Joint Nuclear and Astrophysics Seminar

When: Friday November 8th at 12.00PM
Where: Room 228 Cyclotron Institute
Speakers: Sunghoon Ahn and Terese T. Hansen

Study of the direct neutron capture cross section on $^{80}$Ge

The rapid neutron capture process (r-process) occurs in astrophysical environments with exceedingly high temperatures (> 1 GK) and neutron densities (> $10^{22}$/cm$^3$) such as neutron star mergers. It is also known as the source of roughly half of the elements heavier than iron. During r-process freeze-out, the temperature drops and the $(n, \gamma) - (\gamma, n)$ equilibrium breaks. Neutron capture reactions on abundant nuclei can significantly alter the number of free neutrons, affecting the final abundances of hundreds of nuclei. Sensitivity studies by R. Surman et al. demonstrated that this effect at the $A = 80$ peak in the solar abundance pattern occurs on select nuclei around neutron closed shells, including $^{80}$Ge. The $^{80}$Ge$(n, \gamma)$ rate was shown to have a significant impact on final abundances with more than twice the impact of either the $^{92}$Ge$(n, \gamma)$ or $^{84}$Se$(n, \gamma)$ reaction rates. It has not been possible to estimate the direct $(n, \gamma)$ rate on $^{80}$Ge with any level of confidence because the spin assignments and spectroscopic strengths of low-lying $^{81}$Ge levels were unknown. The low-lying levels of the $N = 49$ nucleus $^{81}$Ge have been studied by measuring the $^{50}$Ge$(d,p)^{81}$Ge neutron transfer reaction at 310 MeV (3.875 MeV/u) in inverse kinematics at the Holifield Radioactive Ion Beam Facility at Oak Ridge National Laboratory. Newly-measured spins and spectroscopic factors of low-lying states of $^{81}$Ge are determined, and the neutron-capture cross section on $^{80}$Ge was calculated in a direct-semi-direct model to provide a more realistic $(n, \gamma)$ reaction rate for r-process simulations. Details of the experimental setup and interpretation of the data analysis will be discussed.

The R-Process Alliance - a new search for r-process enhanced stars

A small fraction (5%) of metal-poor stars show large enhancement in r-process elements. These stars are excellent laboratories for studying the r-process as the gas from which these stars formed was polluted by at most a few enrichment events — perhaps even a single explosion. However, many of the currently known r-process enhanced stars are faint, impeding a detailed abundance analysis. A full abundance pattern for these stars is needed to disentangle nucleosynthesis signatures from different r-process element production sites. I will report on recent results from the R-Process Alliance (RPA), a new effort to uncover bright metal-poor halo stars with r-process element enhancements. The RPA has already identified >30 new r-II stars, increasing the number of known r-II stars by almost 100%. This sample includes the brightest, most metal-rich, and most Uranium enhanced r-II stars discovered to date.