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The Collimation of Relativistic Jets in Late Post-Neutron Star Binary Merger Simulations

The gravitational waves from the binary neutron star merger GW170817 were accompanied by a multiwavelength electromagnetic counterpart, which confirms the association of the merger with a short gamma-ray burst (sGRB). The afterglow observations implied that the event was accompanied by a narrow, ~5°, and powerful, ~1e50 erg, jet. We study the propagation of a Poynting flux-dominated jet within the merger ejecta (kinematic, neutrino-driven, and magnetorotational instability turbulence-driven) of a neutrino-radiation-GRMHD simulation of two coalescing neutron stars. We notice that a postmerger low-density/low-pressure polar cavity, which arose due to angular momentum conservation, is crucial to letting the jet break out. At the same time, the ejecta collimates the jet to a narrow opening angle. The collimated jet has a narrow opening angle of ~4°-7° and an energy of 1e49-1e50 erg, in line with the observations of GW170817 and other sGRBs. Furthermore, we run a set of 2.5D high-resolution cylindrical RHD simulations where we inject a narrow, powerful jet into the post-merger phase of the BNS for different opening angles, luminosities, and times after the merger. We explore the case of an early launch of the jet at 0.1 s and a late launch at 1 s after the merger; the latter is consistent with the time delay of ≈ 1.74 s observed between GW 170817 and GRB 170817A.

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