Do circumstellar collisions make observable transients in aspherical supernovae?

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Intro

ABSTRACT

When aspherical supernovae (SNe) produce substantially oblique flows, equatorial collisions can occur. It remains to be answered whether these collisions are observable. We use hydrodynamic simulations to determine that conditions exist such that an equatorial collision can be observable.

BACKGROUND

Equatorial collision energetics have been studied and potential emission is predicted to be in the UV/low-energy gamma ray band-ranges. However, it is not clear whether it is possible for these collisions to be observable. In order for the collision to occur, photon diffusion must be low enough to trap photons during the acceleration phase, but for the collision to be observable, diffusivity must be high enough for photons to escape during the collision phase.

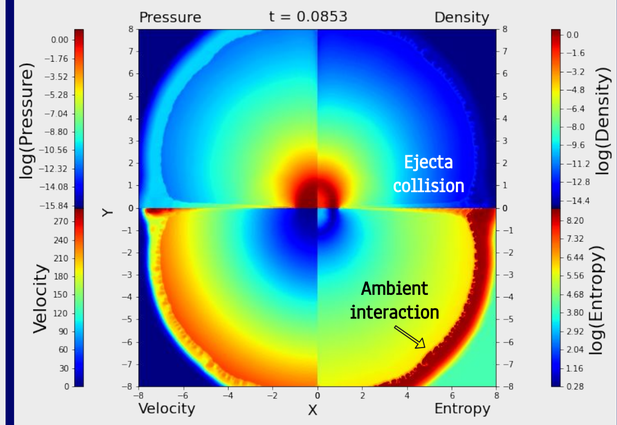
With ULTRASAT (a wide field UV telescope) planned to launch in 2025, answering this question is exceedingly relevant.

RESEARCH

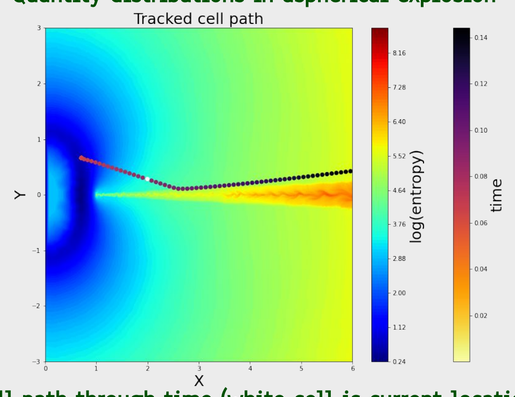
METHOD

We use a hydrodynamic simulation (HUJI-RICH) to model aspherical SNe. We model the progenitor as a simple n=3 polytrope and neglect details for an internal engine. Although not highly realistic, this allows for more general analysis in post processing.

We track cells from the surface of the star into the collision zone in order to conduct our analysis.



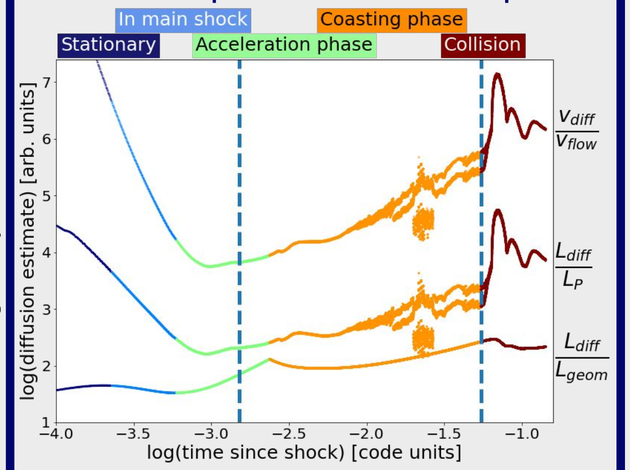
Quantity distributions in aspherical explosion



Cell path through time (white cell is current location)

ANALYSIS

We construct three dimensionless diffusion parameters ($\mathcal{D}$) relating diffusion length to geometric and pressure length scales as well as diffusion speed to flow speed. We compare $\mathcal{D}$ in the acceleration phase to the collision phase.



The dotted blue lines are where we measure $\mathcal{D}$

RESULTS

Each $\mathcal{D}$ parameter increases from the acceleration phase to the collision although not by a large amount. In the real world $\mathcal{D}$ is scaled by a global parameter $\mathcal{D}\sim$. This means that a narrow range of $\mathcal{D}\sim$ exists such that $\mathcal{D} < 1$ during acceleration and $\mathcal{D} > 1$ during collision, which shows conditions exist for the collision to occur and be observable.

CONCLUSION

DISCUSSION

Our simplified and general approach provides findings that act as a stepping stone for further research. Using radiation hydrodynamic simulations to analyze more specific cases and determine how SN light curves would be affected is a relevant next step. Since the collision is predicted to be observable in the UV band range it's especially relevant with the planned launch of ULTRASAT in 2025.

CONCLUSION

With a simplified analysis, we find that equatorial ejecta collisions could make observable X-ray flares in some compact supernovae. Further study is warranted.

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