

Project:

Integrated Quantum Devices Atomic Bose-Einstein condensates on nanofabricated chips

Bose-Einstein condensation (BEC) of neutral atoms started a new era of human control over the state of matter. Atoms can now be prepared and manipulated in a completely well-defined quantum state, and atom lasers have been built that emit coherent matter waves. In recent work to which the applicant has made crucial contributions, it has become possible to prepare atomic Bose-Einstein condensates near the surface of simple microelectronic chips, now called “atom chips”. In a first step, this has enabled the miniaturization of the BEC apparatus. Here it is proposed to explore three new and potentially far-reaching applications of atom chips:

1. Integrated matter-wave sensors and miniaturized atomic clocks.
2. Detection and manipulation of BECs with very few atoms, and of individual trapped atoms, with the goal of quantum information processing on atom chips.
3. Use of BECs as coherent quantum probes and actuators interacting with nanofabricated devices.

The first subject is relevant to navigation and precision sensing, in particular of acceleration, rotation, and gravity gradients. The second subject contributes to experimental quantum information science and is also of fundamental interest because the coherent interaction of individual, trapped atoms has not been accessible to observation yet. The third subject is proposed here for the first time and has a correspondingly more explorative character. It brings together BEC and nanoscience, two of the most active areas of current experimental physics.

Comments:

This proposed combination of ground-breaking experiments, using Bose-Einstein condensates on guiding micro-structured solid surfaces and nano-structuring, defines the forefront of the field.

The applicant is of German nationality, did his PhD in France, and currently works in Munich. He proposes to carry out this project in a leading French laboratory. He seems to be a strong scientific leader, with considerable experience of team management. He shows a good combination of novel ideas and technical skills and is already highly regarded in the field.

The application is defining the state-of-the-art in the field. By opening up a new field, the applicant could, in principle, choose among many potentially ground-breaking experiments. The proposal is, however, well contained and focused on 3 main subjects, all of them at the very front line of physics.

The candidate is moving to one of the very few top places for this research in Europe.

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