Exploding Core-Collapse Supernovae with Jittering Jets

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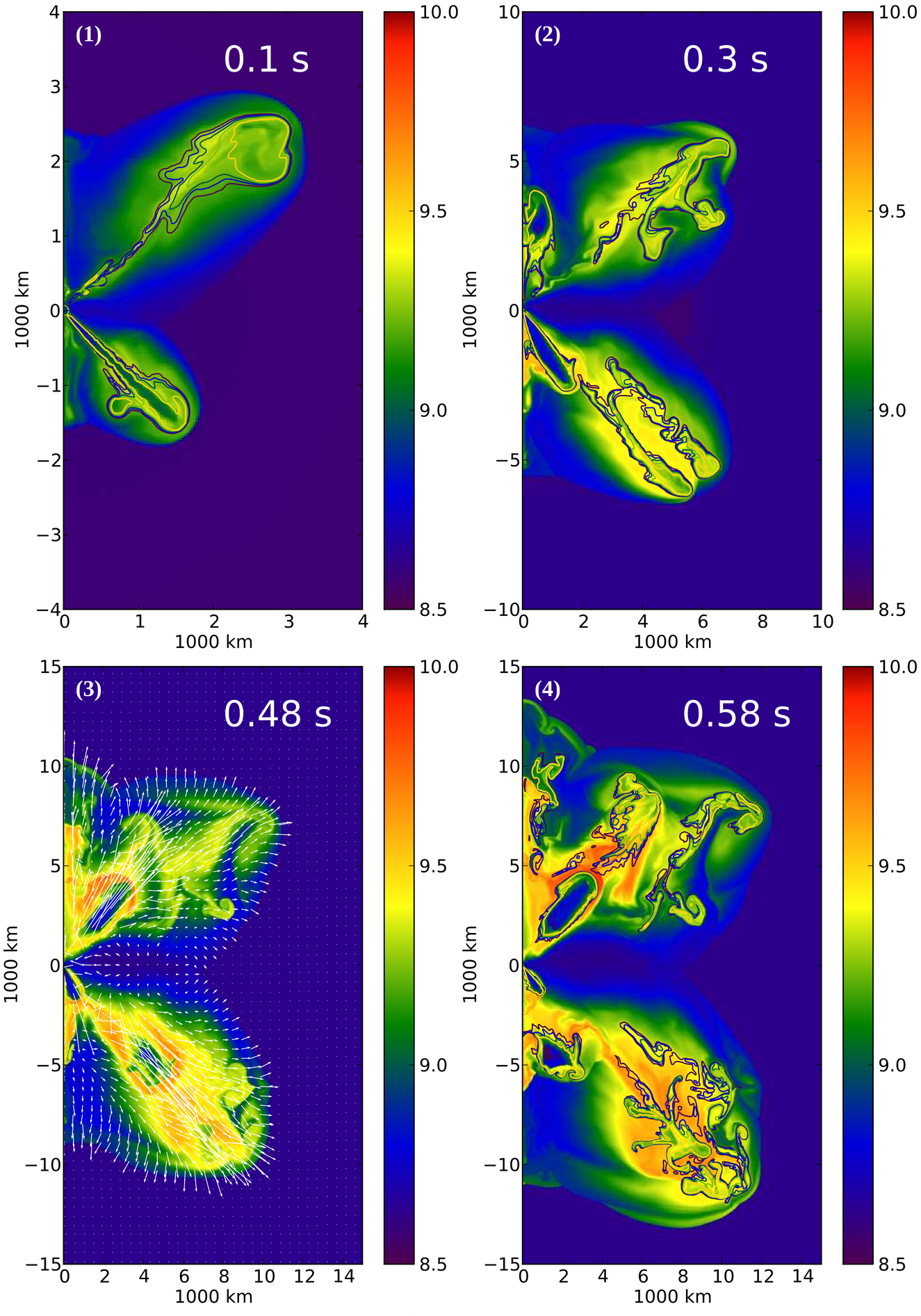
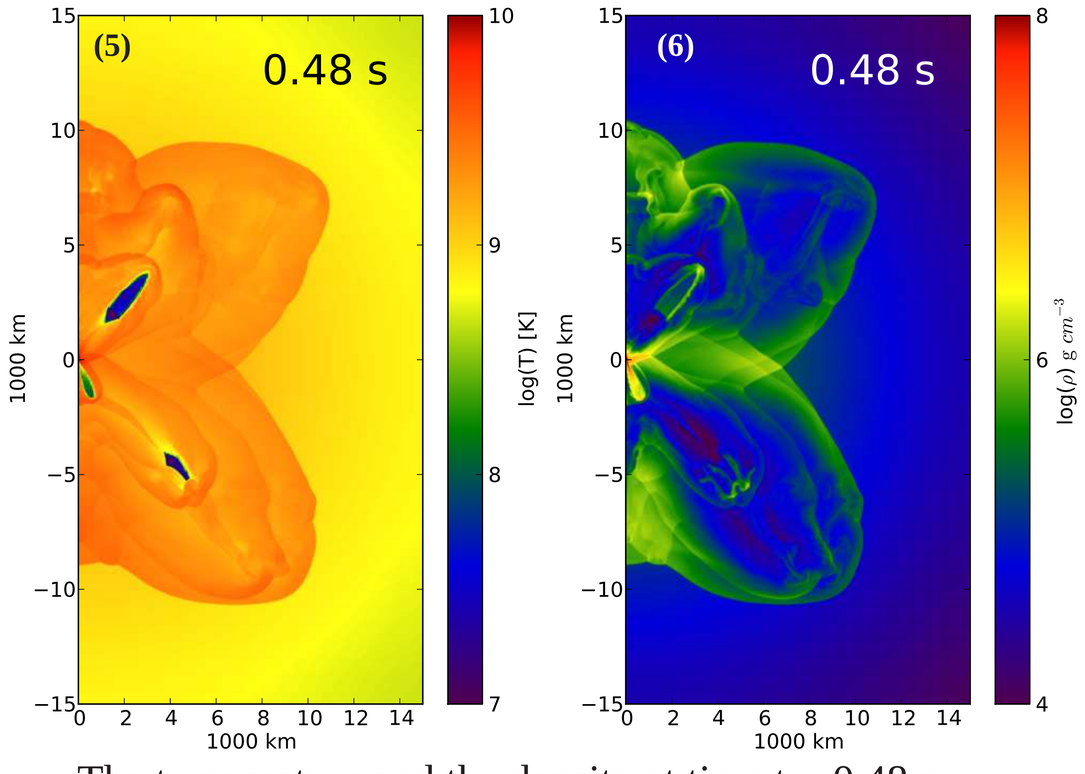
Abstract: We present new results of the jittering-jets model for the explosion of core collapse supernovae (CCSNe). In this model part of the collapsing gas possesses local angular momentum as a result of stochastic processes and instabilities (e.g., SASI) and forms an intermediate accretion disk. This accretion disk launches two opposite jets. Due to the rapid change in the disk's axis, the jets can be intermittent and their direction can be rapidly varying. We present new post-bounce 2.5D simulations using the FLASH hydrodynamic numerical code, which show that the jittering jets model can explode the star. We investigate the parameters by which the jittering jets can deposit their energy inside the star forming hot bubbles that lead to the explosion.

