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Is there a low energy enhancement in the photon strength function in molybdenum?

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Is there a low energy enhancement in the photon strength function in molybdenum?

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Abstract. Recent claims of a low energy enhancement in the photon strength function of ^{96}Mo are investigated. Using the DANCE detector the gamma-ray spectra following resonance neutron capture was measured. The spectrum fitting method was used to indirectly extract a photon strength function from the gamma-ray spectra. No strong low energy enhancement in the photon strength function was found.

Keywords: photon strength function, resonance neutron capture, ^{96}Mo, gamma-ray spectroscopy.
PACS: 23.20.-g, 24.60.Dr, 25.70.Gh

INTRODUCTION

An unusual low energy enhancement ($E_\gamma < 4$ MeV) in the γ-ray strength function has recently been observed in a series of medium mass nuclei. These observations were made by the Oslo Cyclotron Laboratory which used (^{3}He,αγ) and (^{3}He, ^{3}He'γ) reactions and the sequential extraction method to extract the γ-ray strength function and nuclear level density. In a series of nuclei ^{56,57}Fe[1], ^{50,51}V[3], $^{93-98}$Mo[2], and ^{44,45}S4c a U-shaped γ-ray strength function having γ energies with a minimum around $E_\gamma = 3$ MeV.

A low energy enhancement in the photon strength function is not expected by any standard theory of the nucleus and may suggest new physics. Therefore, we performed a new experiment to see if there was an evidence of a low energy enhancement in the γ-ray spectra of ^{96}Mo following neutron resonance capture.

EXPERIMENTAL SETUP

DANCE Detector

The experiments where performed at the spallation neutron source of the Los Alamos Neutron Science Center (LANSCE). The 800-MeV H^- beam produces protons which impinge upon a tungsten target to produce spallation neutrons. The beam has a repitition rate of 20 Hz and the neutrons are moderated by a water moderator before entering the experimental flight paths.

The DANCE detector is a ~4π BaF_2 calorimeter designed for measuring neutron capture cross sections of small samples of radioactive materials or isotopic samples. The detector consists of 160 BaF_2 crystals which detect gamma-ray following neutron capture. DANCE is located on a 20-m flight path and measures neutron energies from E_n = 1 eV-100 keV.

Spectrum Fitting Method

The spectrum fitting method was adopted to extract the photon strength function from the measured γ-ray spectral distribution. This indirect find the γ-ray strength function by calculating the shape of the spectral distribution until good agreement is found with the measured shape.

Simulating the gamma-ray spectra

The Monte Carlo program DICEBOX[5] was used to simulated the decay of the compound ^{96}Mo nucleus. To simulate γ-ray cascades DICEBOX requires the user to supply a γ-ray strength function, a nuclear level density, and nuclear level information up to a given excitation energy, E_{crit}. Above E_{crit} DICEBOX performs a random discretization of the nuclear level density and generates a series of partial widths from the capture state using the γ-ray strength function supplied. The γ-ray cascades generated by DICEBOX obey the selection rules and follow a Porter-Thomas distribution.

The DICEBOX γ-ray cascades served as input into GEANT simulations of the DANCE detector response. To verify that GEANT gave an accurate description of DANCE's response function numerous comparisons were made between source spectra generated by GEANT and those measured by the DANCE detector.

EXPERIMENTAL RESULTS

γ-ray spectra from different resonances as measured with DANCE were compared to simulations using DICEBOX+GEANT. Figure 1 gives an example of the comparison between DANCE and simulated spectra. For every resonance studied the γ-ray strength function given from (^{3}He,αγ) and (^{3}He, ^{3}He'γ) data over-estimated the intensity of high multiplicity γ-cascades and gave poor agreement with the DANCE spectra. This is easily understood since a low energy enhancement of the γ-ray strength function is expected

