THE MASS OF ^{29}S*

W. BENENSON, E. KASHY and I.D. PROCTOR**
Cyclotron Laboratory, Michigan State University, East Lansing, Michigan 48823, USA

and

B.M. PREEDOM
Department of Physics, University of South Carolina, Columbia, South Carolina 29208, USA

Received 27 November 1972

The mass of ^{29}S has been measured with the $^{32}S(\tau, {}^6He)$ reaction at 70 MeV. The mass excess is -3.16 ± 0.05 MeV.

The ground state of ^{29}S is the fourth member ($T_z = -3/2$) of a mass quartet which includes the lowest $T = 3/2$ states in ^{29}Si ($T_z = 1/2$) and ^{29}P ($T_z = -1/2$) and the ground state of ^{29}Al ($T_z = +3/2$). The half-life of ^{29}S has been measured [1] to be 195 ± 8 ms by observing the delayed protons following the proton bombardment of natural S and P targets. Previous attempts to measure its mass have only shown it to be consistent with the predictions of the isobaric multiplet mass equation and Coulomb energy systematics [2].

The present measurement consisted in observing the $^{32}S(\tau, {}^6He)^{29}S$ reaction at 7.5° nd 10° in a split-pole spectrograph. Fig. 1 gives a schematic representation of the apparatus. A 70.5 MeV ^3He beam was produced by the Michigan State University Cyclotron. The position on the focal plane was measured by a charge division wire proportional chamber. A plastic scintillator behind the proportional counter was used for particle identification by time-of-flight and total energy. This information plus the energy loss in the wire counter produced spectra which are virtually 100% ^6He particles.

The main difficulty of the experiment consisted in producing and maintaining a thin target containing sulfur. A self-supporting CdS foil with 800 $\mu g/cm^2$ areal density was used, and did not flake off or change thickness under bombardment. This is crucial to the experiment since target thickness is an important source of error in measurements of this type. The best spectrum obtained is shown in fig. 2. A much shorter run on a Mg target, which provided one of the calibrations, is also shown in fig. 2. The background in the CdS spectrum is due to the cadmium isotopes which produce profilic ^6He particles leaving the final nuclei in highly excited states (15–20 MeV). At 10° the ^{29}S yield was reduced significantly, and at 12° no peak corresponding to ^{29}S was observed in the spectrum.

The mass determination was made by comparing the rigidity of the ^6He particles leading to ^{29}S to those from the $^{24}Mg(\tau, {}^6He)^{21}Mg$ [3] and $^{58}Ni(\tau, {}^6He)^{55}Ni$ [4] reactions. The target thickness of the three targets ^{24}Mg, ^{58}Ni, and CdS was measured with americium α-particles both before and after the experiment. The resulting mass excess for ^{29}S is -3.16 ± 0.05 MeV.

The isobaric multiplet mass equation, with the most accurate values for the mass of the three other members [5], predicts a mass excess of -3.14 ± 0.03 MeV for ^{29}S. Hence the present experiment is consistent with a quadratic T_z dependence. A cubic fit to the four masses of the form $M(T_z) = a + bT_z + cT_z^2 + dT_z^3$ gives $a = -11\,137 \pm 9$, $b = -5\,025 \pm 16$, $c = 200 \pm 13$ and $d = 3 \pm 11$ keV.

The c-coefficient obtained can be compared to a shell model calculation [6] which used the simplest possible configuration for the $5/2^+$ spin and parity found for the ground state of nucleus ^{29}Al. The

* Work supported by the National Science Foundation.
** Present address: Lawrence Livermore Laboratory, Livermore, California.

