STARS2013 - 2nd Caribbean Symposium on Cosmology, Gravitation, Nuclear and Astroparticle Physics / SMFNS2013 - 3rd International Symposium on Strong Electromagnetic Fields and Neutron Stars

Contribution ID: **19** Type: **Talk**

Gravitational waves from the cosmological QCD phase transition

Wednesday 2 July 2014 14:00 (30 minutes)

We study the evolution of turbulence in the early universe at the QCD epoch using a state-of-the-art equation of state derived from lattice QCD simulations. Since the transition is a crossover we assume that temperature and velocity fluctuations were generated by some event in the previous history of the Universe and survive until the QCD epoch due to the extremely large Reynolds number of the primordial fluid. The fluid at the QCD epoch is assumed to be non-viscous, based on the fact that the viscosity per entropy density of the quark gluon plasma obtained from heavy-ion collision experiments at the RHIC and the LHC is extremely small. Our hydrodynamic simulations show that the velocity spectrum is very different from the Kolmogorov power law considered in studies of primordial turbulence that focus on first order phase transitions. This is due to the fact that there is no continuous injection of energy in the system and the viscosity of the fluid is negligible. Thus, as kinetic energy cascades from the larger to the smaller scales, a large amount of kinetic energy is accumulated at the smallest scales due to the lack of dissipation. We have obtained the spectrum of the gravitational radiation emitted by the motion of the fluid finding that, if typical velocity and temperature fluctuations have an amplitude (Δv) /c ≥ 10^(-2) and/or (ΔT)/Tc ≥ 10^(-3), they would be detected by eLISA at frequencies larger than ~ 10^(-4) Hz.

Reference: V. R. C. M. Roque and G. Lugones, to appear in Phys. Rev. D

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Track Classification: STARS2013