NITheCS Colloquium
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"The case for the necessity to quantize the quantum gravitational field, or the lack of it"

ABSTRACT

Quantum Electrodynamics received its modern form in the work by Tomonaga, Schwinger, Feynman and Dyson in the 1940ies, but was already widely studied in the 1930ies. One paper from that first period remains relevant and cited to this day -- Bohr and Rosenfeld's investigation by Gedankenexperiments whether the electromagnetic field needs to be quantized at all. Bohr and Rosenfeld found this to be so, a conclusion which was born out by the successful development of the theory about a decade later.

The question whether the same kind of arguments applies to the gravitational field was raised already by Bronstein in 1936, and again by Dyson in 2014. Both these authors found, in different ways, that a very massive test particle needed to achieve high accuracy in a Bohr-Rosenfeld-like Gedankenexperiment would collapse into a black hole. A Bohr-Rosenfeld argument in favor of the necessity to quantize the gravitational field is therefore logically incomplete.

I will survey the above question, and discuss two more recent papers which try to answer the question by other Gedankenexperiments using more modern tools of quantum science. I will discuss why we believe that also these arguments do not prove the necessity of quantizing the gravitational field, if one allows as an independent assumption that the Planck length is a lower limit on position measurements.

The talk is based on joint work with Erik Rydving and Igor Pikovski [in preparation].

References

G. Baym and T. Ozawa, "Two-slit diffraction with highly charged particles: Niels Bohr's consistency argument that the electromagnetic field must be quantized," Proceedings of the National Academy of Sciences of the United States of America 106, 3035–3040 (2009).

A. Belenchia, R. M. Wald, F. Giacomini, E. Castro-Ruiz, C. Brukner, and M. Aspelmeyer, "Quantum superposition of massive objects and the quantization of gravity," Physical Review D98, 1–9 (2018)

N. Bohr and L. Rosenfeld, "Zur Frage der Messbarkeit der elektromagnetischen Feldgr¨ossen," Kgl.Danske Vidensk. Selskab. Math.-Fys. Medd12, 3 (1933).

M. Bronstein, "Quantentheorie schwacher Gravitationsfelder", Physikalische Zeitschrift der Sowjetunion, Band 9, Heft 2–3, pp. 140–157 (1936); republished as Gen Relativ Gravit (2012) 44:267–283

F. Dyson, "Is a graviton detectable?" in XVIIth International Congress on Mathematical Physics(World Scientific (2014) pp. 670–682

BIOGRAPHY

Erik Aurell has a BSc (1983) and PhD (1989) from Göteborg University, Sweden. He holds since 2003 the position as professor of Biological Physics at KTH Royal Institute of Technology in Stockholm, Sweden. He has held guest professorships in Finland and China. He is still active in what was his main research interest of biological physics and the interface to computational biology and genomics; since about 2015 he has however focused on open quantum systems, and other problems of quantum science. He is Board member of European Physical Society Division for Nonlinear and Statistical Physics.

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