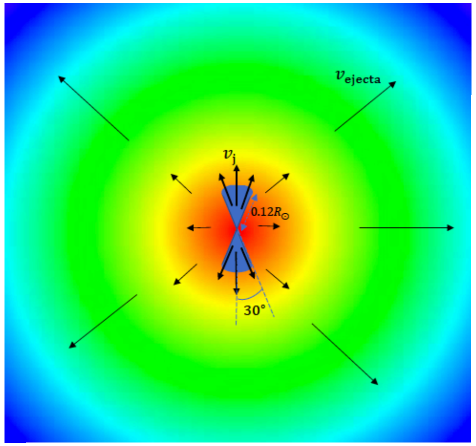
Post-explosion positive jet-feedback activity in inner ejecta of core collapse supernovae

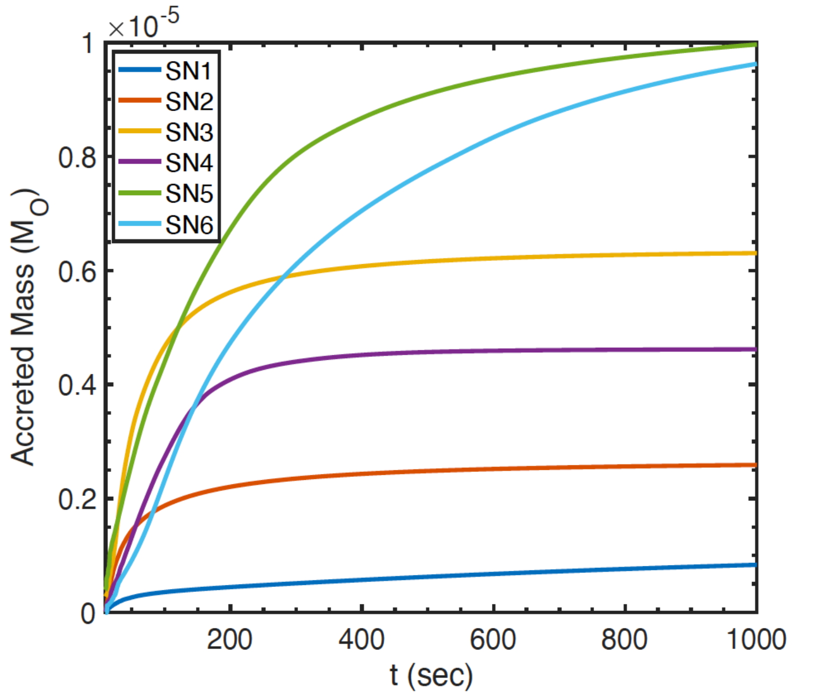
Muhammad Akashi[1,2] and Noam Soker[1]

We conduct three-dimensional hydrodynamical simulations of weak jets that we launch into a core collapse supernovae (CCSNe) ejecta half an hour after the explosion and find that the interaction of the fast jets with the CCSN ejecta creates high pressure zones that induce a backflow that results in mass accretion onto the newly born neutron star. In cases of weak jets, a total power of $\approx 10^{45} - 10^{46}$ erg, the backflow mass accretion might power up to an order of magnitude more energetic jets. In total, the jets of the two post-explosion jet-launching episodes have enough energy to influence the morphology of the very inner ejecta, a mass of $\approx 0.1 M_{\odot}$. Our results imply that in some, probably a minority of, CCSN remnants the very inner regions might display a bipolar structure that results from post-explosion weak jets. The regions outside this part might display the morphology of jittering jets.

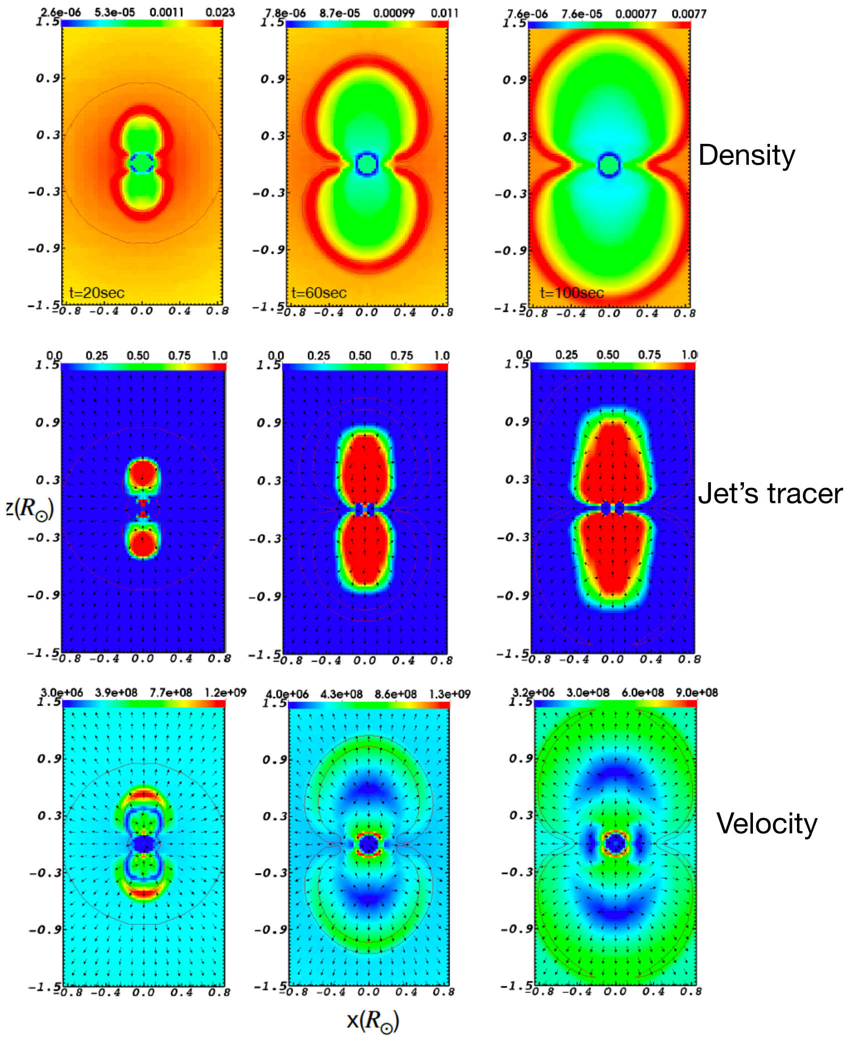
The Model: (FLASH Code)



$$\rho(r,t) = \begin{cases} \rho_0 \left(\frac{r}{t_e v_{\rm br}}\right)^{-1} & r \le t v_{\rm br} \\ \rho_0 \left(\frac{r}{t_e v_{\rm br}}\right)^{-10} & r > t v_{\rm br}, \end{cases}$$



Backflow accreted mass (in $M_{\odot}$) onto the inert core as a function of time for the six simulations we perform here In the inset we list the the names of the different simulations.



In light of our results, we predict that in some cases, probably only in a small fraction of CCSNe, the very inner part of a supernovae remnant might display a bipolar structure that results from post-explosion weak jets. The regions outside this part might display the morphology of jittering jets. More detail studies of the structure will require hydrodynamical simulations to much later times and that include more ingredients, like radiative transfer.