

Matter wave interferometry as a tool for molecule metrology

S. Gerlich, S. Eibenberger, J. Tüxen, M. Mayor, M. Arndt

Faculty of Physics

University of Vienna

Boltzmanngasse 5, 1090 Wien, Austria

e-mail: stefan.gerlich@univie.ac.at

Abstract

Talbot-Lau interferometry has recently been established as an ideal method to perform quantum matter wave experiments with large, highly polarizable molecules in the so far inaccessible mass range of beyond 1000 atomic mass units [1]. We will address benefits, challenges and potential limits of matter wave experiments with very massive objects.

Especially for thermally excited, complex molecules with a rich structure and dynamics, the interaction between their internal motion and their center-of-mass motion has often been considered as a serious obstacle for de Broglie interferometry. We present ways how information about the internal molecular properties can be extracted in matter wave experiments without destroying the quantum interference.

Specifically, by combining Talbot-Lau matter wave interferometry with optical phase gratings and external electric deflection fields, we were able to get a quantitative measure of total electric susceptibilities, including static polarizabilities and dipole moments, as well as optical polarizabilities since these properties significantly influence both, the visibility and the phase shift of the resulting interference patterns.

From these data we could then derive statements about the origin of molecular fragmentation [2], demonstrating that molecular interferometry may serve as a useful complement to mass spectrometry.

Furthermore, we could reveal the existence of thermally activated dipole moments in otherwise non-polar molecules [3] and we could show that quantum interferometry may well distinguish constitutional isomers, i.e. molecules of equal mass and equal chemical sum formula but with a different in-

ternal atomic arrangement, in spite of the fact that de Broglie interferometry is describing delocalized center of mass wave functions only.

Keywords: MATTER WAVES, INTERFEROMETRY, METROLOGY, DECOHERENCE

References

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