Molecule Interferometry and Metrology (MIME)

New ESF EUROCORE project granted for 2008-2011

The ESF collaborative research project MIME aims at exploring new mass limits in de Broglie interferometry and at exploiting quantum interferometry for the analysis of *intra*molecular properties.

Coherence experiments with *large complex molecules* are still very young. Since the first successful demonstration of matter wave diffraction with large hot molecules at the University of Vienna in 1999, several new methods have been developed for nanosized objects. Existing experiments at the University in Vienna set today's limits in particle mass and complexity for matter wave interferometry.

The MIME project now aims at pushing the *mass limit* in de Broglie interferometry by about one order of magnitude over the next three years. The increased molecular complexity is also associated with more possibilities to couple the quantum system to its environment. This offers new handles for studying *quantum decoherence* and aspects of the quantum-to-classical transition:

Molecules may be internally as hot as fire, while still showing full quantum behavior in their center of mass motion. Molecules of equal chemical sum formula may have different internal conformations, chemical structure, chirality, temperature, electric or magnetic moments. This permits us both to experimentally investigate the role of the internal structure in de Broglie dynamics of a quantum object and also reversely to use quantum interference to reveal aspects of the intra-molecular structure.

In the proposed experiments, matter wavelengths down to one picometer, thousand times smaller than the diameter of the molecules, can still be resolved. Lateral shifts of the interference patterns can be measured down to 1 nm, the diameter of single molecules!

This turns molecule interferometry into an interesting tool for measuring molecular properties, which may again appear as decohering agents in other quantum experiments. Interferometric *molecule metrology* becomes possible through developments in modern chemistry, nanophysics and quantum interferometry, and it opens an exciting new branch in quantum nanophysics.

The MIME consortium is composed of internationally renowned research teams with very complementary expertise:

- Prof. Markus Arndt (network coordinator) & Dr. Hendrik Ulbricht, University of Vienna
  … *will perform the quantum interferometry and metrology experiments*
- Prof. Marcel Mayor, University of Basel & Karlsruhe Institute of Technology,
  … *will provide tailor-made molecules, complexes, chemical analysis & functionalization*
- Prof. Horst Hahn & Prof. Herbert Gleiter, TU Darmstadt & KIT Karlsruhe
  … *will explore novel detection schemes and beam technologies for nanoparticles*
- Dr. Klaus Hornberger, Ludwig-Maximilians-Universität München
  … *will contribute theoretical guidance with regard to interferometry and decoherence.*