Contribution ID: **37** Type: **Paralela**

Chiral symmetry breaking and pion condensation in the early universe

Thursday 4 December 2025 14:20 (20 minutes)

The origin of the matter-antimatter asymmetry remains a mystery despite many theoretical and observational efforts in the last decades. This is partially due to the difficulty in probing the early stages of the cosmic evolution (≈ 1 s or less). In particular, the baryon asymmetry, given by the ratio between the baryon number density and the total entropy, $b = n_B/s$, can be precisely determined by CMB (Cosmic Microwave Background) and BBN (Big Bang Nucleosynthesis) observations to be $b = (8.7 \pm 0.06) \times 10^{-11}$. However, the reason for this value remains unknown and many attempts to explain it predict that a large total primordial lepton asymmetry $l = \sum_\alpha n_{L_\alpha}/s$ ($\alpha = e, \mu, \tau$), with n_{L_α} the lepton number density, may have been present before BBN. This quantity has been poorly constrained by observations and the bounds on the asymmetries for the individual leptons are even weaker. Within this scenario, one is naturally lead to investigating the consequences of such large lepton asymmetries on the physics of the standard model and asking what observational signatures might be generated. In this work, we determine the possible trajectories the universe may have followed in the QCD phase diagram during the QCD epoch. We focus on the roles of chiral symmetry breaking and pion condensation under high imbalances in lepton asymmetry. Adopting the quark-meson model as an effective description of QCD at finite temperature, charge and baryon chemical potentials we show that, for sufficiently large but physically motivated asymmetries, the universe may have entered the pion condensation phase through a first-order phase transition, followed by a second-order phase transition when it exits it. Such a first-order phase transition represents a new possible source of primordial gravitational waves during the QCD epoch.

Altas energias

Presenter: NETO, Osvaldo Ferreira (UFRJ)

Session Classification: Altas Energias