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Model-independent energy budget of cosmological first-order phase transitions

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We study the energy budget of a first-order cosmological phase transition, which is an important factor in the prediction of the resulting gravitational wave spectrum. Formerly, this analysis was based mostly on simplified models as for example the bag equation of state. Here, we present a model-independent approach that is exact up to the temperature dependence of the speed of sound in the broken phase. We find that the only relevant quantities that enter in the hydrodynamic analysis are the speed of sound in the broken phase and a linear combination of the energy and pressure differences between the two phases which we call pseudotrace (normalized to the enthalpy in the broken phase). The pseudotrace quantifies the strength of the phase transition and yields the conventional trace of the energy-momentum tensor for a relativistic plasma (with speed of sound squared of one third). We study this approach in several realistic models of the phase transition and also provide a code snippet that can be used to determine the efficiency coefficient for a given phase transition strength and speed of sound. It turns out that our approach is accurate to the percent level for moderately strong phase transitions, while former approaches give at best the right order of magnitude.

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