Half-Life of ^{44}Ti

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One of the few long-lived gamma-ray emitting radioisotopes expected to be produced in substantial quantities during a supernova explosion is ^{44}Ti. The characteristic 1157-keV γ ray from the decay of ^{44}Ti has recently been observed from the supernova remnant Cas A [1]. In order to compare the theoretically predicted gamma-ray flux to that actually observed from this remnant, one must know the half-life of ^{44}Ti. However, published values for this quantity range from 39 to 66.6 years [2,3]. Given that the Cas A supernova is believed to have occurred approximately 300 years ago, this translates to an uncertainity by a factor of 6 in the amount of ^{44}Ti ejected by this supernova. Thus, in order to provide an accurate and reliable value for this important quantity, we have performed a new experiment to determine the half-life of ^{44}Ti.

We produced ^{44}Ti via the ^{45}Sc(p,2n) reaction using 40 MeV protons from the 88-Inch Cyclotron. This energy was chosen to be just above the maximum of the excitation function for this reaction as reported by McGee *et al*. [4]. However, in the course of preparing this source, we produced far less ^{44}Ti than expected. We therefore remeasured the excitation function for this reaction and found that it peaks at much lower energy and has a significantly smaller maximum cross section than previously reported [5]. To produce the source for the present half-life measurement, a 99.9% pure metallic scandium target 37.8mg/cm^2 thick was irradiated for approximately 24 hours with 1 microampere of beam. After allowing the short-lived activities to decay away, approximately 0.01 μCurie of ^{44}Ti was chemically separated from the target, mixed together with 0.04 μCurie of ^{22}Na and 0.05 μCurie of ^{137}Cs, and then dried to make the source for this experiment. This mixed source and a separate 1-μCurie source of ^{241}Am were then rigidly mounted to a shielded 110-cm^3 high-purity germanium detector for γ-ray counting. Data were collected in 1-day time bins for approximately 2 years.

In the present experiment, we attempted to use all three ^{44}Ti γ-ray lines to determine its half life. However, analysis of the ^{241}Am and ^{137}Cs lines produced an incorrect value for the half life of each of these isotopes. On the other hand, the analysis of the ^{22}Na line produced a result that agreed to within 0.5% of the known value of 2.603 years. Also, a small ^{54}Mn contaminant line at 835 keV yielded a half life that agreed to within 1% of its known value. Thus, we decided to concentrate our effort on the analysis of the 1157-keV line. In order to reduce systematic effects such as the possibility of a change in the source-detector distance or a change in the detection efficiency, we compared the area of the 1157-keV ^{44}Ti line to that of the nearby 1275-keV line from the ^{22}Na standard. The ratio of these peak areas was plotted versus time and then fitted to an exponential whose argument was the difference in decay rates between ^{44}Ti and ^{22}Na. The chi-squared per degree of freedom for the fit is 1.1. The half life of ^{44}Ti that we deduce from this experiment is 62 ± 2 years.

Footnotes and References

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