Indirect $(n,\gamma)^{91,92}$Zr Cross Section Measurements for the s-Process

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The playground for the nucleosynthesis is found in the interior of stars and/or in extreme cosmic events. The major contributors to creating heavier elements are the neutron capture processes [1]. The key question for these processes is whether the nuclear system after neutron absorption will keep the neutron and emitting γ rays to dissipate the energy, or will it eject the neutron or other particles/fragments and thereby producing other elements? For the s-process, this question is important at the so-called *branch points*, where the β^--decay rate is comparable with the (n,γ) rate.
Nuclear level densities (NLDs) and γ-ray strength functions (γSFs) are essential quantities in the determination of the (n,γ) rates. At the Oslo cyclotron laboratory, we have used the ^{92}Zr$(p,p'\gamma)^{92}$Zr and ^{92}Zr$(p,d\gamma)^{91}$Zr reactions to extract NLDs and γSFs using the Oslo method.
These ^{91,92}Zr γSF data [2], combined with photonuclear cross sections [3], cover the whole energy range from $E_\gamma \approx 1.5$ MeV up to the giant dipole resonance at $E_\gamma \approx 17$ MeV. The wide-range γSF data display structures at $E_\gamma \approx 9.5$ MeV, compatible with a superposition of the spin-flip $M1$ resonance and a pygmy $E1$ resonance. Furthermore, the γSF shows a minimum at $E_\gamma \approx 2-3$ MeV and an increase at lower γ-ray energies, known as *upbend*.
The experimentally constrained NLDs and γSFs are shown to reproduce known (n,γ) and Maxwellian-averaged cross sections for ^{91,92}Zr using the TALYS reaction code, thus serving as a benchmark for this indirect method of estimating (n,γ) cross sections for Zr isotopes.

References

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