On the interface of quantum and gravity

Wolfgang P. Schleich

Quantum mechanics and general relativity constitute two major pillars of modern physics. Although their predictions have been tested in numerous experiments we still have not been able to completely grasp their consequences nor put to use their subtleties to the fullest extent. Indeed, even today the measurement problem, the application of entanglement to technology and the unification of the two theories illustrate in a striking way this fact by representing active fields of research.

In the present lecture we focus on the last issue and discuss three questions located on the interface between quantum and gravity: (i) inertial and gravitational mass in quantum mechanics, (ii) proper time in atom interferometry, and (iii) quantum clocks. We argue that the answers to these questions will shine some light on why general relativity and quantum mechanics still resist their unification. Moreover, the recent experiments with cold atoms in space in the framework of the MAIUS-rocket mission provide an excellent testing ground for these ideas.

Fig. – The Schrödinger energy spectrum of a linear potential in the presence of a hard wall is discrete. The energy eigenvalues, determined by the fact that the Airy function has to vanish at the wall, depend on fractional powers of the inertial and gravitational mass.