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Characterisation of the power spectrum of acoustically generated gravitational waves with a soft equation of state

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Future space-based interferometers, such as LISA, offer an unprecedented opportunity to detect signals from the stochastic gravitational wave background originating from a first-order phase transition at the electro-weak scale, when elementary particles become massive. The generation of masses can induce a softening of the equation of state of the cosmic fluid and thereby accelerate the expansion rate of the Universe. In this work we study the effect of a softer equation of state on the power spectrum of gravitational waves generated by the sound waves in the plasma during the acoustic phase of the transition. We carry out the analytic calculation assuming that the sound speed and the fluid shear-stress that sources tensor perturbations remain approximately constant during the acoustic phase. The effect of a softer equation of state is twofold: (i) a scale-independent suppression of the power spectrum at all scales, due to the modified propagation of both sound and gravitational waves and (ii) the peak of the spectrum moves to smaller frequencies as the equation of state becomes softer. The power-law scaling of the power spectrum is unaffected by the softening of the equation of state. Our work improves the current estimation of the gravitational waves power spectrum from first order phase transitions and expands the possible scenarios of transitions that can be tested by LISA.

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