helium than in aluminum, and a quantitative analysis of results obtained in this way should be feasible.

Further work is in progress.

FOOTNOTES AND REFERENCES

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†On leave from the Israel Atomic Energy Commission Laboratories, Rehovoth, Israel.

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