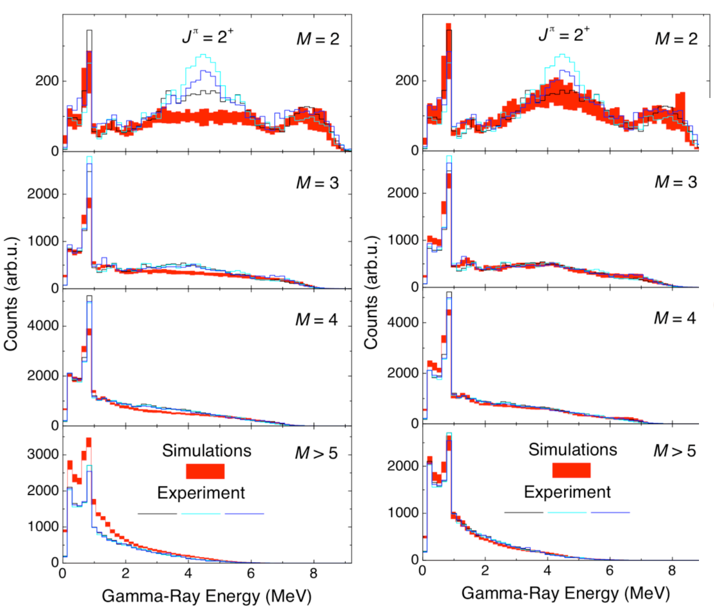

FIGURE 1. γ-ray spectra from the decay of J = 2$^+$ resonances. The spectra are plotted according to the multiplicity of the γ-ray cascade, *M*. The spectra on the left are compared to simulations with a low energy enhancement while the spectra on the right are compared to simulations with an empirical γSF intermediate between a KMF γSF and the Oslo γSF.

The shape of the γSF which gave the best agreement with the DANCE spectra contained a low lying

to shift the multiplicity distribution towards a higher

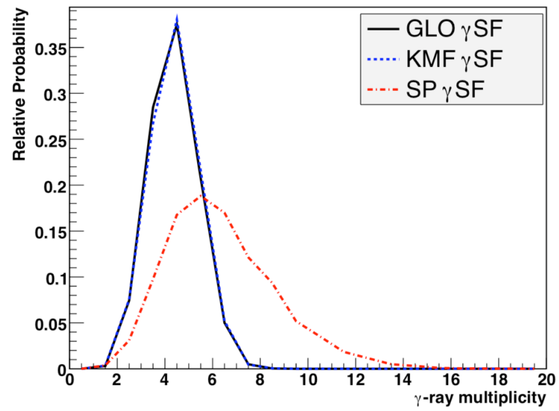

FIGURE 2. Multiplicity distribution from the decay of a J = 3$^+$ resonance in ^{96}Mo. Two standard γ-ray strength functions are compared to a γSF with a low energy enhancement. A low energy enhancement dramatically increases the γ-ray multiplicity.

Lorentzian resonance centered at 1 MeV. However, the strength of the resonance is much less than the strength function found in the (^{3}He,αγ) and (^{3}He, ^{3}He'γ) data.

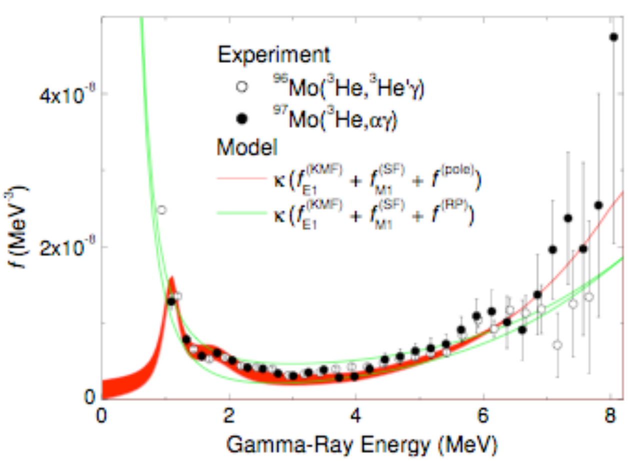

FIGURE 3. A plot of the Oslo γSF and an empirical γSF model with a Lorentzian resonance centered at 1 MeV compared to the Oslo (^{3}He,αγ) and (^{3}He, ^{3}He'γ) data.

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