At What Temperature is the Atom-Nanoparticle Scattering Quantum Mechanical?

T Yamaguchi[1], D Akamatsu[2,3], and R Kanamoto[4]

[1]*Department of Accelerator Science, The Graduate University for Advanced Studies (SOKENDAI), Tsukuba, Japan*
[2]*Department of Physics, Yokohama National University, Yokohama, Japan*
[3]*Precursory Research for Embryonic Science and Technology (PRESTO), Saitama, Japan*
[4]*Department of Physics, Meiji University, Kawasaki, Japan*
Contact Email: kanamoto@meiji.ac.jp

During the last decade, considerable attention has been paid to the physics of an optically levitated nanoparticle [1] because of its potential applicabilities to a variety of unexplored fields. We theoretically study the low-energy scattering of ultracold atoms by a dielectric nanosphere of silica glass levitated in a vacuum, with the emphasis on the comparison of quantum and classical scattering properties. For cesium and rubidium atoms, we compute the atom-surface dispersion force [2] and characterize the stationary scattering states by taking the adsorption of atoms onto the surface into account. As the velocity of the incident atom is lowered, we found that quantum effects emerge in observables at two different temperature regimes. The difference is found to emerge firstly in the differential cross-section at the microkelvin regime, where the thermal de Broglie wavelength of the atom is comparable to the size of the nanosphere. This difference arises due to matter-wave diffraction. Secondly, at a lower temperature than a nanokelvin, where the s-wave scattering is dominant, the quantum effects in the cross-sections are found as manifestations of the discrete nature of angular momentum and the occurrence of the classically forbidden reflection.

References

[1] L P Neukirch and N A Vamivakas, Contemp. Phys. **56**, 48 (2015)

[2] S Y Buhmann, Dispersion Forces I, Springer-Verlag, Berlin, 2012