NOVA OUTBURST AND UNCERTAINTIES DUE TO NUCLEAR REACTION RATES

W. R. Hix[1], *M. S. Smith, A. Mezzacappa, S. Starrfield*[2], *M. W. Guidry*[3]

Nova explosions are important astrophysical events that generate enormous amounts of energy in a few hundred seconds, while synthesizing a variety of isotopes. We have begun an investigation of the nova ignition mechanism and nucleosynthesis that is unique in several ways. We will utilize for the first time Monte Carlo and sensitivity analyses to correlate uncertainties in the input nuclear physics, especially uncertainties in the reaction rates of unstable isotopes (measurements made using radioactive ion beam accelerator facilities worldwide) with uncertainties in the predicted nova energy production and nucleosynthesis. Recent investigations[4] have shown that improvments in reaction rates produce noticable effects not just on the nucleosynthesis of the nova outburst, but on such gross observables as the peak luminosity and the mass ejected. Our analyses will quantify the effects on the nova energy production and nucleosynthesis of crucial input nuclear reaction rates that are poorly known. We will focus, in particular, on the production of radioisotopes that are observational tracers of nucleosynthesis activity — such as ^{22}Na, ^{26}Al, and ^{7}Be — as well as nuclei with odd masses like ^{15}N, ^{17}O, and ^{13}C, for which novae are thought to be the prinicpal source.[5,6]

In novae outbursts, there is a strong interdependance between the nucleosynthesis and convection which eventually encompasses virtually the entire accreted layer.[7] We will therefore follow-up our Monte Carlo and sensitivity analysis with one, and ultimately multidimensional, nova simulations which couple nuclear burning and radiation hydrodynamics. In this effort we have enlisted the assistance of Sumner Starrfield. As a result of the similarity between the convective time scales and the time scales for the β-decays which limit the speed of CNO cycle nucleosynthesis, succeeding reactions in the CNO cycle often occur under very different thermodynamic conditions. This “out-of-equilibrium” hydrogen burning is responsible for the odd massed nuclei thought to typify nova nucleosynthesis. With one-dimensional models, we will be able to examine this feedback between the nucleosynthesis (and the attendant nuclear uncertainties) and the hydrodynamics of the outburst. We will also be able to quantify the impact of nuclear uncertainties on gross observables like luminosity and ejected mass.

---

[1]Guest assignee from University of Tennessee, Knoxville.
[2]Arizona State University, Tempe.
[3]Adjunct staff member from University of Tennessee, Knoxville.
[4]S. Starrfield, J. W. Truran, M. C. Wiescher, and W. M. Sparks, *MNRAS* **296**, 502 (1998).
[5]S. E. Woosley et al., *Nucl. Phys.* A **621**, 445 (1997).
[6]J. Jose and M. Hernanz, *Nucl. Phys.* A **621**, 491 (1997).
[7]See, e.g., S. A. Glasner, E. Livne, and J. W. Truran, *Ap. J.* **475**, 754 (1997).