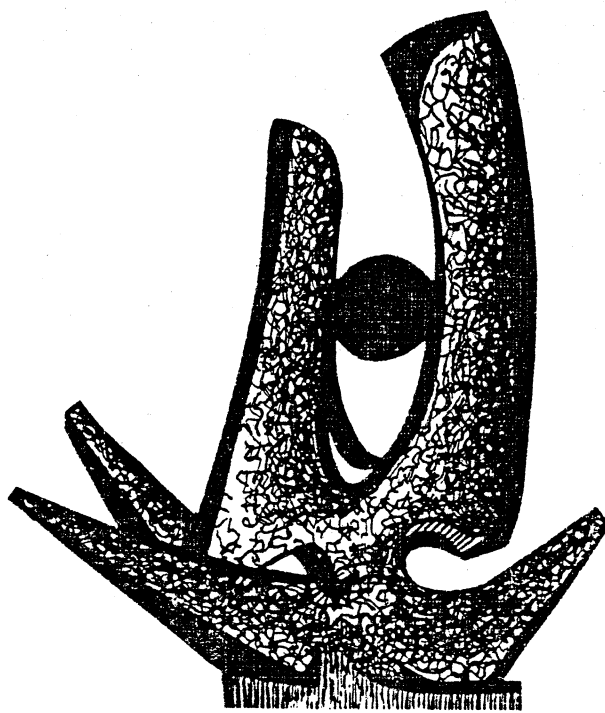


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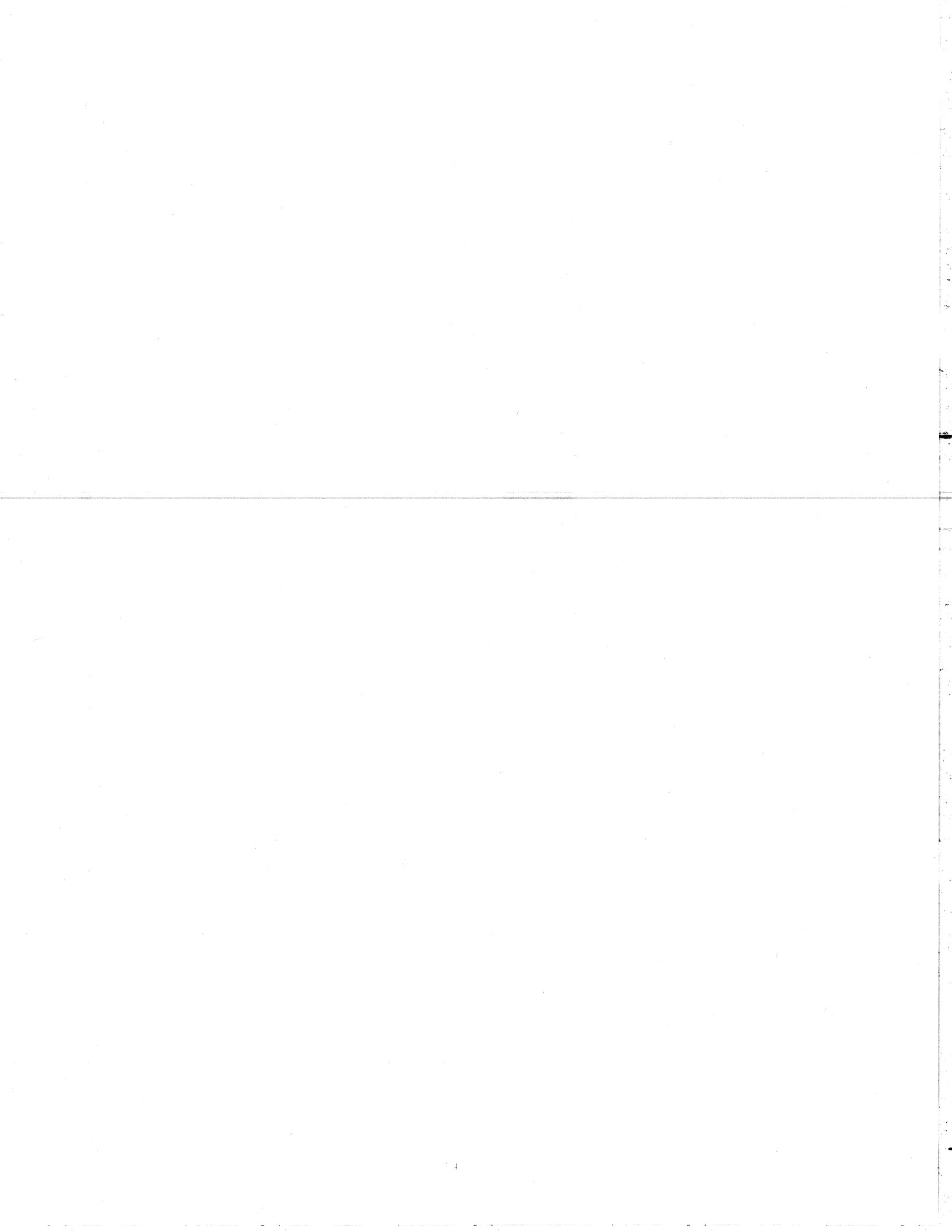
CYCLOTRON LABORATORY

