Quantum waves and gravity

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Atom interferometry represents a powerful tool to probe the interface of quantum and gravity. It is conventional wisdom that the corresponding phase shift caused by gravity scales quadratically with the time the atom spends in the interferometer. The recent experimental realization of the Stern-Gerlach interferometer [1] displays a cubic rather than a quadratic phase shift. We illustrate this phenomenon in quantum phase space using the Wigner function [2] and, in particular, compare and contrast the sensitivity of this device to uncertainties to the one predicted in the Humpty-Dumpty discussion [3].

[1] O. Amit, Y. Margalit, O. Dobkowski, Z. Zhou, Y. Japha, M. Zimmermann, M.A. Efremov, F.A. Narducci, E.M. Rasel, W.P. Schleich, and R. Folman, T3–Stern-Gerlach matter-wave interferometer, to be published.

[2] E. Giese, W. Zeller, S. Kleinert, M. Meister, V. Tamma, A. Roura, and W.P. Schleich, Interface of gravity and quantum mechanics illuminated by Wigner phase space, in: "Atom Interferometry", Varenna Summer School 2013.

[3] B.G. Englert, J. Schwinger, and M.O. Scully, Is spin coherence like Humpty-Dumpty? I. Simplified Treatment, Foundations of Physics 18, 1045 (1988); J. Schwinger, M.O. Scully, and B.G. Englert, Is spin coherence like Humpty-Dumpty? II. General Theory, Z. Phys. D 10, 135 (1988); M.O. Scully, B.G. Englert, and J. Schwinger, Is spin coherence like Humpty-Dumpty? III. The effects of observation, Phys. Rev. A 40, 1775 (1989).