Hawking radiation cannot exist if quantum vacuum fluctuations are gravitational dipoles

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Abstract

- While it is neglected, Hawking radiation is model-dependent; it depends on our model of the quantum vacuum. It was recently suggested that what we call dark matter and dark energy can be explained as the local and global effects of the gravitational polarization of the quantum vacuum by the immersed Standard Model matter. This result appears as the consequence of the working hypothesis that by their nature quantum vacuum fluctuations are virtual gravitational dipoles. Here, as a consequence of the same hypothesis we argue that instead of the nonexistent thermal Hawking radiation there is a much stronger non-thermal radiation which is caused by the conversion of virtual particle-antiparticle pairs into real ones; this conversion happens deep inside the horizon. Contrary to Hawking radiation which leads to the black hole information paradox, there is no information loss paradox within the framework of the quantum vacuum "enriched" with virtual gravitational dipoles.

Hawking radiation

- One of the most beautiful and the most famous relations of theoretical physics

$$k_B T_H = \frac{\hbar c^3}{8\pi GM}$$

- The physical meaning of the above relation is that a Schwarzschild black hole of mass *M* radiates as a black body of temperature T_H
- The hottest astronomical black holes have a temperature 100 million times smaller than the tiny temperature of the cosmic microwave background.
- While it is always neglected, as a phenomenon depending on the existence of the quantum vacuum, Hawking radiation is *model-dependent*; it depends on the used model of the quantum vacuum.
- If the thermal Hawking radiation doesn't exist, the information loss paradox doesn't exist as a well

The working hypotheses

*(1) Quantum vacuum fluctuations are virtual gravitational dipoles**

*(2) The Standard Model matter*** and quantum vacuum are **the only** matter-energy content of the Universe*

* Apparently the simplest realisation of this hypothesis is if particles and antiparticles have the gravitational charge of the opposite sign. A virtual gravitational dipole is defined in analogy with an virtual electric dipole: two gravitational charges of the opposite sign at a distance smaller than the corresponding reduced Compton wavelength. The **Standard Model Matter means matter made from quarks and leptons interacting through the exchange of gauge bosons

Important Note: We do not modify the Standard Model of Particles and Fields and its understanding of quantum vacuum! Gravity is not included in the Standard Model.

What if *quantum vacuum fluctuations are virtual gravitational dipoles*? Summary of consequences.

Our working hypothesis might be the basis for a new model of the Universe. According to the new model, ***the only* content of the Universe is the known Standard Model matter** (i.e. matter made from quarks and leptons interacting through the exchange of gauge bosons) *immersed in the quantum vacuum* "enriched" with virtual gravitational dipoles. Apparently, **what we call dark matter and dark energy, can be explained as the local and global effects of the gravitational polarization of the quantum vacuum by the immersed baryonic matter**. Further, **the hypothesis leads to a *cyclic model* of the Universe with cycles alternatively dominated by matter and antimatter**; with each cycle beginning with a macroscopic size and the accelerated expansion. Consequently, there is *no singularity*, *no need for inflation field*, and there is an elegant explanation of the matter-antimatter asymmetry in the universe: **our universe is dominated by matter because the previous cycle of the Universe was dominated by antimatter**. The forthcoming experiments (AEGIS, ALPHA, GBAR …) will reveal if particles and antiparticles have gravitational charge of the opposite sign, while study of orbits of tiny satellites in trans-Neptunian binaries (e.g. UX25) can be a reasonable test of some astronomical predictions of the theory.

Reminder: Quantum vacuum in QED
an "ocean" of virtual electric dipoles

In QED quantum vacuum can be considered as an omnipresent "ocean" of virtual electric dipoles (for instance electron-positron pairs) with random orientation

Reminder: Quantum vacuum in QED

vacuum fluctuations can be converted into real particles

- A virtual electron-positron pair **can be converted to a real one** by an external field which, during their short lifetime, can separate particle and antiparticle to a distance of about one reduced Compton wavelength
- **The Schwinger mechanism**: For a constant acceleration ***a*** (which corresponds to a constant electric field) the particle creation rate per unit volume and time, can be written as

$$\frac{dN_{m\bar{m}}}{dt\,dV} = \frac{c}{\lambda\!\!\!^{-}{}^4}\left(\frac{a}{a_{cr}}\right)^2 \sum_{n=1}^{\infty}\frac{1}{n^2}\exp\left(-n\frac{a_{cr}}{a}\right), \quad a_{cr} \equiv \pi\frac{c^2}{\lambda\!\!\!^{-}{}_m}$$

$$\lambda\!\!\!^{-}{}_m = \frac{\hbar}{mc}, \textit{ the reduced Compton wavelength}$$

Valid for gravity if there are virtual gravitational dipoles!

