General Relativity and Quantum Cosmology

Relativistic Bose-Einstein Condensates: a New System for Analogue Models of Gravity

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In this paper we propose to apply the analogy between gravity and condensed matter physics to relativistic Bose-Einstein condensates, i.e. condensates composed by relativistic constituents. While such systems are not yet subject of experimental realization, they do provide us with a very rich analogue model of gravity. In particular we show here that they are characterized by several novel features with respect to their non-relativistic counterpart. First they are characterized by two (rather than one) quasi-particle excitations, a massless and a massive one, the latter disappearing in the non-relativistic limit. Secondly, the metric associated to the massless mode is a generalization of the usual acoustic geometry allowing also for non-conformally flat spatial sections. This is relevant, as it implies that these systems can allow the simulation of a wider variety of geometries. Finally, while in standard Bose-Einstein condensates the transition is from Lorentzian to Galilean relativity, these systems represent an emergent gravity toy model where Lorentz symmetry is present (albeit with different limit speeds) at both low and high energies. Hence they could be used as a test field for better understanding the phenomenological implications of such milder form of Lorentz violation at intermediate energies.

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