Title: Physics of slow and rapid neutron capture processes
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A description and justification:

Production mechanisms for elements heavier than iron, by slow (s-process) and fast (r-process) captures of neutrons, have been known for a long time , yet finding conditions in Nature and understanding the physics that allow these processes to robustly operate has been more elusive. Half of the elements heavier than iron are made by the s-process. The astrophysical origin sites are assumed to be helium core burning in massive stars and helium shells of low-mass giants. The search for an r-process production site has proven especially difficult, although recent work on a new production mechanism (r-process without excess neutrons) and origin site (ejecta of fallback material in core-collapse supernovae) shows the vitality of the science.

The solar r-process abundances are defined as solar minus s-process. The physics of both processes are intertwined and include theoretical nuclear physics, experimental nuclear physics, observations of stars, astrophysics models, and measurements of presolar meteortic grains. We believe that it is time to renew ties between the s- and r-processes and the the five physics communities as new developments are taking place in all of these fields.

In the nuclear physics domain new experimental possibilities are available at facilities like DANCE@LANL or nTOF@CERN. These are enabling neutron-capture cross-section measurements on a broad range of stable and radioactive isotopes. Even more capable instruments (e.g., FAIR-GSI or a reborn-RIA) may emerge in the future to address questions of nucleosynthesis at higher neutron flux conditions. In parallel, theoretical efforts continue to account for nuclear effects in hot, dense stellar plasmas and for environments that will remain inaccessible to direct experiment.

Significant advances in laboratory analytical instrumentation, coupled with more sophisticated methods of processing meteorites, make it possible to measure isotopic compositions of trace elements in individual circumstellar grains extracted from primitive meteorites. These measurements are vigorous constraints on models of the s-process and their astrophysical origin site, including grain formation. They motivate new measurements of nuclear physics experiments for the models. Accounting for these grain measurements may require new mechanisms of nucleosynthesis that are currently not part of the standard paradigm.

New technology in astronomy has permitted the number of stars whose neutron capture nucleosynthesis is directly probed by observations, particularly stars with extremely low metalicities (e.g. SDSS-II SEGUE). Such observations give new insights into the evolution of the elements heavier than iron, allow new insights on the relationship between the s- and r-processes. Astronomical abundance observations of trans-iron elements are expected to play an important role in future near-field cosmology applications.

Modelling of neutron capture production sites requires a more accurate understanding of burning and mixing in stars. New advances are occurring in the hydrodynamic treatments and thermodynamic conditions at the nuclear origin sites within the model stars. This progress

will require incorporating the new experimental and observational results into a theory which can be implemented into numerical models. For example, the abundance patterns of Sr, Y and Zr in stars and presolar grains suggest a complicated evolution history that requires one to consider the chemical evolution of the entire Milky Way. Models of the s- and r-process origin site(s) need to be promoted to a quantitative, predictive level.

The purpose of the workshop is two-fold:

1. To provide the opportunity to bring researchers working on the different aspects of neutron capture process together for communication and information exchange and to generate new collaborations and research initiatives in this highly interdisciplinary field.

2. To furnish a coordinated approach to the anticipated future developments, including the exerimental nuclear facilities.

Possible Organizers:

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Possible participants:

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