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Machine Learning Left-Right Breaking from Gravitational Waves

First-order phase transitions in the early universe can generate stochastic gravitational waves (GWs), offering a unique probe of high-scale particle physics. The Left-Right Symmetric Model (LRSM), which restores parity symmetry at high energies and naturally incorporates the seesaw mechanism, allows for such transitions — particularly during the spontaneous breaking of $SU(2)_R \times SU(2)_L \times U(1)_{B-L} \to SU(2)_L \times U(1)_Y$. This initial step, though less studied, is both theoretically motivated and potentially observable via GWs.
In this talk, we investigate the GW signatures associated with this first-step phase transition in the minimal LRSM. Due to the complexity and dimensionality of its parameter space, traditional scanning approaches are computationally intensive and inefficient. To overcome this challenge, we employ a Machine Learning Scan (MLS) strategy, integrated with the high-precision three-dimensional effective field theory framework — using PhaseTracer as an interface to DRalgo — to efficiently identify phenomenologically viable regions of the parameter space. Through successive MLS iterations, we identify a parameter region that yields GW signals detectable at forthcoming gravitational wave observatories, such as BBO and DECIGO. Additionally, we analyse the evolution of the MLS-recommended parameter space across iterations and perform a sensitivity analysis to identify the most influential parameters in the model. Our findings underscore both the observational prospects of gravitational waves from LRSM phase transitions and the efficacy of machine learning techniques in probing complex beyond the Standard-Model landscapes.

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