Magnetic Analysis of the $Sr^{88}(d,p)Sr^{89}$ Reaction*

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A magnetic analyzer was used to study proton groups produced when a $SrCO_3$ target was bombarded with 10.43-Mev deuterons. Three excited states of Sr^{89} were found in addition to the ground state. The corresponding Q values are 4.33, 3.26, 2.26, and 1.79 Mev.

THE $Sr^{88}(d,p)Sr^{89}$ reaction has previously been examined by Harvey,[1] who found a reaction energy of $Q=4.32\pm0.2$ Mev when Sr^{89} is formed in its ground state. He also states that "the first excited level to occur (*viz.*, in Sr^{89}) will be separated from the ground state by about 1 Mev." No information about energy levels in Sr^{89} can be obtained from beta- and gamma-decay studies, since its radioactive parent, Rb^{89}, has a rather short half-life.

In the present investigation, a target was prepared from natural $SrCO_3$. The abundance of Sr^{88} in natural strontium is about 82 percent, and we have assumed that any prominent groups of protons can be attributed to reactions involving this isotope. The carbonate was ground to a fine powder in water and then allowed to fall out of this semisuspension onto a 0.2-mil polyethylene foil. The average thickness of carbonate on the target was 1.35 mg/cm^2. The presence of carbon and oxygen in the substrate and the target compound proves to be helpful in evaluating data. We have employed the $C^{12}(d,d')C^{12}$, $C^{12}(d,p)C^{13}$, and $O^{16}(d,p)O^{17}$ reactions as convenient standards for comparison. In particular, we used these reactions to determine the energy of the incident deuteron beam.

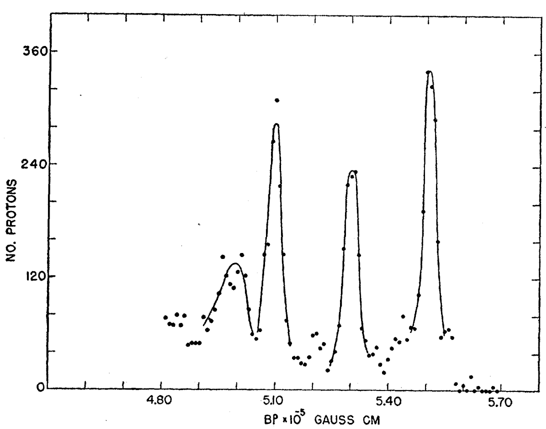

FIG. 1. Proton spectrum from the $Sr^{88}(d,p)Sr^{89}$ reaction.

The reaction products were analyzed with a uniform-field magnetic spectrometer, whose mean radius of curvature is 42.25 cm. The angle between the collimated deuteron beam and the direction of the measured protons was 90°. Photographic plates were used to detect and record charged particles from the reaction. A series of 12 exposures at gradually increasing values of the magnetic field was sufficient to cover the desired momentum range with thoroughness. Each exposed plate encompassed an effective momentum spread of about 0.3×10^5 gauss-centimeters. The total spread covered by the 12 plates was about 1.2×10^5 gauss-centimeters. It is obvious that there was a considerable degree of overlap by adjacent plates. In fact, each of the proton groups plotted in Fig. 1 was observed on at least four different plates. The incident deuteron beam was generated by the Washington University cyclotron; its mean energy, as determined from reaction studies, was 10.43 Mev. To make this determination, the same set of 12 photographic plates was used.

The proton spectrum from the $Sr^{88}(d,p)Sr^{89}$ reaction is pictured in Fig. 1, which shows relative numbers of protons in equal intervals of momentum as a function of momentum measured in gauss-centimeters. The three peaks of greatest momentum seem to be fairly well defined and represent about the maximum resolving power of which the equipment is capable in practice. The fourth peak is less intense and less definite; conceivably, it could result from the superposition of two weak and unresolved groups, but we have chosen to ignore this possibility when computing reaction energies. Should this peak eventually prove to be double, the reaction energy which we have computed from it would correspond to the more energetic member of the pair.

The reaction energies computed from the four proton groups are 4.33, 3.26, 2.26, and 1.79 Mev. The accuracy is estimated to be ±0.1 Mev for the first three and ±0.2 Mev for the fourth. The ground-state Q value compares favorably with the one reported by Harvey. The corresponding excitation energies for nuclear states of Sr^{89} are 0, 1.07, 2.07, and 2.54 Mev. Thus, the first excited state also occupies approximately the position which Harvey claims for it.

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[1] J. A. Harvey, Phys. Rev. 81, 353 (1951).