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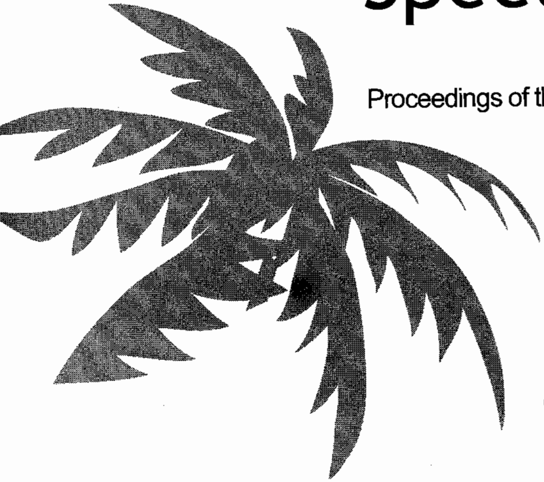

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COLD ATOM GYROSCOPE FOR PRECISION MEASUREMENTS

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We report preliminary results obtained with our atomic gyroscope. The first measurements have been realized in a configuration which enables an estimation of the limit of the signal to noise and the effect of most of the systematics. We present the first interferometric fringes in the usual configuration sensitive to rotation and acceleration.

1. Introduction

In this paper, we report preliminary results of the first cold atom gyroscope. It is based on a symmetrical Ramsey-Bordé configuration ($\pi/2-\pi-\pi/2$ pulse sequence)[1] using a pair of Raman lasers interacting with two cold caesium atom sources traveling with opposite parabolic trajectories.[2] The phase shifts due to acceleration and Raman laser phase noise can be distinguished from the rotation phase shift thanks to the use of the two atomic sources.[3]

2. Co-Propagating Configuration: Estimation of the Signal to Noise Ratio

Noise in the difference of phase between the two Raman lasers appears in the same way as the acceleration signal and can degrade the signal to noise ratio. In order to estimate independently this noise we use a co-propagating configuration in which the two Raman lasers are traveling in the same direction, leading to micro-wave transitions. In this configuration the atomic interferometer is sensitive in the same way to noise from the laser phase difference but insensitive to inertial forces. Moreover, this configuration is sensitive to most of the other sources of noise of the interferometer such as the light shift due to the Raman lasers or fluctuations in the magnetic field.[3]

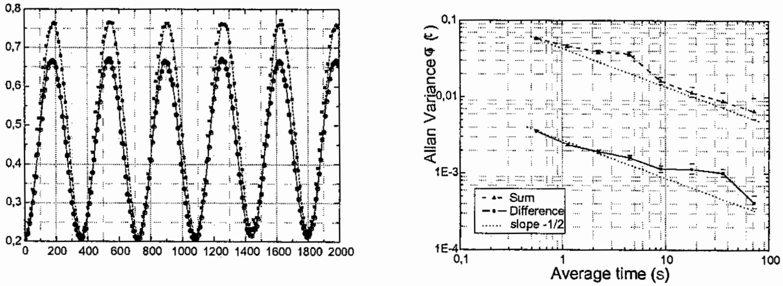

Figure 1. Left: fringe pattern corresponding to the probability of detecting the atoms in the F=4 state at the output of the interferometer when scanning the phase shift between the two Raman lasers pulses. The total interaction time is 20 ms. Right: the Allan variance for the difference (solid line) and the sum (dashed line) of the phase between the two atomic signals at the centre of a fringe with a cycling time of 560 ms.

We obtain a fringe pattern by scanning the phase shift between the two first Raman lasers pulses (Fig. 1). By sitting on the centre fringes one can measure the fluctuations in the two interferometric signals and calculate the sum and the difference to extract the information about the rotation and the acceleration. The signal to noise ratio of the sum is 17 and of the difference 280. In the case of the sum the limitation is not perfectly determined but is probably due to noise in the phase lock of the Raman lasers. The signal to noise ratio of the difference of the signals is coherent with the limit due to the quantum noise projection limit and proves that the rejection of the laser phase noise is efficient.

3. Counter-Propagating Configuration : Inertial Force Signals

In the counter-propagating configuration, in which the Raman lasers are travelling in opposite direction, the interferometers are sensitive to acceleration and rotation. Figure 2 shows the interference fringes obtained in the counter-propagating configuration but with the same experimental parameters as in Figs. 1 and 2. The increase in noise is due to vibrations in the experiment. The reduced interaction time of 20 ms has been chosen in order to have a contribution to the interferometer phase shift due to vibrations smaller than 2π.

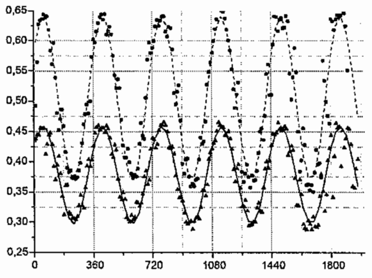

Figure 2. Fringe pattern corresponding to the probability of detecting the atoms in the F=4 state at the output of the two interferometers for a total interaction time of 20 ms. The experimental data have been fitted by sine functions, represented by the solid and dashed lines.

4. Conclusion

We have observed for the first time signals from an atomic gyroscope based on cold atoms. The study with the co-propagating configuration shows that we obtain a signal to noise of 280 thanks to the Raman phase noise rejection. It should be possible to achieve a signal to noise ratio of about 1000 by improving the vacuum, which limits the number of atoms, and by optimizing the phase lock of the Raman lasers. The results are still very preliminary and the experiment will need other improvements such as reducing the temperature of the atomic source (presently 3 μK) and isolation or compensation of the parasitic vibrations.[3] With a signal to noise ratio of 1000 and an interaction time of 90 ms the apparatus should achieve a sensitivity of 30 nrad s^{-1}.

Acknowledgments

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