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Investigating the Statistical Properties of Rare Earth Elements

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Radiative capture and photodisintegration reactions involving neutrons are of particular importance to various nuclear astrophysics applications. For example, all the elements above iron are produced through processes that involve neutrons. In case of s- and r- processes, neutron capture reactions play a role, while for the initial stages of the p-process are driven by (γ,n) reactions.
While the underlying reaction mechanisms of the r-, s-, and p-processes are widely accepted, the results of the network calculations of these processes do not agree with measured galactic abundance patterns.
Therefore, the ability to effectively constrain (n, γ) and (γ, n) reaction rates over the appropriate mass regions and Gamow windows is important to the understanding of nucleosynthesis beyond the iron peak.

Experimental constraints, however, make measurements of these types of cross sections nontrivial.
Therefore, it is essential to have a reliable method for predicting (n, γ) and (γ, n) reaction cross sections.
Since the reactions of interest take place over a mass and energy range where compound-nuclear formation dominates, the Hauser-Feshbach statistical model can be used to calculate (n, γ) and (γ, n) cross sections.
Additionally, surrogate measurements of these reactions using more easily accessible reaction channels can be performed as a way of indirectly measuring the reaction of interest.
Both the indirect measurements and statistical model calculations require a thorough understanding of the statistical properties of the compound nucleus formed during the reaction.
The intention of this work is to measure these statistical properties using the Oslo method.

Data for this experiment was taken at Texas A&M University, using the Hyperion particle-γ detector array.
Reactions measured include $^{148}\mathrm{Sm}(p, d)$, $^{148}\mathrm{Sm}(p, t)$, $^{162}\mathrm{Dy}(p, d)$, and $^{162}\mathrm{Dy}(p, t)$.
Particle-γ coincidence matrices will be generated for these reactions, and run through the Oslo method fitting algorithms to simultaneously extract γ-strength function and nuclear level density.
The data taken will be able to explore the existence of the low energy enhancement of the γ-strength function in a spherical and deformed nuclear system, experimentally probe the electromagnetic character of the low energy enhancement, and potentially be used to make a surrogate measurement of (γ, n) cross sections that can be compared to Hauser-Feshbach calculations performed with the extracted statistical properties.

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Primary author: Mr REINGOLD, Craig (University of Notre Dame)

Co-authors: Dr SIMON, Anna (University of Notre Dame); Dr SAASTAMOINEN, Antti (Texas A&M University); Mr SCHROEDER, Benjamin (Texas A&M University); Mr BLANKSTEIN, Drew (University of Notre Dame); Dr BURKE, Jason (Lawrence Livermore National Laboratory); Prof. CIZEWSKI, Jolie (Rutgers University); Dr CHIPPS, Kelly (Oak Ridge National Laboratory); Dr SCHMIDT, Konrad (National Superconducting Cyclotron Laboratory); Mr HALL, Matthew (University of Notre Dame); Dr COOPER, Nathan (University of Notre Dame); Dr HUGHES, Richard (Lawrence Livermore National Laboratory); Mr BURCHER, Sean (University of Tennessee Knoxville); Dr OTA, Shuya (Texas A&M University); Mr UPADHYAYULA, Sriteja (Texas A&M University); Dr AHN, Sunghoon (Tony) (JINA/NSCL)

Presenter: Mr REINGOLD, Craig (University of Notre Dame)

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