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Unraveling the Influence of Magnetic Fields on the Nucleosynthesis in Magnetorotational Supernovae

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Magnetorotational supernovae are hypothesized as environments for the rapid neutron-capture process (r-process) responsible for the formation of heavy elements in our Universe. The magnetic fields within these events are a key ingredient in this process, yet their precise strength and configuration remain elusive. To address this, we analyzed comprehensive 3D MHD supernova simulations with sophisticated neutrino transport, exploring the impact of both magnetic field strength and topology on the nucleosynthesis. Our findings highlight the critical role not only of magnetic field strength but also of topology in the synthesis of heavy elements. Significantly, our study encompasses a range of magnetic field configurations beyond the conventional aligned large-scale dipole, revealing that the r-process occurs solely under the aligned large-scale dipole scenario. Moreover, we demonstrate the robustness of this result against nuclear physics uncertainties, such as nuclear masses and beta decays. Notably, all calculations were executed utilizing the state-of-the-art single-zone nucleosynthesis network WinNet, recently released as open-source software.

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