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The velocity distribution of outflows driven by choked jets in stellar envelopes

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Many stripped envelope supernovae (SNe) present a signature of high-velocity material responsible for broad absorption lines in the observed spectrum. These include SNe that are associated with long gamma-ray bursts (LGRBs) and low-luminosity GRBs (llGRBs), and SNe that are not associated with GRBs. Recently it was suggested that this high-velocity material originates from a cocoon that is driven by a relativistic jet. In LGRBs, this jet breaks out successfully from the stellar envelope, while in llGRBs and SNe that are not associated with GRBs the jet is choked. Here we use numerical simulations to explore the velocity distribution of an outflow that is driven by a choked jet, and its dependence on the jet and progenitor properties. We find that in all cases where the jet is not choked too deep within the star, the outflow carries a roughly constant amount of energy per logarithmic scale of proper velocity over a wide range of velocities, which depends mostly on the cocoon volume at the time of its breakout. This is a universal property of jets driven outflows, which does not exist in outflows of spherically symmetric explosions or when the jets are choked very deep within the star. We therefore conclude that jets that are choked (not too deep) provide a natural explanation to the fast material seen in the early spectra of stripped envelope SNe that are not associated with LGRBs, and that properties of this material could reveal information on the otherwise hidden jets.

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