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Measurement of astrophysically important excitation energies of ^{58}Zn with GRETINA

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Type I X-ray bursts are thermonuclear explosions taking place on an accreting neutron star in a low-mass X-ray binary system. The accreted material, consisting of H/He, heats up under high pressure and at a certain temperature a thermonuclear runaway is ignited. The main energy generation is driven by the rapid proton capture process (rp-process), which synthesizes elements up to $A \approx 100$ via fast (p,γ),(α,γ) and (α,p) reactions, and slower β^+ and electron-capture decays. Along the reaction path of the rp-process, several waiting points affecting element and energy production have been identified. Of special interest is doubly-magic ^{56}Ni. It has been shown that the reaction ^{57}Cu(p,γ)^{58}Zn determines the effective lifetime of ^{56}Ni since the electron-capture lifetime of ^{56}Ni is larger than 1000 s and ^{56}Ni is in (p,γ) - (γ,p) equilibrium with ^{57}Cu at rp-process temperatures. Proton capture on ^{57}Cu is the only open break-out reaction channel within typical burst timescales. So far, the rate was only calculated theoretically with large uncertainties due to the unknown level structure of ^{58}Zn.

At the National Superconducting Cyclotron Laboratory we studied the astrophysically important excitation energies of ^{58}Zn, which determine the ^{57}Cu(p,γ)^{58}Zn rate. The secondary ^{57}Cu beam was produced by many-nucleon transfer reactions of a primary ^{58}Ni beam impinging on a Be target, and further purification and separation of the beam was performed using the A1900 fragment separator. The secondary beam was transported to the S800 large-acceptance spectrometer, where a CD_2 target with a thickness of 200 mg/cm^2 was installed and surrounded by the next-generation gamma-ray detector GRETINA. Excited levels in ^{58}Zn were populated using a (d,n) reaction in the secondary target, and the de-excitation γ-rays were measured.

The presentation will focus on the details of the study and present the measured excitation energies of astrophysically important 2^+ states in ^{58}Zn and their astrophysical implications.