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Bubble nucleation and gravitational waves from cosmological chiral phase transitions in soft-wall AdS/QCD

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We study the first-order phase transition in holographic QCD models with two-flavor and 2+1-flavor matter at finite temperature and chemical potential. Using the holographic bounce solution, we calculate the key parameters governing phase transition dynamics, including the strength parameter α, the inverse duration time β/H_*, and the bubble wall velocity v_w. Along the phase transition line in the QCD phase diagram, we find that the bubble wall velocity v_w increases as the temperature decreases, while the inverse duration time β/H decreases and the strength parameter α grows. This behavior indicates that the transition becomes stronger and lasts longer at lower temperatures and higher chemical potentials. Our results suggest that the bubble expansion remains in the deflagration regime, with v_w staying below the sound speed ($c_s = 1/\sqrt{3}$). The gravitational wave signal from the QCD phase transition at finite temperature and density could provide a potential explanation for the recent NANOGrav 15-year dataset.

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