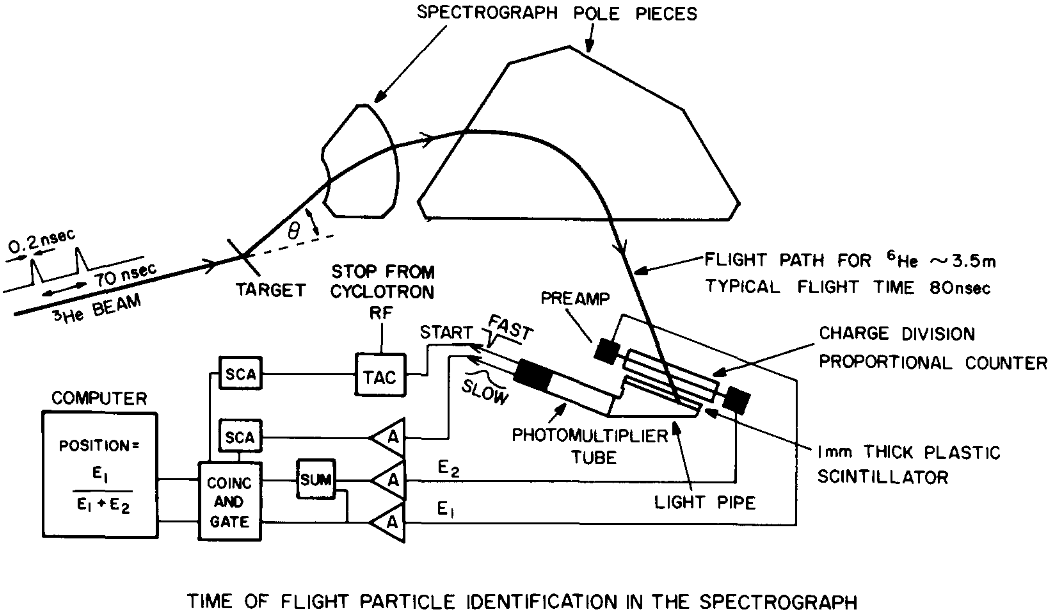

Fig. 1. Experimental apparatus for detecting the (τ, ^{6}He) reaction. The position of the particle on the focal plane is measured by a charge division wire proportional counter. The ratio $E_1/(E_1+E_2)$, which is proportional to the distance along the wire, is calculated by the computer. Particle identification depends on E_1+E_2, the energy loss in the plastic scintillator, and the time-of-flight relative to the cyclotron rf system.

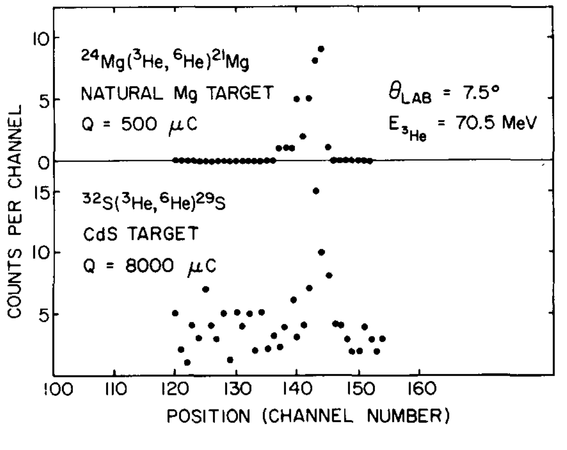

Fig. 2. ^{6}He spectra at 7.5° from the bombardment of ^{24}Mg and CdS with 70 MeV ^{3}He particles. The background under the ^{29}S peak is from the Cd in the target. One channel is equivalent to 0.4 mm or 25 keV.

measured value of 200 keV is about half way between the calculated value of 224 keV, and the value of 180 keV which one gets by treating the nucleus as a uniformly charged sphere. Calculations of the type described in ref. [7] using more complete shell model wave functions are now being carried out for all of the mass quartets in the sd-shell [8].

References

[1] J.C. Hardy and R.I. Verrall, Phys. Lett. 13 (1964) 148.
[2] P.M. Endt and C. Van der Leun, Nucl. Phys. A105 (1967) 1
[3] G.F. Trentelman, B.M. Preedom and E. Kashy, Phys. Rev. C3 (1971) 2205.
[4] I.D. Proctor et al., Phys. Rev. Lett. 29 (1972) 434.
[5] J. Cerny, Ann. Rev. Nucl. Sci. 18 (1968) 27.
[6] N. Auerbach, A. Lev and E. Kashy, Phys. Lett. 36B (1971) 453.
[7] W. Benenson et al., Phys. Rev. C5 (1972) 1426.
[8] J. McGrory and B.H. Wildenthal, to be published.