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The Correlation Between Supernova Fallback and Progenitor's Hydrogen Envelope

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During a core-collapse supernova, a strong reverse shock forms at the interface between the hydrogen envelope and the helium core, slowing the ejecta and driving some material back onto the newborn compact object. Conventional Eulerian simulations usually place an inner radial boundary, yet when the reverse shock reaches this boundary, it can generate a reflecting wave that hides the true accretion history. To avoid this drawback, we treat the stellar core as a point mass that supplies gravity and surrounds it with a very light buffer zone, so inflow passes smoothly to the center, and spurious reflections disappear. Using the hydrodynamics code Athena++, we follow the shock inward for various explosion energies and discover a steep change in remnant compact object mass around the binding energy of the hydrogen envelope (10^{47} up to 10^{50} erg). If the explosion energy exceeds the binding energy of the hydrogen envelope, the reverse shock doesn't reach the core. In contrast, when the explosion energy is similar to or lower than the binding energy of the hydrogen envelope, the reverse shock infalls to the center. More than two solar masses settle on the remnant, making it heavier. This boundary-free method, therefore, gives the first reliable connection between explosion energy, envelope binding energy, and fallback accretion.

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