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Can Supercooled Phase Transitions Explain the Gravitational Wave Background Observed by Pulsar Timing Arrays?

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Several pulsar timing array collaborations recently reported evidence of a stochastic gravitational wave background (SGWB) at nHz frequencies. While the SGWB could originate from the merger of supermassive black holes, it could be a signature of new physics near the 100 MeV scale. Supercooled first-order phase transitions (FOPTs) that end at the 100 MeV scale are intriguing explanations, because they could connect the nHz signal to new physics at the electroweak scale or beyond. Here, however, we provide a clear demonstration that it is not simple to create a nHz signal from a supercooled phase transition, due to two crucial issues that could rule out many proposed supercooled explanations and should be checked. As an example, we use a model based on nonlinearly realized electroweak symmetry that has been cited as evidence for a supercooled explanation. First, we show that a FOPT cannot complete for the required transition temperature of around 100 MeV. Such supercooling implies a period of vacuum domination that hinders bubble percolation and transition completion. Second, we show that even if completion is not required or if this constraint is evaded, the Universe typically reheats to the scale of any physics driving the FOPT. The hierarchy between the transition and reheating temperature makes it challenging to compute the spectrum of the SGWB.

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