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Bose-Einstein graviton condensate in a Schwarzschild black hole

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We analyze in detail a previous proposal by Dvali and Gómez that black holes could be treated as consisting of a Bose-Einstein condensate of gravitons. In order to do so we extend the Einstein-Hilbert action with a chemical potential-like term, thus placing ourselves in a grand-canonical ensemble. The form and characteristics
of this chemical potential-like piece are discussed in some detail. We argue that the resulting equations of motion
derived from the action could be interpreted as the Gross-Pitaevskii equation describing a graviton Bose-Einstein
condensate trapped by the black hole gravitational field. After this, we proceed to expand the ensuring equations
of motion up to second order around the classical Schwarzschild metric so that some non-linear terms in the metric
fluctuation are kept. Next we search for solutions and, modulo some very plausible assumptions, we find out that
the condensate vanishes outside the horizon but is non-zero in its interior. Inspired by a linearized approximation
around the horizon we are able to find an exact solution for the mean-field wave function describing the graviton
Bose-Einstein condensate in the black hole interior. After this, we can rederive some of the relations involving the number of gravitons N and the black hole characteristics along the lines suggested by Dvali and Gómez.

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