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Core-Collapse Supernovae: the connection between explosion and progenitor structure

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The explosion mechanism of core-collapse supernovae has been a longstanding problem in nuclear astrophysics. In the last decade, important steps towards a thorough understanding of what causes supernovae to explode have been made, thanks to the development of very detailed three-dimensional simulations. However, a lot of work still needs to be done. In this talk, I will focus on the connection between the thermodynamic and compositional structure of the progenitor star and its subsequent explosion. I will use spherically symmetric simulations (where neutrino-driven convection is included via a mixing length approach) to simulate the collapse and shock revival of stars with different initial masses. I will highlight how discontinuities in the density profile at the onset of collapse can be used to predict the outcome of the explosion. Specifically, two types of explosions can be identified. The first is triggered at early times after bounce (< 500 ms) and is predominantly caused by an early accretion of sharp density gradients, which significantly decreases the ram pressure that is preventing further expansion of the shock. The second one happens at late times after bounce (> 500 ms), and it does not involve the accretion of sharp density gradients. In this case, it is the strength of neutrino-driven convection that determines the onset of the explosion. Finally, I will comment on the differences between stellar evolution codes and reaction rates and how they can significantly change the explodability pattern of supernovae.

Session

Stellar evolution

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