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Constraining the NiCu cycle in X-ray bursts: Spectroscopy of ^{60}Zn

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Type-I X-ray bursts are thermonuclear explosions in the atmospheres of accreting neutron stars in close binary systems. During these bursts, temperatures are achieved ($0.8 - 1.5$ GK) such that breakout from the HCNO cycle occurs, resulting in a whole new set of thermonuclear reactions; the rp-process.

Sensitivity studies have highlighted the $^{59}\mathrm{Cu}(p,\gamma)^{60}\mathrm{Zn}$ reaction as significant in its impact along the rp-process path. In particular, competition between the $^{59}\mathrm{Cu}(p,\alpha)^{56}\mathrm{Ni}$ and $^{59}\mathrm{Cu}(p,\gamma)^{60}\mathrm{Zn}$ reactions within the NiCu cycle determines whether nucleosynthesis flows towards higher-mass regions. At present, stellar reaction rates for both of these processes are based entirely on statistical-model calculations.

Recently, however, an indirect study of the nucleus ^{60}Zn has surprisingly shown a plateau in the level-density of states in the region of interest, contrary to the usual expectation of exponential growth with increasing excitation energy. As a result, a statistical-model approach of the $^{59}\mathrm{Cu}(p,\gamma)$ reaction rate may be insufficient, and it is therefore now essential to explore the properties of excited states in ^{60}Zn that influence the astrophysical $^{59}\mathrm{Cu}(p,\gamma)^{60}\mathrm{Zn}$ reaction.

In this work, we aim to utilise the $^{59}\mathrm{Cu}(d,n)$ reaction in inverse kinematics at the Facility for Rare Isotope Beams (FRIB) to obtain the first measurement of resonances in the $^{59}\mathrm{Cu}(p,\gamma)$ reaction.

Primary authors: O'SHEA, Connor (University Of Surrey); LOTAY, G. (University of Surrey); RANDHAWA, J. S. (University of Notre Dame)

Co-authors: ESTRADE, A. (Central Michigan University); GADE, A. (FRIB); ROGERS, A. M. (University of Massachussets Lowell); SPYROU, A. (NSCL); BROWN, B. A. (FRIB); REED, B. J. (University of Surrey); LONGFELLOW, B. (Lawrence Livermore National Laboratory); PAXMAN, C. (University of Surrey); BARDAYAN, D. (University of Notre Dame); SEWERYNIAK, D. (Argonne National Laboratory); DOHERTY, D. T. (University of Surrey); WEISSHAAR, D. (NSCL); MONTES, F. (NSCL); SCHATZ, H. (NSCL); HENDERSON, J. (University of Surrey); PEREIRA, J. (NSCL); CANETE, L. (University of Surrey); MOUKADDAM, M. (University of Strasbourg); WIESCHER, M. (University of Notre Dame); TIMOFEYUK, N. K. (University of Surrey); BENDER, P. C. (University of Massachussets Lowell); GASTIS, P. (Los Alamos National Laboratory); O'MALLEY, P. (University of Notre Dame); ZEGERS, R. G. T. (NSCL); KANUNGO, R. (Saint Mary's University); BYRNE, S. (University of Massachussets Lowell); NOJI, S. (FRIB); AHN, T. (University of Notre Dame); CATFORD, W. N. (University of Surrey); MEISEL, Z. (Ohio State University)

Presenter: O'SHEA, Connor (University Of Surrey)

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