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Dark, Cold, and Noisy: Constraining Secluded Hidden Sectors with Gravitational Waves

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We explore gravitational wave signals arising from first-order phase transitions occurring in a secluded hidden sector, allowing for the possibility that the hidden sector may have a different temperature than the Standard Model sector. We present the sensitivity to such scenarios for both current and future gravitational wave detectors in a model-independent fashion. Since secluded hidden sectors are of particular interest for dark matter models at the MeV scale or below, we pay special attention to the reach of pulsar timing arrays. Cosmological constraints on light degrees of freedom restrict the number of sub-MeV particles in a hidden sector, as well as the hidden sector temperature. Nevertheless, we find that observable first-order phase transitions can occur. To illustrate our results, we consider two minimal benchmark models: a model with two gauge singlet scalars and a model with a spontaneously broken U(1) gauge symmetry in the hidden sector.

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