Low-lying level structure of $^{56}$Cu and its implications to the rp process

The low-lying energy levels of proton-rich $^{56}$Cu have been extracted using in-beam γ-ray spectroscopy with the state-of-the-art γ-ray tracking array GRETINA in conjunction with the S800 spectrograph at the National Superconducting Cyclotron Laboratory at Michigan State University. Excited states in $^{56}$Cu serve as resonances in the $^{55}$Ni(p,γ)$^{56}$Cu reaction, which is a part of the rp process in type-I X-ray bursts. To resolve existing ambiguities in the reaction Q-value, a more localized isobaric multiplet mass equation (IMME) fit is used, resulting in $Q = 639 \pm 82$ keV. We derive the first experimentally constrained thermonuclear reaction rate for $^{55}$Ni(p,γ)$^{56}$Cu. We find that, with this new rate, the rp process may bypass the $^{56}$Ni waiting point via the $^{55}$Ni(p,γ ) reaction for typical X-ray burst conditions with a branching of up to $\sim 40\%$. We also identify additional nuclear physics uncertainties that need to be addressed before drawing final conclusions about the rp-process reaction flow in the $^{56}$Ni region.