MASTER

DETERMINATION OF NEUTRON CROSS SECTIONS
AND
RESONANCE PARAMETERS FOR VANADIUM,
THE STABLE THALLIUM ISOTOPES
AND
THE STABLE TELLURIUM ISOTOPES

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R. R. Winters
Denison University
Granville, Ohio 43023

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Abstract

The analysis of the neutron capture cross section data for $^{51}\text{V} + n$ has now been completed up to 215 keV. Using a few neutron widths and spin and parity assignments from the literature, the capture data has yielded estimates of radiative widths for 45 s-wave resonances and capture areas for 139 resonances. Of particular interest is the very large s-wave radiative widths for this reaction and the rather broad distribution of radiative widths. A paper describing these results is included with this report.

The analysis of the neutron capture cross sections for the reaction $^{205}\text{Tl}(n,\gamma)$ is presently being extended to incident neutron energy 115 keV. Because of a relative shift in the zero of the energy scales for the total and capture data, this work did not progress as rapidly as expected. However, the analysis now is complete and a paper is in preparation.

The study of the scattered-beam sensitivity of the total energy detectors at the ORELA capture facility continues. This small but troublesome effect has now been parameterized, but the errors to be assigned to the parameterization are not yet well defined. However, in obtaining additional data for the parameterization, a series of $^{208}\text{Pb}(n,\gamma)$ cross section measurements were made. The analysis of these data led to results important in understanding stellar nucleosynthesis and are reported in a paper included with this report.

The analysis of the $\text{Te}(n,\gamma)$ data proceeds methodically but slowly. The FTS telephone connection between Denison University and the Oak Ridge National Laboratory has been particularly valuable in this effort.

Progress Report $^{51}\text{V}(n,\gamma)$

The capture data combined with spin and parity assignments and a few neutron widths from the literature provide full sets (E_λ , Γ_γ , Γ_n) of the resonance parameters for 45 s-wave resonances. Analysis of these parameters has yielded values for the s-wave strength function $\langle S \rangle_{J=3}^{\ell=0} = (8.3_{-2.5}^{+4.0}) \times 10^{-4}$ and $\langle S \rangle_{J=4}^{\ell=0} = (7.0_{-2.2}^{+3.8}) \times 10^{-4}$ (10-90% confidence interval). The level spacing found for the $J^\pi = 4^-$ levels is $\langle D \rangle_{J=4}^{\ell=0} = (10.2_{-0.5}^{+0.8})$ keV. However, the spacing of the $J^\pi = 3^-$ levels shows "non-statistical" effects as measured by the Dyson-Mehta Δ_3 statistic and is well described by two average values: $\langle D \rangle_{J=3}^{\ell=0} = (6.1_{-0.8}^{+1.1})$ keV below 90 keV and $\langle D \rangle_{J=3}^{\ell=0} = (8.1_{-1.1}^{+1.4})$ keV above 115 keV. The s-wave total radiation widths are large and fluctuate widely: $\langle \Gamma_\gamma \rangle_{J=3}^{\ell=0} = 1467 \pm 183$ meV and $\langle \Gamma_\gamma \rangle_{J=4}^{\ell=0} = 1629 \pm 352$ meV. The variances of these distributions are consistent with Chi-squared distributions of 5 degrees of freedom for the 3^- resonances and 2 degrees of freedom for the 4^- resonances. The reduced neutron widths and the total radiative widths for the 4^- s-wave resonances exhibit strong correlation ($\rho = 0.93$, significant at >99.9% confidence level), but the 3^- s-waves are less significantly correlated ($\rho = 0.42$ significant at the 96% confidence level). The contribution of these resonances to the thermal capture cross section is determined to be 3.11 b, approximately 50% of the measured thermal value. The capture resonance integral derived from this work is in good agreement with the published value.

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The 30 keV Maxwellian averaged cross-section, (30 ± 2) mb is of interest in stellar nucleosynthesis.

A paper has been submitted to the Physical Review C in which this work is described. A preprint of that paper is included with this report. A preprint has also been forwarded to the National Neutron Cross Section Center for inclusion in the next edition of BNL-325.

$^{208}\text{Pb}(n,\gamma)$ and the Capture Detector Sensitivity to Scattered Beam

The liquid scintillation detectors used in R. L. Macklin's ORELA capture facility display a small but important sensitivity to scattered beam components. The principal investigator and Macklin have worked industriously on this problem for more than five years and have been able to parameterize this background effect using the nearly resonance-free $^{208}\text{Pb}(n,\gamma)$ reaction. While the parameterization is not yet completely satisfactory, the $^{208}\text{Pb}(n,\gamma)$ data has allowed the study of this reaction which is of importance in astrophysics.

The most interesting results from this work were the discovery of two new capture resonances at energies 43.29 and 47.26 keV which would be of importance in the nucleosynthesis processes in stellar interiors. The complete results of this work are reported in the reprints of a paper submitted with this report.

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$^{205}\text{Tl}(n,\gamma)$

The analysis of the capture cross section data in the region 100-110 keV has proved very difficult because of a relative shift in energy scales for the capture and total neutron cross section data. This section of the data has now been satisfactorily fitted resolving the question about the J^π assignment for one resonance near 100 keV. A paper is presently in preparation reporting these results as well as those reported in the previous Progress Report.

$\text{Te}(n,\gamma)$

This work proceeds methodically, complicated by confusion of resonances resulting from isotopic impurities. This analysis is being done via the Federal Telephone System computer connection between Denison and the Oak Ridge National Laboratory.

Federal Telephone System Computer Connection

The computer connection between Denison University and the ORELA pdp-10 computer has been in operation for nearly one year and is very satisfactory. In particular, since the acquisition of the Vadic 1200 baud modems (model VA3405), data transmission at 1200 baud is now possible over the FTS telephone lines. Such high data transmission rates are possible only because of the phase and amplitude equalization circuit option available with the VA3405. The signal distortion at 1200 baud caused by the telephone lines between Granville, Ohio, and Oak Ridge, Tennessee, was so

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severe as to cause a transmission error on the average for each eighty characters transmitted. However, the compensating circuit of the VA3405 has essentially eliminated these errors.

The remote analysis of the $\text{Te}(n,\gamma)$ data has been significantly enhanced by the FTS. In addition, the FTS has made it possible for the primary investigator to enjoy almost daily contact with other researchers, resulting in a much more productive research effort. Records of phone calls made over the FTS, maintained over the first six months covered by this report, indicate that the FTS has been used for about 10-20 research-related conversations each week and data transmission about four nights per week. Hence, the FTS has proven of great value to the research program at Denison.