Graeme Gossel

School of Physics, University of New South Wales, Sydney

Quantum particles around near-black hole objects: resonant particle capture, spectrum collapse, and the smooth transition to black hole absorption

Authors: J. C. Berengut, V. V. Flambaum, G. H. Gossel, G. F. Gribakin, A. F. Spencer-Smith and Y. Stadnik

We investigate quantum properties of particles in the gravitational fields of "near black-hole objects". These bodies have radius R that slightly exceeds the Schwarzschild radius, and we describe them using interior and exterior metrics that allow us to examine the black-hole limit, $R \to r_s$. We find that massless quantum particles scattered by the gravitational field of such an object possess a dense spectrum of narrow resonances: a set of long lived meta-stable states whose lifetimes and density tend to infinity in the black-hole limit. We have confirmed the behavior for particles of spin-0, 1/2 and 1. The cross section of particle capture into these resonances is equal to the absorption cross section for a Schwarzschild black hole; thus, a non-singular static metric acquires black-hole properties before the actual formation of a black hole [1].

Bound states exist for massive particles in these near black-hole metrics, and we examine their energies in the limit $R \to r_s$. In this limit all bound states tend to zero energy, where the binding energy is equal to the rest mass of the particle. However until there is a singularity in the metric, there are no zero-energy states, and hence no pair production occurs in these metrics. This contrasts with the Coulomb case, where a large non-singular field can produce pairs from the vacuum. We have also shown that the energy spectrum becomes quasi-continuous as the metric becomes singular [2].

Additionally we examine the Schwarzschild interior metric which develops a pressure singularity before $R = r_s$ (at $r_s = 8R/9$), hence we consider particle properties as the metric approaches this limit. Sharp resonances still occur in the scattering problem, but there is no absorption for zero-energy scattering (in contrast to the black hole case). The absorption cross-section is finite for non-zero energy particles. Once again the bound state spectrum of massive particles collapses to zero [2].

[1] V. V. Flambaum, G. H. Gossel, and G. F. Gribakin, accepted to Phys. Rev. D (2012), arXiv:1012.2134

[2] G. H. Gossel, J. C. Berengut and V. V. Flambaum, Gen. Rel. Gravit., 43, 2673 (2011), arXiv: 1006:5541