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Calibrating the medium effects of light clusters in heavy-ion collisions

Light nuclei are found in core-collapse supernova matter and in binary neutron star mergers. Their abundance can affect the dynamics and properties of supernovae [1-3] and binary neutron star mergers [4-8], both directly through their weak reactions with the surrounding medium, and indirectly through their competition with heavy nuclei [9], which can modify the proton fraction and the size of nucleosynthesis seeds [10]. They can also have a significant (indirect) effect on the dynamics of the core-collapse supernova explosion giving rise to a faster shock retreat and an early neutrino luminosity [11], even though, only a negligible (direct) impact from the weak reactions involving the light clusters was obtained. The transport coefficients are determined by the collision rates of electrons and/or neutrinos with clusters, which in turn depend on the cluster abundances and sizes. In binary mergers, the recombination of free nucleons into α particles can generate enough energy to induce mass outflows [12]. Therefore, the study of light nuclei is essential to obtain a good description of these astrophysical events. In particular, in the scope of relativistic mean-field models, their nuclear couplings need to be calibrated to experimental data such as heavy-ion collisions. In this work [15], we propose a Bayesian inference estimation of in-medium modification of the cluster self-energies from light nuclei multiplicities measured in selected samples of central ^{136,124}Xe+^{124,112}Sn collisions with the INDRA apparatus. The data are interpreted with a relativistic quasi-particle cluster approach in the mean-field approximation without any prior assumption on the thermal parameters of the model. An excellent reproduction is obtained for H and He isotope multiplicities, and compatible posterior distributions are found for the unknown thermal parameters, for two different nuclear models.

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