Quantifying Asymmetries in Supernovae: A Study on the Deaths of Massive Stars

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Supernovae are among the most energetic phenomena in the cosmos, occurring at the end of the life of a massive star. The stellar explosions not only supply the universe with kinetic energy, but they also fuel chemical reactions and the creation of elements, as well as provide the material and conditions required for new stars and planets to form. Neutron stars and black holes are also results of these explosions. In order to study the many intricate processes in supernovae, astrophysicists use numerical computer simulations in addition to observational data. These simulations give an insight to the asymmetries in supernovae, which are thought to play a crucial role in the origin and mechanisms of the supernova explosion. In this study, the programming language Python has been used to quantify geometrical properties in these numerical simulation models. The results suggest that rotation in the supernova is what possibly causes the elements to be expelled in a coplanar manner. The results also show that the heavier elements, i.e. the core elements in the progenitor star, have centres of mass with the highest velocities in the supernova ejecta, and that the supernovae are more asymmetric in the intermediate than in the innermost regions of the ejecta. In this paper, a method of presenting and defining asymmetries in supernovae using the centre of mass for the different elements in the ejecta is also proposed.

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