A **black hole** forms a second after shock revival and yet culminates in a **successful supernova**. Microphysics dictate the **ejecta composition**.

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Black Hole Supernovae and their Equation-of-state Dependence

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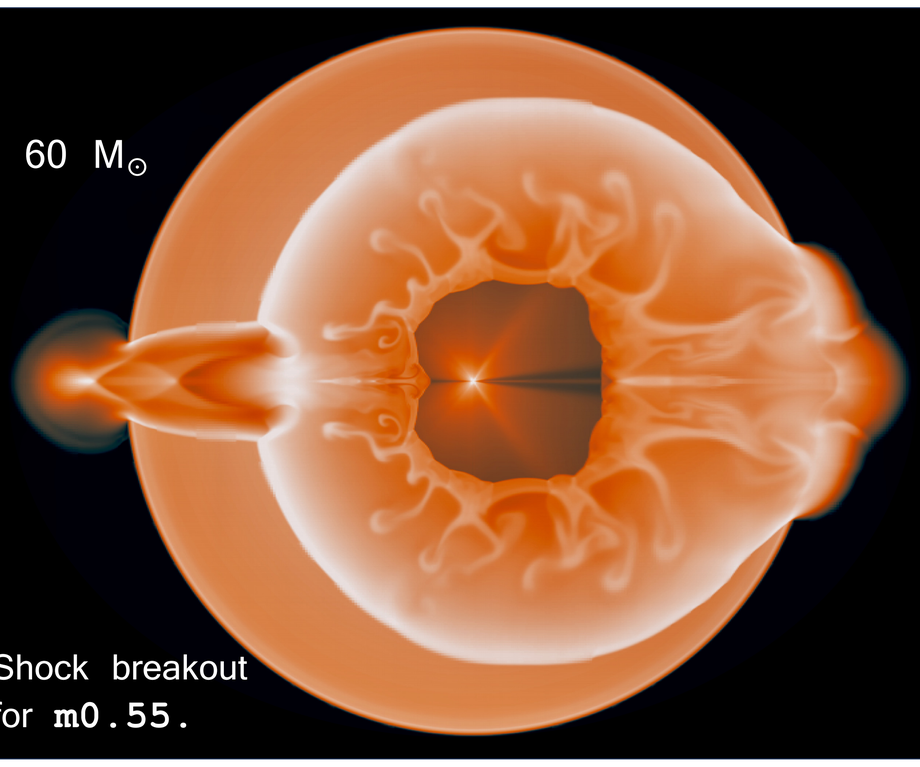
ABSTRACT

We perform comprehensive, self-consistent, 2D simulations of core-collapse supernovae through collapse, shock revival, past black hole (BH) formation and beyond shock breakout. We vary the effective mass parameter in the thermal part of the nuclear equation-of-state, one of the main uncertainties in the outcome of core-collapse supernovae [1]. We perform 3 end-to-end simulations in total.

METHODS

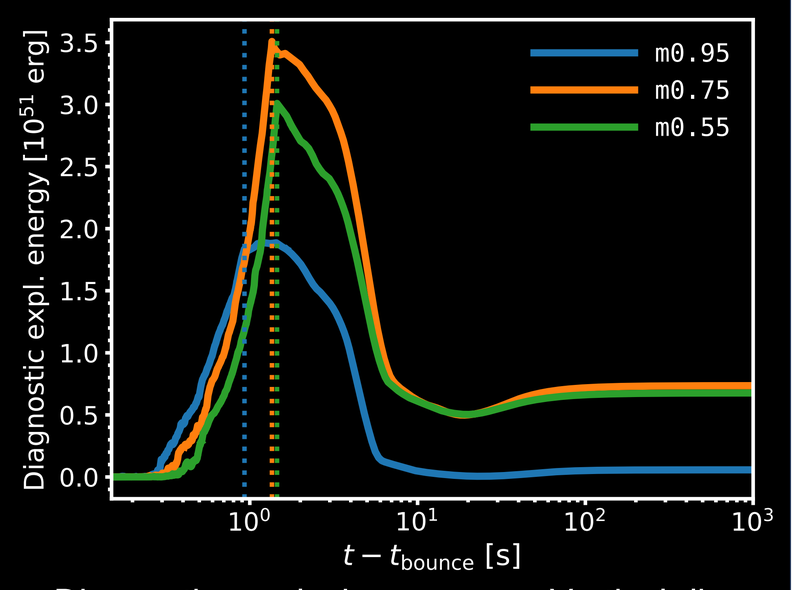
We evolve a 60 $M_\odot$ ZAMS progenitor [2] within the FLASH simulation framework [3] with multi-group, energy-dependent, two moment M1 neutrino transport and an effective general relativistic potential [4]. As a post-processing step at the time of BH formation, we calculate the nucleosynthetic yields using SkyNet [5]. After BH formation, we mask the central region and accumulate the accreted mass onto a point mass and continue the evolution past 22 days.

