

New 3-D model could solve supernova mystery

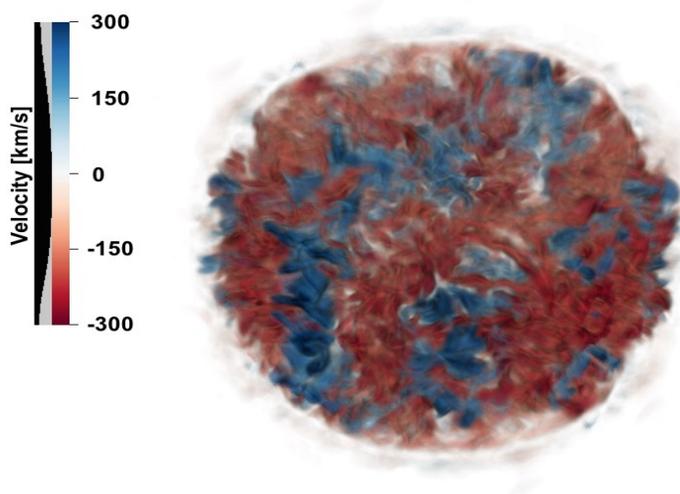
Giant stars die a violent death. After a life of several million years, they collapse into themselves and then explode in what is known as a supernova. In such a devastating stellar explosion as much energy is radiated as our Sun is expected to emit over its entire life. But how these massive stars explode and what mechanisms drive the explosion remains a mystery. However, recent work led by JINA-CEE researchers may bring some answers to this long-lasting astronomical question.

In a paper published in the *Astrophysical Journal Letters* [1], the team details how it developed a three-dimensional model of a giant star's last moments. The ongoing problem is that, until now, researchers have only been able to model these processes in one-dimension. Nature, of course, is three-dimensional and, so far, computer models did not match what was observed in the real world. Particularly, these 1-D models could not reproduce the final blow up, so obviously the models were missing something.

The other problem the 3-D model addresses is the actual shape of the star. Older computer models yielded stars that were perfectly spherical. However, that is not what real stars look like, especially massive stars at the end of their lives. The new model shows that the messy details matter for understanding supernova explosions.

Millions of years of nuclear burning in massive stars results in central cores made of inactive iron. Since iron is so tightly bound that no energy can be created by fusion, iron cannot be used by the star as fuel anymore. Eventually, without any energy source, the star collapses from its own enormous gravitational weight.

This is exactly what the JINA-CEE investigators could see in their simulations: An iron core building up to where it can no longer support itself, before it explodes in a supernova. The development of the 3-D model is only an early step in pinning down the reasons why stars explode, but could completely change the way scientists approach the supernova mechanism.



Volume rendering of the radial velocity from a 3D simulation of the final minutes in the life of a massive star carried out by JINA researchers.

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[1] S.M. Couch, E. Chatzopoulos, W.D. Arnett, and F.X. Timmes, *ApJL* **808**, L21 (2015)