Why is There No Ultraviolet Catastrophe in Gravity?

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The "ultraviolet catastrophe" is the term given by Ehrenfest [1] to the prediction of classical electromagnetism that the intensity of blackbody radiation would be infinite at short wavelengths, as remarked by Rayleigh in 1905.[1,2]

Thermal agitation of the blackbody give its atoms electric oscillating electric dipole moments, which leads to the observed blackbody radiation. However, there is no gravitational dipole radiation,which is associated with quadrupole oscillations. Thermal agitation of bodies also leads to quadrupole oscillations, and if the energy of these oscillations were not quantized, there would be an ultraviolet catastrophe associated with the quadrupole, electromagnetic blackbody radiation. This quantization also serves to eliminate the ultraviolet catastrophe that could be associated with quadrupole, gravitational blackbody radiation. That is there is no purely classical gravitational blackbody radiation.

Hawking [7, 8] noted that quantum effects lead to electromagnetic (not gravitational) blackbody radiation of a black hole with surface gravity g with an apparent temperature $T = \hbar g/2\pi ck$, where c is the speed of light in vacuum and k is Boltzmann's constant. Being a quantum effect, there is no ultraviolet catastrophe in Hawking radiation.

The association of gravity with blackbody radiation implies that the gravitational blackbody radiation involves quanta (gravitons) with energies that are multiples of $h\nu$.[3] However, this does not give much insight into a possible full quantum theory of gravity.

This question was posed by Anwar Shiekh.

References

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[1] Already in 1900, Planck [3, 4] (see also [5]) had inferred that the departure of the blackbody radiation from classical expectations at short wavelength can be explained by supposing that the energy of oscillations with frequency ν of atoms in the black body have energies quantized in amounts of $h\nu$.

[2] Jeans [6] noted an error of a factor or 8 in Rayleigh's calculation, which is now known as the Rayleigh-Jeans law.

[3] Skeptical views of gravitons by Dyson are given in [9, 10].

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