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## Strong interactions in Cosmology: strong CP problem, neutrino mass, Dark Matter, Dark Energy and gravitational radiowaves

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An unexpected explanation for neutrino mass, Dark Matter (DM) and Dark Energy (DE) from genuine Quantum Chromodynamics (QCD) of the Standard Model (SM) is proposed here, while the strong CP problem is resolved without any need to account for fundamental axions. We suggest that the neutrino sector can be in a double phase in the Universe: i) relativistic neutrinos, belonging to the SM; ii) non-relativistic condensate of Majorana neutrinos. The condensate of neutrinos can provide an attractive alternative candidate for the DM, being in a cold coherent state. We will explain how neutrinos, combining into Cooper pairs, can form collective low-energy degrees of freedom, hence providing a strongly motivated candidate for the QCD (composite) axion. Besides, we propose a novel mechanism for the production of gravitational waves in the early Universe that originates from the relaxation processes induced by the QCD phase transition. While the energy density of the quark-gluon mean-field is monotonously decaying in real time, its pressure undergoes a series of violent oscillations at the characteristic QCD time scales that generate a primordial multi-peaked gravitational waves signal in the radio frequencies' domain. The signal is an echo of the QCD phase transition that is accessible by planned measurements at the FAST and SKA telescopes.

### In-person participation

Yes

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