## Brief Reports

*Brief Reports are short papers which report on completed research or are addenda to papers previously published in the* **Physical Review**. *A Brief Report may be no longer than 3½ printed pages and must be accompanied by an abstract.*

# $^{127}$I($^3$He,$t$)$^{127}$Xe reaction with relevance to neutrino detection

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The $^{127}$I($^3$He,$t$)$^{127}$Xe reaction has been measured for low-lying states in $^{127}$Xe which may play a role in neutrino capture by $^{127}$I. High-spin states at excitation energies $E_x=309$ and 646 keV are found to be much more strongly populated than the $J^\pi=(\frac{3}{2}\text{-}\frac{7}{2})^+$ states relevant to neutrino capture by $^{127}$I.

Recently, Haxton[1] examined the feasibility of $^{127}$I as the basis for a new radiochemical detector of astrophysical neutrinos. From estimates of the $^{127}$I($\nu_e$,$e^-$)$^{127}$Xe cross section, he concluded that the capture rate per unit volume for this detector could be an order of magnitude greater than that of the existing $^{37}$Cl detector of Davis *et al.*[2] At this level, a detector based on $^{127}$I would not only be a sensitive detector of $^7$Be and $^8$B solar neutrinos, but could also be used to detect neutrinos produced by supernovae.

At present, the Gamow-Teller (GT) strength for neutrino capture by $^{127}$I has not been measured. This strength can be obtained from the $^{127}$I($p,n$)$^{127}$Xe reaction at intermediate energies where the forward-angle cross section is a direct measure of the GT matrix elements. However, the energy resolution for such ($p,n$) studies is expected to be no better than about 200 keV, making it difficult to resolve the low-lying levels of $^{127}$Xe, which have been inferred indirectly from gamma-ray studies.[3,4] The present study was therefore undertaken to observe the low-lying level structure of $^{127}$Xe via the $^{127}$I($^3$He,$t$)$^{127}$Xe reaction, with an overall energy resolution of about 25 keV. The ($^3$He,$t$) reaction is too complex to permit the Gamow-Teller strength function to be inferred directly, but the general characteristics of this charge-exchange reaction should result in relative cross sections similar to those expected in the ($p,n$) reaction. Neutrino capture by $^{127}$I will produce states in $^{127}$Xe with $J^\pi=(\frac{3}{2}\text{-}\frac{7}{2})^+$ and therefore particular attention was directed toward these states. It was thus hoped that this measurement might assist in the interpretation of the ($p,n$) reaction and might also indicate the presence of energy levels missed in the gamma-ray studies. In addition, the reaction $Q$ value was measured to compare with the value derived from a recent mass table.[5]

The $^{127}$I($^3$He,$t$)$^{127}$Xe reaction was investigated using $^3$He beams [$E$($^3$He)=29.78 MeV] provided by the Princeton cyclotron. Outgoing tritons were momentum analyzed in the focal plane of a quadrupole-dipole-dipole-dipole (QDDD) magnetic spectrometer. A triton spectrum collected at $\theta_{\rm lab}=7°$ using a KI target is shown in Fig. 1. The energy dispersion in the spectrometer was measured using the energies of well-known states populated in the $^{81}$Br($^3$He,$t$)$^{81}$Kr and $^{70}$Zn($^3$He,$t$)$^{70}$Ga reactions. The triton-energy difference between the $E_x=125$ keV, $J^\pi=\frac{3}{2}^+$ first-excited state in $^{127}$Xe and the ground state of $^{70}$Ga (measured using a KI+$^{70}$Zn sandwich target) implies $Q=-0.676(6)$ keV for the $^{127}$I($^3$He,$t$)$^{127}$Xe reaction. This result is in good agreement with $Q=-0.680(7)$ keV obtained from a recent mass compilation.[5] All observed peaks could be identified as $^{127}$Xe levels proposed from the gamma-decay measurements. No clear evidence of the expected states at $E_x=297$ keV ($\frac{9}{2}^-$) and 322 keV ($\frac{3}{2}^+$) was obtained. On the basis of its spin, the latter state may play a role in neutrino capture by $^{127}$I. The most strongly populated states in the spectrum shown in Fig. 1 are the high-spin states at $E_x=309$ keV ($\frac{11}{2}^-$) and $E_x=646$ keV ($\frac{9}{2}^+$) previously observed by Urban *et al.*[4] For comparison, the strongest low-lying state of interest for neutrino capture is the 125-keV state ($\frac{3}{2}^+$) which is weaker than the nearby 309-keV state by a factor of 6.5. Angular distributions were measured up to

 

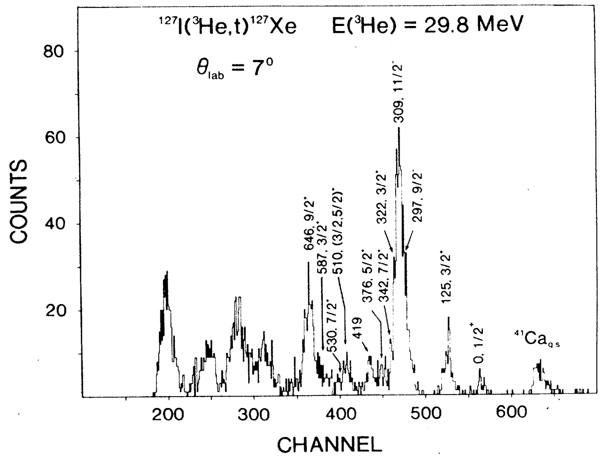


FIG. 1. Triton spectrum from the $^{127}$I($^3$He,$t$)$^{127}$Xe reaction at $\theta_{lab}=7°$. The locations of known states in $^{127}$Xe are indicated. Excitation energies (in keV) and spin parities are from Refs. 3 and 4.

$\theta_{lab}=30°$, but were found to be relatively featureless.

At the best resolution currently achieved in $(p,n)$ measurements (on the order of 200 keV), the 309-keV and 646-keV high-spin states could obscure the GT state between 110 keV $\leq E_x \leq$ 850 keV. This has particular significance when determining the cross section for capture of $^7$Be neutrinos, since these captures would populate the 125-keV state which will not be resolved from the 309-keV state in $(p,n)$ measurements. The astrophysically interesting $J^\pi=\frac{3}{2}^+$ states are formed via $L=0$ angular-momentum transfer with angular distributions that are quite different from the $L=2$ or $L=3$ distributions of the high-spin states. Thus, considerable care must be taken in the $(p,n)$ measurements to extract the $L=0$ strength in the presence of the stronger $L>0$ states.

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