Scale Factor Measurements for a Gyroscope Based on an Expanding Cloud of Atoms  
GREGORY HOTH, BRUNO PELLE, STEFAN RIEDL, JOHN KITCHING, ELIZABETH DONLEY, NIST — We present an atom interferometer that can simultaneously measure two-axis rotations and one-axis accelerations with a single cloud of atoms in an active evacuated volume of about 1 cm$^3$. This is accomplished by extending the point-source interferometry technique (Dickerson et al. PRL, 111, 083001, 2013) to a compact regime. In this technique, the cloud of atoms is imaged after the interferometer sequence. Rotations cause spatial fringes to appear across the cloud. To realize a gyroscope with this method, it is necessary to know how the wave-vector of the spatial fringes, $k$, is related to the rotation rate, $\Omega$. If the cloud is initially infinitesimally small, it can be shown that $k = F\Omega$ with a scale factor $F$ determined by the time between interferometer pulses, the total free expansion time, and the wavelength of the interrogating laser. However, the point-source approximation is not appropriate in our case because the final size of the cloud in our experiment is between 1.4 and 5 times its initial size. We show experimentally that in this finite expansion regime the phase gradient is still well described by $k = F\Omega$, but the scale factor $F$ depends on the initial distribution of the atoms. We also present modeling that explains this dependence.

Gregory Hoth  
NIST

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