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¹⁴⁹Sm Results from DICER Plus DANCE

Nuclear Data Advisory Group



Paul Koehler

19 November 2021



DICER Experiment Overview



1mm Binocular System – Flightpath Stations



Flight Path Installation

- Flight path was torn down to the shutter and realigned all the way to 30m using a suite of metrology equipment
- Position of individual components were calculated online, based from as-built and as-installed data
- Inspecting and fiducializing components first in the lab, as well as the development of alignment files ahead of time, allowed for efficient and rapid alignment of each individual flightpath component



DANCE Experiment Overview

- 1.4, 3.2, and 10.4 mg metallic ¹⁴⁹Sm samples
- Empty sample holder used to measure and subtract background
- Flux measured with ²³⁵U in fission chamber, ⁶Li viewed by solid state detectors, and BF₃ detector
- Technique of Koehler et al., PRC 76, 025804 (2007) used to determine resonance spins
- ¹⁴⁹Sm(n,γ) cross section in good agreement with
 Wisshak et al. in the URR





R-matrix Analysis

- SAMMY used to simultaneously fit five data sets
- Fitted range; 0.4 525 eV (DANCE data $E_n > 8.5 \text{ eV}$)
- 158 resonances (37% more than ENDF/B-VIII.0 in same energy range)
- Twice as many spin assignments as from all previous work
- Often need $\Gamma_n < 0$ to fit shapes of J = 3 resonances
- First measurements of D₀, S₀, and $\langle \Gamma_{\gamma 0} \rangle$ values for each *s*-wave spin state
- First measurements of Γ_n^0 and $\Gamma_{\gamma 0}$ distributions for each *s*-wave spin state

Who	D _o (meV)			10 ⁴ S ₀		
	<i>J</i> =3	J=4	Total	<i>J</i> =3	<i>J</i> =4	Total
This work	4.44±0.25	3.39±0.16	1.925±0.070	1.72±0.26	2.94±0.38	4.66±0.46
Mughabghab	-	-	2.2±0.2	-	-	4.6±0.6



Preliminary Physics Results

- Nearest-neighbor spacing distribution (NNSD) is significantly different from the predicted one (Wigner distribution)
- Neutron strength functions for the two spins are significantly different Sign of a spin-spin interaction?
- D₀ values consistent with 2*J*+1
 Spin cutoff parameter at S_n is larger than predicted
- Tests of nuclear level density and photon strength function models will be possible using Γ_{γ} distributions for the two spins
- Many new doublets revealed
 9-eV "resonance" is actually a J = 3, 4, 3 triplet



Impact on NCSP

- ¹⁴⁹Sm total and capture cross sections identified in Leal et al. (ORNL/TM-2005/65) as being important for burnup credit applications
- The only data in EXFOR are total cross section from 0.0006 to 0.28 eV
- Benchmark calculations indicate the ¹⁴⁹Sm capture cross section in all evaluations may be low
- "...total and capture ¹⁴⁹Sm cross-section measurement are needed from 10⁻⁵ eV and extending through the resonance region. ...energies up to about 1 eV are most important for burnup credit applications."
- We already have measured ¹⁴⁹Sm total and (spin separated) capture cross sections over almost the entire energy region needed
- We could easily extend the measurements to subthermal energies and to other nuclides DANCE is the best instrument for measuring resonance spin for odd-A nuclides



DICER Gen 2 Coming Soon

- First test of imaging detector was very successful Based on LAPPD (20x20 cm) Scintillator thickness and type easily changed TOF spectra comparable to ORELA detectors
 Expect 1 mm spatial resolution
- Design for 100 μm diameter binocular collimator and sample holder/shield nearly completed
 4 micro-actuator-adjusted components
 Remote handling of highly radioactive (~2 Ci) samples
 Main components are tungsten
 100 times smaller samples
- New Mark-IV neutron-production target will result in improved resolution and increased flux above ~1 keV Will be installed before the 2022 LANSCE run cycle L Zavorka, M. Mocko, and P. Koehler, NIMA 901, 189 (2018)



Summary

- DICER and DANCE can provide detailed and accurate resonance parameters and on smaller samples than any other facility from sub-thermal energies through the RRR
- Many additional experiments of interest to NCSP could easily be performed at DICER
 and DANCE
- DANCE also can provide accurate (n, γ) cross sections in the URR
- These experiments were performed in collaboration with T. Bredeweg, A. Couture, B. DiGiovine, J. O'Donnell, R. Reifarth, G. Rusev, A. Stamatopoulos, and J. Ullmann
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