A virtual pair can be converted to a real one *only deep inside the horizon* of a black hole

- The Schwinger equation contains a sum of exponential functions with negative exponents; hence, the particle creation rate is significant only for a gravitational field a greater than the critical value $a_{cr}(m) = \pi c^2 / \lambda_m$.
- Let us compare the critical acceleration with the gravitational acceleration $g_s = GM / R_s^2 \equiv c^2 / 2R_s$ at the Schwarzschild radius of a black hole with mass *M* ; the comparison leads to the conclusion $a_{cr} >> g_s$ i.e. **a virtual pair can be converted to a real one *only deep inside the horizon* of a black hole.**
- If, for instance, a black hole is made from ordinary matter, produced particles must stay confined inside the horizon, while antiparticles should be violently ejected because of the gravitational repulsion.

Two Schwarschild metrics

- While it is often neglected, from a mathematical point of view there are two solutions: the positive mass Schwarzschild solution

$$ds^2 = c^2\left(1-\frac{2GM}{c^2 r}\right)dt^2 - \left(1-\frac{2GM}{c^2 r}\right)^{-1} dr^2 - r^2 d\theta^2 - r^2 \sin^2\theta\, d\varphi^2$$

considered as the physical space-time metric; and the negative mass Schwarzschild solution

$$ds^2 = c^2\left(1+\frac{2GM}{c^2 r}\right)dt^2 - \left(1+\frac{2GM}{c^2 r}\right)^{-1} dr^2 - r^2 d\theta^2 - r^2 \sin^2\theta\, d\varphi^2$$

considered as a nonphysical solution. It serves as the simplest example of a naked singularity and a repulsive space-time allowed by mathematical structure of general relativity but rejected as non- physical. However, in the framework of the gravitational repulsion between matter and antimatter, both solutions may be given a physical meaning: the positive mass metric is the metric "seen" by a test particle, while the negative mass metric is the metric "seen" by a test antiparticle . In simple words, a black hole made from matter acts as a black hole with respect to matter and as a white hole with respect to antimatter.

Black hole radiation under the hypothesis of vurtual gravitational dipoles

- Let us define a *critical „radius”* $r_{Cm} < R_S$ as the distance at which the gravitational acceleration produced by a Schwarzschild black hole, has the critical value $a_{cr}(m) = \pi c^2 / \lambda_m$. Consequently

$$r_{Cm} = \sqrt{\frac{\lambda\!\!\!^{-}{}_m R_S}{2\pi}}$$

- The mass of a black hole is not in singularity but within a sphere of radius $r_H << R_S$ which can be approcimated by the critical radius r_{Ce} corresponding to electron (*D.S. Hajdukovic, Advances in Astronomy, Article ID 196852 (2011)*)

Hence a spherical shell with the inner radius r_H and the outer radius r_{Cm} acts as a “factory”for creation of particle–antiparticle pairs with mass *m* . It is evident that there is a series of decreasing critical radiuses r_{Cm} . For instance, the critical radius $r_{C\nu}$ corresponding to neutrinos is nearly four orders of magnitude greater than the critical radius r_{Ce} for electrons, which is about 43 times greater than the critical radius r_{Cn} for neutrons.

Black hole radiation under the hypothesis of vurtual gravitational dipoles

- Integration of the Schwinger's particle-antiparticle creation rate over the shell determined by r_H and r_{Cm} (and taking $r_{Cm} >> r_H$) leads to

$$\frac{dN_{m\overline{m}}}{dt} \approx \left(\frac{R_S}{\lambda\!\!\!^{-}_m}\right)^2 \frac{c}{r_H}; \; r_H \approx \sqrt{\frac{\lambda\!\!\!^{-}_e R_S}{2\pi}}$$

- This radiation is much stronger than the Hawking radiation and **incompatible** with the Hawking radiation (because they are based on radicaly differant models of the gravitational charge of the quantum vacuum).
- The radiation caused by the gravitational version of the Schwinger mechanism is not thermal; **hence the information loss paradox doesn't exist**

Radiation related to infalling matter

- We have suggested non-thermal black hole radiation related to the quantum vacuum „enriched” with virtual gravitational dipoles
- If particles and antiparticles have the gravitational charge of the opposite sign, an additional radiation must exist; all antiparticles created in collisions of infalling matter would be violently ejected. Together with the vacuum related radiation it eliminates completely the information loss paradox