EGU General Assembly 2011

Measurements of gravity acceleration and gravity gradient with cold atom interferometry

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[10pt,a5paper]article graphics

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Matter-wave interferometry has recently led to the development of new techniques for the measurement of inertial forces, finding important applications both in fundamental physics and in applied research. The remarkable stability and accuracy that atom interferometers have reached for acceleration measurements can play a crucial role for gravimetry. Atom interferometry has been already demonstrated for precise measurements of gravity acceleration Earth's gravity gradient and rotations[1]. Accelerometers based on atom interferometry have been developed for many practical applications including metrology, geodesy, geophysics, engineering prospecting and inertial navigation[2]. Ongoing studies show that the space environment will allow to take full advantage of the potential sensitivity of atom interferometers[3].

Atomic gravity sensors are especially interesting for the attainable accuracy and long term stability. Data from gravity surveys at the Earth's surface are usually processed relatively to a network of reference stations. The systems of stations show an accuracy decay during time, which is mostly due to decay of the relative instruments (like spring gravimeter) used. For such stations, therefore, more is the need for instruments monitoring with high accuracy over time. The continuous observation of the local gravity field using sensitive instrumentation with microgal accuracy and over long periods (years) is a major goal to be attained toward a better understanding of geodynamic processes. In satellite missions for the geopotential evaluation, atom interferometry represents a promising technology. Good differential acceleration sensitivities have been already demonstrated on ground and a significant improvement can be foreseen for operation in space on a satellite in geodetic motion.

We will present some laboratory systems for the accurate measurement of gravity acceleration and gravity gradient with atom interferometry. Such systems are based on Raman light-pulse interferometry with a rubidium atomic fountain[4], and on an ultracold strontium sample trapped in an optical lattice[5]. We will also present some recent developments towards transportable ultracold atom devices for applications in gravity monitoring and in space.

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