EXPLOSION ENERGY



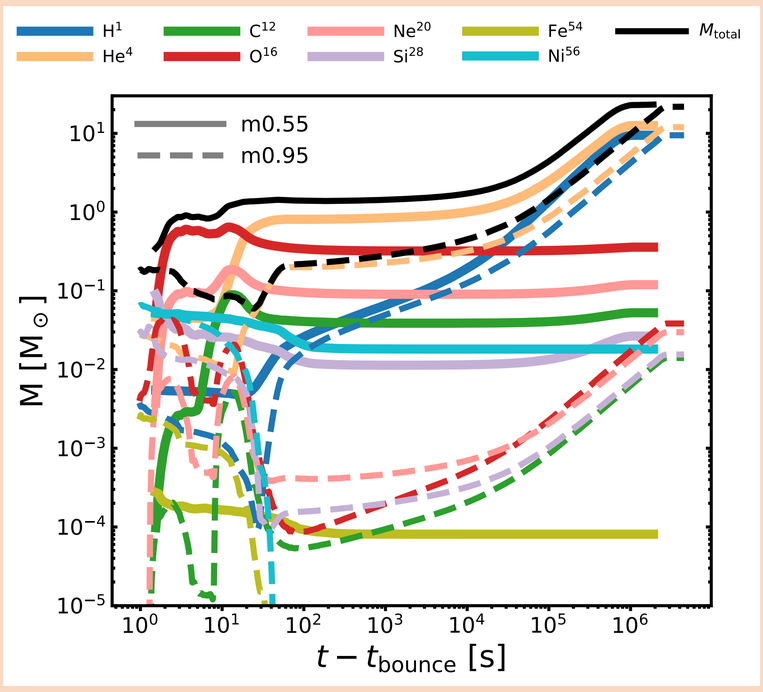
Shock breakout for **m0.55**.

A higher effective mass translates into a thermally soft equation-of-state. Therefore, BH formation occurs sooner for **m0.95**, resulting in both a lower peak and lower final explosion energy. The final explosion energies vary between $0.06 - 0.7 \times 10^{51}$erg across the models.



Diagnostic explosion energy. Vertical lines indicate BH formation.

EJECTA COMPOSITION



Evolution of the ejecta composition.

Much of the explosively produced elements accrete onto the BH for the **m0.95** model compared to **m0.55**. In particular, no Ni^{56} escapes while 1.8% of a solar mass is ejected for **m0.55**. **This impacts the light curve and spectrum**.

Taking this explosive BH formation channel into account **affects the nucleosynthetic feedback into the interstellar medium**.

BLACK HOLE

This BH-formation channel, seen by other simulation groups as well [6,7], **impacts the compact object mass distribution**. The conventional assumption for this progenitor would be that a 47.3 $M_\odot$ BH is left behind. Here, a **~25 $M_\odot$ BH** is made, with additional variation depending on the thermal equation-of-state.

Gravitational mass of the compact object.

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