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# Refining Gravitational Wave and Collider Physics Dialogue via Singlet Scalar Extension

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Employing effective field theory techniques, we advance computations of thermal parameters that enter predictions for the gravitational wave spectra from first-order electroweak phase transitions. Working with the real-singlet-extended Standard Model, we utilize recent lattice simulations to confirm the existence of first-order phase transitions across the free parameter space. For the first time, we account for several important two-loop corrections in the high-temperature expansion for determining thermal parameters, including the bubble wall velocity in the local thermal equilibrium approximation. We find that the requirement of completing bubble nucleation imposes stringent bounds on the new scalar boson mass. Moreover, the prospects for detection by LISA require first-order phase transitions in a two-step phase transition, which display strong sensitivity to the portal coupling between the Higgs and the singlet.
Interestingly, signals from di-Higgs boson production at the HL-LHC probe parameter regions that significantly overlap with the LISA-sensitive region, indicating the possibility of accounting for both signals if detected. Conversely, depending on the mixing angle, a null result for di-Higgs production at the HL-LHC could potentially rule out the model as an explanation for gravitational wave observations.

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