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Effect of density fluctuations on gravitational wave production in first-order phase transitions

We study the effect of density perturbations on the process of first-order phase transitions and gravitational wave production in the early Universe. We are mainly interested in how the distribution of nucleated bubbles is affected by fluctuations in the local
temperature.
We find that large-scale density fluctuations ($H_* < k_* < \beta$) result in a larger effective bubble size at the time of collision, enhancing the produced amplitude of gravitational waves.
The amplitude of the density fluctuations necessary for this enhancement is $calP_\zeta(k_*) > (\beta/H_*)^{-2}$, and therefore the gravitational wave signal from first-order phase transitions with relatively large β/H_* can be significantly enhanced by this mechanism even for fluctuations with moderate amplitudes.

Primary authors: RUBIRA, Henrique; VAN DE VIS, Jorinde (Deutsches Elektronen-Synchrotron DESY); JINNO, Ryusuke (DESY); KONSTANDIN, Thomas Markus

Presenter: RUBIRA, Henrique