Main Points of The Model

- The explosion mechanism is driven by jets.
- We do not assume the revival of the stalled shock.
- We assume the existence of a local angular momentum for segments of the accreted gas.
- We make use of results that show that accreted gas parcels possess stochastic angular momentum. The formation of an accretion disk with varying axis direction is a likely outcome.





The temperature and the density at time t = 0.48 s.

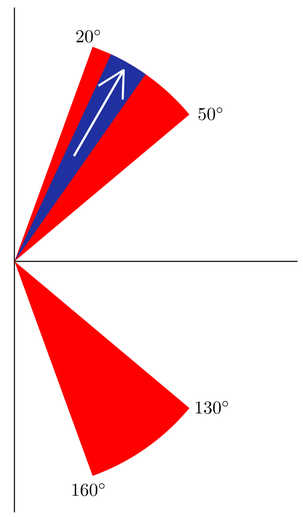
Shown is the entropy at different times. The jets create two hot bubbles that combine into one hot bubble at time t = 0.48 s. The contours represent the jets material. Shown also are the velocity at time t = 0.48 s.

The Simulations

- We use FLASH 4.0-beta.
- 2D cylindrical coordinates.
- Grid size is 15,000 X 30,000 km.
- 12 mesh refinement levels.
- Neutrino cooling scheme includes contributions from electron-positron pair annihilation and electron/positron capture on free nucleons.

The Jets

- The jets are injected in pairs, alternating between the two half planes.
- Jets' half opening angle is $\alpha = 5^\circ$
- $v_{jets} = 100{,}000 \text{ km s}^{-1}$



Each jet episode is injected in a section as marked in blue. The direction is varied within the red region. The geometry has an axial symmetry around the vertical line.