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A new approach for measuring direct neutron capture reactions in storage rings

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Storage rings coupled to radioactive beam facilities have allowed to access experiments of astrophysical interested that cannot be carried out otherwise. If such a storage ring could be coupled to a "neutron target", this would allow for the first time the direct measurement of neutron capture cross sections of short-lived radionuclides down to seconds of half-lives.

The creation of elements heavier than iron in stars is almost completely driven by three neutron capture processes: the "slow" (s) and "rapid" (r) process are responsible for ~99% of the observed stable abundances, while the intermediate (i) process can account for some abundance patterns in so-called "carbon-enhanced metal-poor stars" enhanced with elements associated with the s- and the r-process (CEMP r/s stars).
The most important missing puzzle piece for all of these three neutron capture processes are experimental neutron capture cross sections on short-lived nuclei with half-lives below 100 d. The vast majority of the cross sections of stable and longer-lived nuclei at astrophysically relevant energies (keV) have been measured in the past 50 years and used to benchmark and improve theoretical models, leading to an agreement within a factor of 2-3 with the statistical Hauser-Feshbach model at and close to stability.

However, once one moves away from stability, these predictions become unreliable and show variations up to a factor of 100-1000 between different models with different input parameters. This uncertainty directly translates into large uncertainties in the modelling of astrophysical abundances, especially in the i- and r-process.

To overcome these limitations, neutron capture cross sections for shorter-lived nuclei have to be directly measured and used to benchmark theoretical predictions far off stability. So far the direct measurement of neutron capture cross sections of shorter-lived nuclei is impossible due to the unavailability of macroscopic amounts (sample sizes larger than 1e15 atoms) of the "target" material for neutron activations at astrophysical energies.

In "inverse kinematics" a radioactive beam could be used to impinge on a "neutron" target. I will summarize a path forward for the construction of such a pioneering "neutron capture storage ring" at the TRIUMF-ISAC facility and outline the limitations of such a facility of the "first generation".

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