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The photon strength functions from (p, γ) capture reactions.

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Abstract:
In the 1970s and 80s, (p, γ) reactions [1] were successfully utilized to measure the Photon Strength Function (PSF) using the Average Resonance Proton Capture (ARPC) Method [1, 2]. In this research, these reactions have been used to extract the slope of the PSF from the ^{50}Cr(p, γ)^{51}Mn proton capture data using the Shape method [3] with no s-wave resonance spacing data (D_0). The reactions populated entry states between the 5.3 MeV proton and 13.7 MeV neutron separation energies, which decayed through primary γ-ray transitions to low-lying discrete states. For the proof-of-principle ^{50}Cr(p, γ)^{51}Mn reaction, the Tandetron accelerator at iThemba LABS delivered proton beams of 2500 to 2740, 2760 to 3000, 3675 to 4100 and 4100 to 4500 keV in intervals of 20-25 keV with the primary γ-rays emitted being detected using a segmented Clover detector. A total of 64 γ-ray spectra were collected and with the use of the ARPC method were summed into ARPC spectra, which cover 260, 260, 425 and 400 keV excitation-energy bins. Using the average intensities of the primary γ-rays from these ARPC spectra, the slopes of the PSFs to $1/2^-$, $3/2^-$, $5/2^-$ and $7/2^-$ final states of known spin and parity in ^{51}Mn were extracted. The scaling and sewing techniques of the Shape method were used to determine the shape of the total PSF to $1/2^-$, $3/2^-$, $5/2^-$ and $7/2^-$ final states despite having no spin distribution data. The shape of the total PSF was normalized to the Simple Modified Lorentzian (SMLO) and DM1 Gogny force plus Quasi-Particle Random Phase Approximation (D1M+QRPA) PSF models [2] to obtain the absolute values of the shape of the total PSF. Despite predicting different absolute values, the two models predict slopes that are comparable to each other. The shape of the total PSF shows what might be three low-lying $E1$ structures that could influence nuclei abundance calculations. The ^{50}Cr(p, γ) cross sections calculated with the Hauser-Feshbach statistical model by using the total PSF as input when compared with the cross section calculated from direct methods shows good agreement. The level scheme of the ^{51}Mn compound nucleus was built with several new transitions and states being identified.

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Primary author: NETSHIYA, Adivhaho (WSU, WITS and iThemba LABS)

Co-authors: Prof. PELLEGRI, Luna (WITS and iThemba LABS); Prof. WIEDEKING, Mathis (WITS, iThemba LABS and Lawrence Berkeley National Laboratory, Berkeley)

Presenter: NETSHIYA, Adivhaho (WSU, WITS and iThemba LABS)

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