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universidade de aveiro

Gravitational Geometry and Dynamics Group Seminar

Wed., December 3, 2025, at 11h00.

Room: Sala Sousa Pinto and **Teams ID:** 393 518 065 346 9

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More about *Gr@v* at: gravitation.web.ua.pt

How much can gravitons be squeezed?

Dyson, just before the first detection of Gravitational Waves (GWs) by LIGO, raised the question of whether the detection of a single graviton can be achieved with GW strain detectors. If this is possible, then it would be a direct evidence for the quantization of the gravitational field. Detection of single graviton signals, though, requires Planck scale accurate length measurements, which seems rather impossible, at least for the present status of our knowledge and available technology. Collective Graviton States (CGS) of purely quantum origin, still challenging to be detected, consist a promising way to bypass this constraint. CGS can admit macroscopically large occupation numbers (as is the case of GWs detected by LIGO, with approximately 1035 gravitons). Such CGS admit no classical analogue and thus are explainable, if detected, only when a quantum theory for the gravitational field is enforced. In this talk, we treat General Relativity (GR) as an Effective Field Theory (EFT), introducing a weak graviton perturbation about an appropriate fixed spacetime background, to study the production of multi-mode squeezed CGS by local sources, relevant for astrophysical processes. In particular, we consider condensates of axion-like particles (ALPs) formed around rotating (astrophysical) black holes, via the superradiance instability. The latter is characterized by the very large number of ALPs involved in the "cloud" and the long lifetime of the configuration. These properties can offer a macroscopic amplification mechanism of potential quantum-gravity effects. We estimate the order of magnitude of the squeezing effect, in the non-relativistic limit, relevant for the superradiance process, through the number of graviton excitations in the multi-mode squeezed vacuum. Then, we comment on observational prospects and particularly on how the relevant ALP physics can be constrained by null quantum – gravity results, when compared with data. Finally, we stress on the entanglement properties and the inherent Bell states of the multi-mode squeezed CGS, in contrast to the single – mode squeezing, that so far been discussed in the relevant literature.

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