AN INTERACTING BOSON-FERMION MODEL CALCULATION
FOR THE ODD-MASS PROMETHIUM ISOTOPES

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JANUARY 1983



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Abstract

A calculation in the framework of the Interacting Boson-Fermion model for the excitation energy and spectroscopic factors for the negative parity levels in the odd-mass Promethium isotopes is presented. The parameters are compared with those obtained from an earlier calculation of the Europium isotopes.

In the Interacting Boson-Fermion Model¹ (IBFM) the spectra of odd-even nuclei are described by coupling the degrees of freedom of the odd particle to the even-even core, which is described in terms of the Interacting Boson Model² (IBM). The model has been applied with much success to many odd-A nuclei in different regions of the periodic table. In this work we will focus our attention on the Promethium (Pm) isotopes ($Z = 61$) which are adjacent to the Europium (Eu) isotopes ($Z = 63$). An extensive study of the Eu isotopes has already been published.³ This allows us to determine the variation of the IBFM parameters, not only as a function of neutron number but also as a function of the number of protons. The Hamiltonian can in general be written as

$$H = H_B + H_F + V_{BF}$$

where H_B is the IBM Hamiltonian that describes the even-even core, H_F contains the single particle energies and V_{BF} describes the boson-fermion interaction. As is discussed in Ref. 1, V_{BF} can be written as a sum of three terms, a quadrupole-quadrupole interaction with a strength Γ_0 , an exchange force with strength Λ_0 , and a monopole interaction with strength A . The occupancies v_j^i of the different spherical single particle (s.p.) orbits also enter into the interaction.

The odd-mass Pm isotopes are described in the model by coupling the degrees of freedom of the odd proton to the Neodymium (Nd) core with the same neutron number. For the Nd isotopes there exists a calculation in the IBM.⁴ To calculate the negative parity levels, which are the subject of this paper, it is sufficient to

consider only the $h_{11/2}$ proton orbit. In the case of an unique orbit for the odd particle, only two of the three parameters (Γ_0 , Λ_0 and ν^2) enter as linear independent parameters in the calculation of excitation energies. For each isotope therefore the value of ν^2 has been kept fixed to the value indicated by single particle spectroscopic factors while Γ_0 and Λ_0 have been adjusted so as to give a best agreement for the excitation energies. The strength of the monopole force, Λ_0 , has been taken to be the same as for the Eu isotopes: $\Lambda_0 = -0.1$ MeV. In Fig. 1 the calculated excitation energies are compared with experiment. There is a clear transition in the type of spectra. For the lighter isotopes the spectrum is typical for a particle vibrator model in which the $h_{11/2}$ s.p. states are lowest and higher in the spectrum a multiplet of levels can be found arising from the coupling of the $h_{11/2}$ to the 2_1^+ in the core. In ^{153}Pm on the other hand, clear rotation bands have developed as is expected in a Nilsson picture. The partial occupancy of the spherical $h_{11/2}$ orbit gives rise to the fact that here the $5/2_1^-$ is the lowest negative parity level.

The spectroscopic factors for single particle pickup and stripping leading to the $11/2_1^-$ state are given in Fig. 2. The operator for single particle transfer² depends only on the occupancies ν_j^2 , which are the same as used in the Hamiltonian, and thus does not introduce any free parameters.

The IBM parameters which were obtained from a best fit to the experimental excitation energies are plotted in Fig. 3, together with the parameters used in the calculation of the Eu isotopes.³

The parameters are very similar, in their magnitude as well as in their dependence on the number of neutrons. In the figure, the N-dependence which one can expect from a simple microscopic estimate⁵ is also plotted.

