FM 91: Special Session: Quantum Information Concepts in Astrophysics

Time: Friday 11:00–13:00 Location: 2004

Invited Talk FM 91.1 Fri 11:00 2004

Information Theoretic Methods in Inflationary Cosmology — •Achim Kempf — University of Waterloo, Canada

At the Planck scale, and close to a big bang, the conventional notions of space-time and matter are widely expected to reach the very limit of their range of applicability. For this reason, the use of quantum information-theoretic tools could be useful in these circumstances: no matter how counter intuitive the phenomena at the Planck scale are, it should always make sense to quantify how much information and how much information processing is involved. I will first review related information-theoretic concepts such as covariant bandlimitation. I will then focus on the prospect that information-theoretically-described Planck scale physics has left an imprint in inflation and that it has, therefore, possibly left an observable imprint in the cosmic microwave background and in structure formation.

Invited Talk FM 91.2 Fri 11:40 2004

Quantum Information and Cosmic Inflation — •Jerome Martin — Institut d'Astrophysique de Paris, 98bis boulevard Arago, 75014 Paris, France

According to the theory of cosmic inflation, the large scale structures observed in our Universe (galaxies, clusters of galaxies, Cosmic Background Microwave - CMB - anisotropy ...) are of quantum mechanical origin. They are nothing but vacuum fluctuations, stretched to cosmological scales by the cosmic expansion and amplified by gravitational instability. At the end of inflation, these perturbations are placed in a two-mode squeezed state with the strongest squeezing ever produced in Nature (much larger than anything that can be made in the laboratory on Earth). In this talk, one studies whether astrophysical observations could unambiguously reveal this quantum origin by borrowing ideas from quantum information theory. One argues that cosmic inflation is not only a successful paradigm to understand the early Universe. It is also the only situation in Physics where one crucially needs General Relativity and Quantum Mechanics to derive the predictions of a theory and, where, at the same time, we have high-accuracy data to test these predictions, making inflation a playground of utmost importance to discuss foundational issues in Quantum Mechanics

Invited Talk FM 91.3 Fri 12:20 2004

Collective excitations as quantum sensors for fundamental physics — •Ivette Fuentes — School of Mathematical Sciences, University of Nottingham, UK

Quantum sensors that are used to measure gravitational fields and detect dark energy typically use single particle interferometric techniques that are limited by the time of flight in the interferometer arm. In this talk I will present a new detection method that uses quantum resonances and the sensitivity of collective excitations (phonons) to gravitational fields. When phonons in a Bose-Einstein condensate are initially prepared in a squeezed state, spacetime distortions can create additional excitations through parametric amplification. This effect can be used to detect gravitational waves at high frequencies. We have also developed a phonon based scheme to estimate spacetime parameters, miniaturize devices to measure gravitational fields and gradients and set further constrains on dark energy models.