Matter-Wave Interferometers on the Atom Chip

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Matter-wave interferometry provides an excellent tool for fundamental studies as well as technological applications. In our group, several interferometry experiments have been done with a BEC on an atom chip [1], examining different effects. For example, we studied fluctuations in the nearby environment by the interference of atoms trapped in a magnetic lattice very close (5 μm) to a room temperature surface [2,3]. We realized a new interferometry scheme of self-interfering clocks and showed, in a proof-of-principle experiment, how this could probe the interplay of QM and GR [4]. We also described a rule for "clock complementarity", which we deduce theoretically and verify experimentally [5]. In the clock interferometer, we have observed phase jumps due to the existence of a geometric phase [6]. Furthermore, we realized Stern-Gerlach interferometry [7-10] despite several theoretical works which have shown over the years that fundamental barriers exist.

I will give a brief description of the advantages of the atom chip and will then describe several of the interferometric schemes and their connection to issues such as environmentally and gravitationally (red-shift) induced decoherence, as well as loss of coherence due to interferometer imprecision (the Humpty-dumpty effect). I will conclude with an outlook concerning ideas for possible tests of exotic physics such as quantum gravity [11] and mention several speculations which we hope to examine in the future.

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