Shock-turbulence interaction in core-collapse supernovae

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Abstract

Nuclear shell burning in the final stages of the lives of massive stars is accompanied by strong turbulent convection. The resulting fluctuations aid supernova explosion by amplifying the non-radial flow in the post-shock region. In this work, we investigate the physical mechanism behind this amplification using a linear perturbation theory. We model the shock wave as a one-dimensional planar discontinuity and consider its interaction with vorticity and entropy perturbations in the upstream flow. We find that, as the perturbations cross the shock, their total turbulent kinetic energy is amplified by a factor of ~2, while the average linear size of turbulent eddies decreases by about the same factor. These values are not sensitive to the parameters of the upstream turbulence and the nuclear dissociation efficiency at the shock. Finally, we discuss the implication of our results for the supernova explosion mechanism. We show that the upstream perturbations can decrease the critical neutrino luminosity for producing explosion by several per cent.

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