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BETAFLOWNET: A Practical Nuclear Network Geared Towards Coupling with Hydrodynamics Simulations

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Accounting for out-of-NSE (nuclear statistical equilibrium) r-process nucleosynthesis is one of the most sought-after goals in the (numerical) modelling of binary neutron star (BNS) mergers. While post-processing analysis via full nuclear networks is a reliable technique, the computational and storage costs prevent such calculations to be directly coupled to hydrodynamics codes, thus neglecting the dynamical influence of the r-process heating. We present here a novel framework, akin to a reduced network, based on top of the "beta-flow" approximation, that drastically reduces the computational and storage requirements w.r.t. a full network while returning accurate predictions for both isotope abundances and heating rate. This technique features: 1) far less degrees of freedom than a full network ($\sim$ 500 vs. $\sim$ 7500); 2) explicit split between dominant/subdominant and fast/slow reactions; 3) ability to accurately track the time evolution of abundances and heating rate. We summarize its base assumptions and derivation, practical implementation issues, and its application to parametrized BNS ejecta along with a detailed comparison w.r.t. to full networks such as SkyNet and WinNet. Finally, we show the first results of BNS merger simulations with inline nucleosynthesis performed with this model.

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