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Decay of three-dimensional acoustic turbulence and the resulting power spectrum for cosmological gravitational waves

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A key determinant of the intensity of GWs from a first order phase transition is the lifetime of the acoustic turbulence which follows. We have simulated acoustic turbulence in three dimensions using a highly optimized Python code and study the decay of the shocks and derive simple functional forms for the time evolution of the kinetic energy and the integral length scale at late times using the physical properties of the system. We make a new prediction for the universal shape of the energy spectrum by using its self-similar decay properties and the shape of individual shocks. The obtained model for the spectrum and the decay is used to build an estimate for the GW power spectrum generated by decaying acoustic turbulence under approximations where the expansion of the universe can be neglected. We find that due to the decay the spectrum is modified compared to the non-decaying case by having a convergence in time both in the spectral amplitude and in the power law of the peak, so that the converged amplitude corresponds to that of the non-decaying case at high wavenumbers after two shock timescale units, and the power law converges to k^4 at times for which the integral length scale has grown to be at least three times the initial one.

Author: DAHL, Jani

Co-authors: WEIR, David (University of Helsinki); RUMMUKAINEN, Kari; HINDMARSH, Mark (University of Helsinki)

Presenter: DAHL, Jani

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