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Gravitational wave signal from early-universe turbulence

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The first direct detections of gravitational waves from the mergers of binary black holes and binary neutron stars by the LIGO and VIRGO experiments have electrified the physics and astronomy communities. A clear next experimental step is an interferometer in space, which can detect lower frequency signals than a ground-based detector, including supermassive black hole binary coalescences from early galaxy mergers and a known stochastic background from confusion-limited white-dwarf binaries. An even more intriguing signal is the stochastic background from early-universe physics. In this talk I will present our recent work (in collaboration with Axel Brandenburg, Arthur Kosowsky, Sayan Mandal, and Alberto Roper Pol). Using direct numerical simulations of early universe hydromagnetic turbulence with energy densities of up to 10% of the radiation energy density, we show that gravitational waves with energy densities of about 10^{-10} times the critical energy density of the Friedmann universe today were produced. Their characteristic strain today is found to be about 10-20 and should be observable with the Laser Interferometer Space Antenna (LISA) in the mHz range. The gravitational waves have positive (negative) circular polarization if the magnetic field has positive (negative) magnetic helicity. The gravitational wave energy reaches a constant value after the turbulent energy (kinetic or magnetic) has reached its maximum. Compressive modes are found to produce about 10 times stronger gravitational waves than solenoidal ones. Finally, I will discuss the range of phase transition energy scales and properties that may be detectable with the envisioned space-based interferometer configurations such as LISA.

Summary

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