3rd URSI AT-AP-RASC, Gran Canaria, 29 May – 3 June 2022

Temperature Measurement of Cold Atoms in Cesium Fountain Experiments

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Abstract

This contribution reports a new approach to determine if a cloud of cold atoms has or not a unique, well-defined temperature. We report an accurate determination of the velocity distributions of cold atom clouds produced in a Cs fountain experiment [1, 2] using the Point by Point (PBP) method [3]. Those distributions were experimentally obtained using the magneto-optical trap (MOT) of CENAM's cesium fountain primary frequency standard. The trap has a (0, 0, 1) geometry for cooling and launching stages and the magnetic quadrupole field, with a flux density gradient of 0.75 $\mathrm{mT \cdot cm^{-1}}$ at the trap center, is produced using a pair of coils in an anti-Helmholtz configuration. To get the TOF signals at different times, two detection regions were implemented. The first probe region was positioned at the MOT's center, and the other one was placed 13.6 cm below [4].

The temperature of cold atom clouds can be determined using the width of the velocity distribution. However, the temperature may not be well-defined if the velocity distribution does not turn out to be Gaussian. In this case, the width of the velocity distribution cannot be associated to a unique temperature. In the cesium fountain primary frequency standard (CsF_1) at *Centro Nacional de Metrología* (CENAM), we found that most of the velocity distributions are not Gaussian. However, it is possible to describe such distributions by using two Gaussian functions. This strategy allows us to infer that, under some experimental conditions, a cloud of cold atoms could be formed by two groups of atoms, each of them with a well-defined temperature. This new approach provides so far, the most accurate method for temperature estimation for cold neutral atoms experiments along with an uncertainty evaluation. Accurate temperature determination in a cloud of cold atoms allows the evaluation of post-cooling stage performance and their implications related to systematic effects that depend on the atom's temperature. This approach may have an impact in the systematics frequency shifts since it can generate displacements with respect to the central frequency in the Ramsey signal [5].

References

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