QUANTUM REFLECTION FROM NANOSTRUCTURES: AN EXPERIMENTAL TEST OF QED AND NON-NEWTONIAN GRAVITY

M. F. M. DeKieviet
Physics Department, Heidelberg University, Heidelberg, Germany

The quantum mechanical nature of (empty) space has far-reaching consequences in many branches of physics, ranging from (sub-) atomic physics to cosmology. The existence of electro-magnetic vacuum fluctuations, for example, manifests itself most impressively in the Casimir force, a stochastic and feeble force, so hard to measure properly, that it was considered to be solely of academic interest for a long time. With the current revolution in nano-technology, however, there is a rising, yet even economic need for a quantitative understanding. I will present an experiment, in which the Casimir-Polder force between a single atom and the surface of a solid is determined quantitatively at a few % level. It is based on the Atomic Beam Spin Echo method developed in Heidelberg, an atom interferometry method, in which we combine the exclusive surface sensitivity of thermal atom scattering with the resolution of in-beam magnetic resonance techniques. This technique will be introduced and its high resolving power (down to sub-neV) shown in some simple scattering experiments. In addition to this "classical" reflection from the repulsive wall, we also succeeded in quantum reflecting 3 He atoms at unexpectedly high kinetic energies, up to sub-meV. It is shown, that quantum reflectivity depends very sensitively on the long-range details of the attractive atom-surface interaction. Utilizing quantum reflection as a tool, we have been able to clearly identify the Casimir and the van der Waals branches for a variety of surfaces. Finally, the potential of Atomic Beam Spin Echo is addressed in particular with respect to testing QED beyond the Casimir force. I will show on-going measurements focussing on the dependency of the working of the vacuum fluctuations on temperature, geometry and spectral properties of the solid. For example, our data show the Casimir interaction can be significantly altered by heating the surface, or by using specifically nano-crafted ones. As an outlook, I will describe a novel quantum reflection experiment that has the sensitivity for testing gravity beyond Newton's law