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Gravitational Wave Backgrounds and Bursts from Terascale Phase Transitions and Cosmic Strings

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The millihertz frequency band probed by LISA corresponds to horizon scales at the Terascale frontier in the relativistic early Universe. A first order phase transition, possibly associated with electroweak or supersymmetry breaking, late inflationary reheating, or activity and stabilization of warped extra dimensions of space, causes supercooling, cavitation, catastrophic explosive bubble growth, and relativistic turbulence, leading to bulk motions of matter on what was then a submillimeter scale, and efficient gravitational wave production. LISA is capable of detecting a stochastic background from such events at cosmic temperatures from about 100 GeV to about 1000TeV, if gravitational waves in the LISA band were produced with an overall efficiency more than about 10^{-7}, a typical estimate from a moderately strong relativistic first-order phase transition, and about a million times below current limits from big bang nucleosynthesis. This corresponds to times about 10^{-10} to 10^{-18} seconds after the start of the Big Bang, a period and range of scales not directly accessible with any other technique. LISA also deeply probes possible new forms of energy such as cosmic superstrings, relics of the early Universe predicted to form by certain kinds of symmetry breaking at the end of inflation, that are invisible in all ways except by the gravitational waves they emit. Estimates are presented of predicted spectra of gravitational wave backgrounds from cosmic strings, current limits on their mass per length from millisecond pulsar timing limits on gravitational waves, and the new discovery space probed by LISA. In addition, cusp catastrophes in the oscillations of nearby cosmic strings sometimes beam gravitational waves in our direction leading to a burst with a cleanly predicted waveform signature; estimates will be presented of the predicted rate and detectability of these events.