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Direct radiative neutron captures for astrophysics - Status quo

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Neutron capture reactions play a crucial role for the understanding of the synthesis of elements heavier than iron in stars and stellar explosions via the slow (s), intermediate (i), and rapid (r) neutron capture processes. In all three processes, the fine balance between neutron capture and beta-decay rates under the given astrophysical conditions defines how long a nucleus can accumulate material before decaying into the next isotopic chain.

Most of the s-process neutron captures on stable or long-lived nuclei (t(1/2)» 10 y) along the line of stability and have been experimentally constrained in the past 50 years [1], with satisfying precision for most astrophysical modelling. However, the direct measurement of neutron cross sections with shorter half-lives (t(1/2) <1 year) requires the use of radioactive beams in inverse kinematics and the development of new methods. Only a few measurements have been performed so far with these indirect methods. This general lack of experimentally constrained data leads to large deviations between various Hauser-Feshbach predictions for very neutron-rich nuclei [2] which also makes abundance predictions for the r-process very unreliable [3].

I will give a short introduction about the limitations of direct measurements, as well as the status of direct neutron capture reactions in the astrophysical energy range.

[1] I. Dillmann, O. Kester, et al., Eur. Phys. J. A59 (2023) 105
[2] S.N. Liddick, A. Spyrou, et al., Phys. Rev. Lett. 116 (2016) 242502.
[3] S. Nikas, et al. (2020). https://doi.org/10.48550/arXiv.2010.01698

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