In this letter it has been shown that it is possible in the IBM model to calculate a series of isotopes with parameters varying smoothly from nucleus to nucleus. Furthermore, the N- and Z-dependence of the parameters is in agreement with a microscopic estimate. In a forthcoming longer paper the positive parity states and the electromagnetic properties will also be discussed.

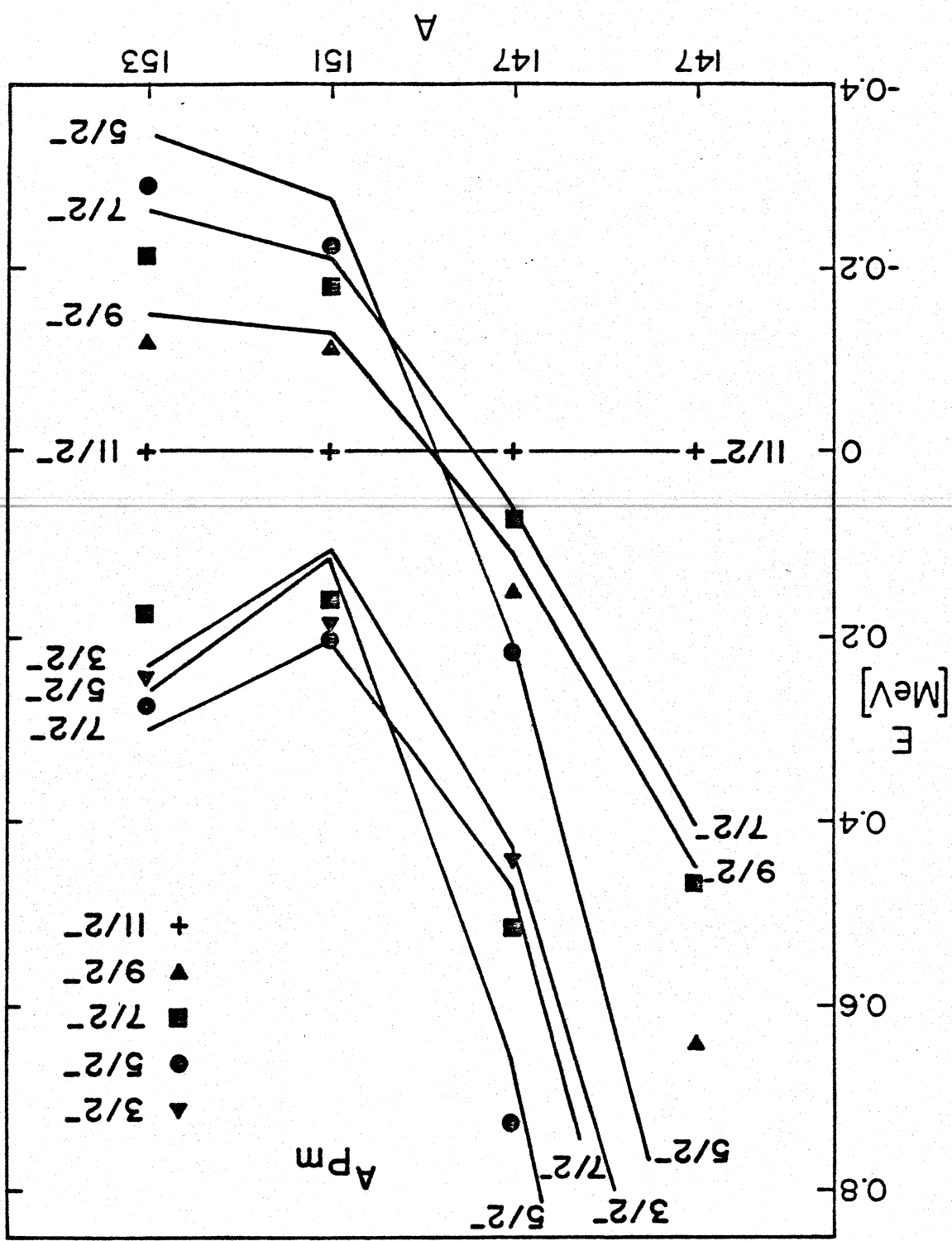
This work is supported by the National Science Foundation under grant no. PHY-80-17605.

