Neutron production and capture in stellar nucleosynthesis: $^{22}Ne(\alpha,n)^{25}Mg$ reaction and radiative neutron captures of radioactive nuclei

Most of elements heavier than Fe in the Universe are produced by a series of neutron capture reaction and β^--decay in stars. The *s*-process, which occurs under moderate neutron environments ($\sim 10^{7\text{-}10}$ neutrons/cm^3) such as in He burning of massive stars, is responsible for producing almost half of the heavy elements. Neutrons for the *s*-process environment is believed to be supplied by two dominant reactions, one of which is $^{22}Ne(\alpha,n)^{25}Mg$ reaction. This reaction in massive stars is dominated by a few resonance reactions. Nevertheless, there remain large uncertainties about contribution of the reaction to the *s*-process nucleosynthesis because the reaction cross sections are too small for direct measurements due to Coulomb barrier ($E\alpha$ = 400-900 keV in the lab system). In the first half of this seminar, I will present our experiment to determine these resonance strengths with a cyclotron accelerator at Texas A&M University. The experiment was performed by an indirect approach using $^{6}Li(^{22}Ne,^{25}Mg+n)d$ α-transfer reaction, in which resonance properties such as neutron decay branching ratios of produced ^{26}Mg were studied by measuring deuterons, γ-ray, and ^{26}Mg in coincidence using large arrays of Si and Ge, and a magnetic spectrometer. Our results showed neutron production from $^{22}Ne(\alpha,n)^{25}Mg$ reaction can be about 10 times lower than past measurements. The effect of our measurements on the *s*-process nucleosynthesis will be discussed.

In the second half of this seminar, I will present our experiments to determine neutron capture cross sections of radioactive nuclei using the Surrogate Reaction method [1]. Neutron capture reactions for the *s*-process involve relatively long-lived nuclei neighboring stability in the nuclear chart. Therefore, the Surrogate Reaction, which creates the same compound nuclei as the neutron capture reaction using a stable beam and target, can be a useful approach. On the other hand, the *r*-process, which produces the other half of the heavy elements under extremely strong neutron environments ($\sim 10^{20\text{-}22}$ neutrons/cm^3) such as neutron-star mergers, involves short-lived neutron-rich nuclei far from stability. I will introduce a possible approach to deduce neutron capture reaction cross sections of these nuclei using radioactive ion beams.

[1] S. Ota et al., Phys. Rev. C 92 054603 (2015).