Title:	Signature of Quantum Effects in Late Time Cosmology
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Abstract:	Quantum field theory in curved spacetime is an important framework not only from the point of view of understanding conceptual notions like particle creation, Hawking radiation, etc., but it has turned out to be useful in explaining many cosmological observations. Particularly, the quantization of the metric perturbations during the inflationary phase of the Universe seems to provide a good explanation for the observed temperature anisotropies in the cosmic microwave background. This thesis explores different aspects of quantum field theories in cosmologically important FRW spacetimes. In the semiclassical gravity approach, one is mainly concerned with the expectation value of the stress-energy operator and ignores the quantum fluctuations in it assuming them to be insignificant. However, these considerations, based solely on the first-order effects, are bound to fail in case the quantum fluctuations are significant. The stochastic gravity paradigm considers these fluctuations and quantifies them by the noise kernel. We show that, for scalar fields in de Sitter spacetime, the late time limit of the noise kernel shows a transition from vanishing to divergent behavior as the ratio, m/H, is changed in the range [0, 3/2]. Similarly, the noise kernel is found to diverge for massless scalar fields in certain FRW spacetimes. In those cases in which the noise kernel is non-vanishing (and comparable to the expectation values) or divergent, the first-order semiclassical analyses are expected to break down and must be supplemented with the second-order effects in order to make any robust predictions. For massive spinor fields in de Sitter spacetime, the late time limit of the noise kernel vanishes irrespective of the mass of the spinor field. As far as massless spinor fields in FRW spacetimes are concerned, the late time limit of the noise kernel vanishes for expanding FRW spacetimes whereas it diverges for contracting FRW spacetimes. In addition to the noise kernel behavior, one can also study the dynamics of quantum fields in FRW spacetimes by coupling them with Unruh deWitt (UdW) detectors. This thesis includes analysis for the case of both conventional as well as derivatively coupled UdW detectors with a particular focus on studying the infrared divergences in FRW spacetimes. We find that the infrared divergence of massless scalar fields in de Sitter spacetime contributes to the response rate of conventional UdW detector whereas it does not for derivatively coupled UdW detector. However, for massless scalar fields in nearly matter-dominated spacetimes, the infrared divergences contribute to the rates of both types of UdW detectors. Applying these results to the coupling of gravitational waves (GWs) with a hydrogen atom, which takes the form of a generalized derivative UdW coupling, it is argued that the quantized GWs lead to very rapid transitions within the states of a hydrogen atom while the Universe passes through matter-dominated phase in the expansion history. These conclusions provide an opportunity to witness quantum effects in relatively later phases of the Universe as opposed to the quantum effects studied mostly for the early inflationary phase of the Universe. These 1investigations suggest that the cosmological observations corresponding to the later phases of the Universe may also contain potential quantum signatures. 2
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