Very long baseline atom interferometry for gravity sensing and tests of fundamental physics

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The Very Long Baseline Atom Interferometer (VLBAI) introduces a new scale of ground-based interferometers employing ultra-cold atoms on a 10 m baseline, enabling absolute measurements of gravity and its gradients with unprecedented accuracy through macroscopic separation of superposition states, as well as probing the frontiers of quantum and gravitational theories.

Thanks to the long free fall time, sensitivities competing with those of relative superconducting gravimeters are feasible, while providing the repeatability of absolute measurements inherent to atomic sensors. In collaboration with geodesists, this can contribute to the verification of models for local and global mass transport, and serve as a gravity reference station for mobile gravimeters.

Additionally, tests of fundamental physics can be conducted to narrow down boundaries of theoretical models. On the question of macroscopic properties of quantum ensembles, delocalisation on the meter scale can be realized [1], while the simultaneous operation of interferometers with two distinct species will enable tests of the universality of free fall [2].

However, performing high-accuracy atom interferometry over such extended distances and interferometry times poses severe challenges to all the components in order to avoid technical limitations, questioning the scalability of known methods and constraints.

In my contribution, I will therefore present the status of this device, which is currently being assembled in Hanover. Details will be given on the setup of the sources of ultra-cold rubidium and ytterbium, fulfilling the set of requirements for a large-scale atom interferometer. Aspects of environmental control, especially the control of magnetic and gravitational fields in the setup, as well as the isolation from vibrational noise, will be discussed and respective data will be examined.

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References

[1] T. Kovachy et al., Nature 528 (2015)

[2] J. Hartwig et al., New J. Phys. 17 (2015)