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Figure Captions

- Fig. 1 - Comparison of experimental $5-11$ and calculated excitation energies of some negative parity states.
- Fig. 2 - Comparison of experimental $6-11$ and calculated spectroscopic factors for stripping and pickup leading to the $11/2^-$ state in Nd.
- Fig. 3 - The parameters as used in the calculation of the Nd-isotopes (full dots) are compared with those used in the calculation of the Eu isotopes³ (open circles) and a microscopic calculation (drawn lines).



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Figure 1

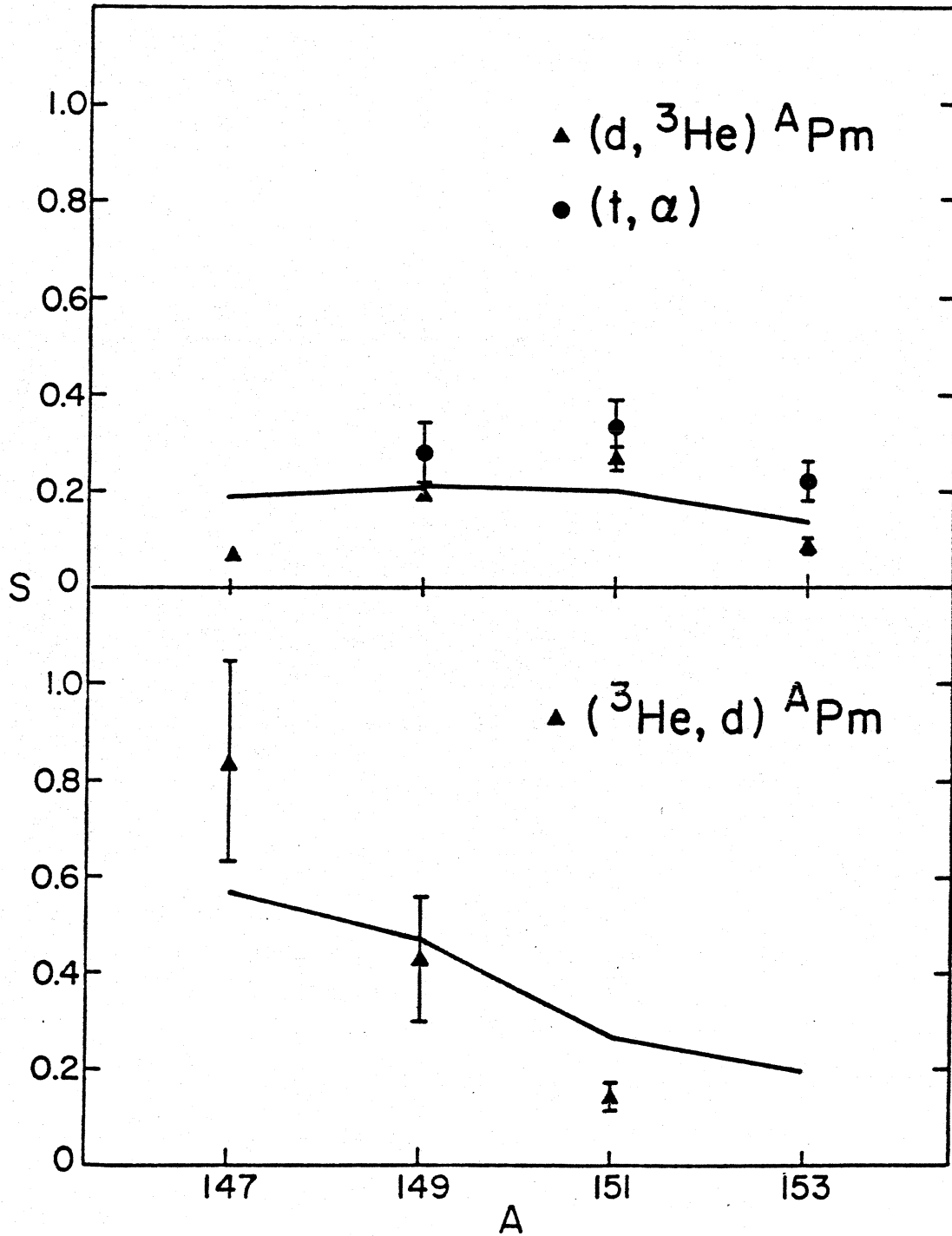


Figure 2

Figure 3

