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Exploring the Cosmos from the Ground: Nuclear Astrophysics at UNC/TUNL

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Nuclear astrophysics is an inherently interdisciplinary field encompassing observational astronomy, astrophysical modeling, and measurements of thermonuclear reaction rates. In general, a group studies only one of these branches in depth; however, the unique nuclear astrophysics group at University of North Carolina–Chapel Hill and Triangle Universities Nuclear Laboratory (TUNL) incorporates both theoretical and experimental research. Currently focusing on nuclear reaction measurements involved in thermonuclear explosions and heavy-element synthesis, the Laboratory for Experimental Nuclear Astrophysics (LENA) utilizes two accelerators with an energy range of $\sim 50 - 1000$ keV and current up to ~ 1.5 mA to measure proton fusion with various targets. Recent and on-going measurements include $^{23}\text{Na}(p, \gamma)^{24}\text{Mg}$, $^{14}\text{N}(p, \gamma)^{15}\text{O}$, and $^{17,18}\text{O}(p, \gamma)^{18,19}\text{F}$. Our group has also formulated a new Monte Carlo method for calculating thermonuclear reaction rates from experimental results (such as resonance strengths), in which a rigorous statistical definition of uncertainties arises naturally. These rates provide a backbone for a new type of stellar reaction rate library currently in preparation, STARLIB. This library attempts to bridge the gap between experimental nuclear physics data and stellar modelers by providing a convenient tabular format with reliable uncertainties for use in simulating astrophysical phenomena. We expect to submit STARLIB for publication by year's end, which will coincide with the unveiling of a webpage for ease of dissemination and updating. Finally, our group uses this library to run simplified models of astrophysical events, such as novae or AGB stars, via network calculations. The results from these models indicate which reactions significantly influence various isotopic abundances, thus providing motivation for new reactions to measure at LENA and other laboratories.