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Analytic gravitational wave spectrum from bubble collisions

We consider gravitational wave production by bubble collisions during a cosmological first-order phase transition. In the literature, such spectra have been estimated by simulating the bubble dynamics, under so-called thin-wall and envelope approximations in a flat background metric. How- ever, we show that, within these assumptions, the gravitational wave spectrum can be estimated in an analytic way. Our estimation is based on the observation that the two-point correlator of the energy-momentum tensor ⟨T(x)T(y)⟩ can be expressed analytically under these assumptions. Though the final expressions for the spectrum contain a few integrations that cannot be calculated explicitly, we can easily estimate it numerically. As a result, it is found that the most of the contributions to the spectrum come from single-bubble contribution to the correlator, and in addition the fall-off of the spectrum at high frequencies is found to be proportional to f^{−1}. We also provide fitting formulae for the spectrum.

Summary

Gravitational waves from bubble collisions can be a probe to a physics beyond the standard model which triggers cosmic phase transition. The gravitational-wave spectrum from bubble collisions has been calculated in numerical simulations in the literature with a couple of reasonable assumptions and approximations. We show that this spectrum can be derived analytically in the same setup as in such numerical-simulation literature, without statistical errors. This work helps to fix the theoretical prediction for the GW spectrum from bubble collisions.

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