Tomographic reconstruction of molecular properties from interference measurements

J. Fiedler[1] and S. Scheel[1]

[1] *Institute of Physics, University of Rostock, D-18055 Rostock*

Presenting Author: johannes.fiedler@uni-rostock.de

Dispersion forces, such as van-der-Waals forces between atoms or molecules, Casimir-Polder forces between atoms and macroscopic bodies and Casimir forces between macroscopic objects, are all effective electromagnetic forces caused by ground-state fluctuations of the quantised electromagnetic field [1]. Because of their short interaction range, dispersion forces can play a major role in situations where two (microscopic or macroscopic) objects are brought close together. For example, in experiments with trapped ultracold atoms the Casimir-Polder interaction can exceed the magnetic trapping force [2] and lead to unwanted losses. In molecular interferometry, these Casimir-Polder interactions influence the intensity distribution in the measured interference pattern [3], as a phase shift depending on the position of the molecule inside the grating is accumulated. Such interactions have already led to estimates of bond lengths and binding energies in small van der Waals clusters [4].

We investigate the possibility of reconstructing the Casimir-Polder potential between an atom or molecule and a dielectric object tomographically from the interference data obtained from atomic or molecular interferometry. We show that information about electromagnetic response properties of the atom/molecule such as transition dipole moments or permanent dipole moments, can be reconstructed in this way. Our method is based on the observation that the interference pattern obtained from varying incidence angles traces different paths of the atom/molecule-surface interaction potential landscape.

References

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