

Alkali dimer molecules slightly influence the chopper data as well. The rotationally averaged alkali dimer polarizabilities are slightly less than twice the atomic polarizabilities [15], but the de Broglie wavelength, and hence path separation $s(v)$, for the dimers is half as large. Therefore, dimers acquire slightly smaller differential phase shifts than atoms. We estimate the number of alkali dimers in the atom beam in three ways. Firstly, we examine the far-field diffraction pattern from the first grating when the diffraction angle (determined by the atoms' mass and velocity) is sufficiently large to observe resolved diffraction orders. Molecules produce diffraction peaks at 1/2 the diffraction angle of atoms and we can determine the fraction of molecules in the beam by comparing diffraction order intensities between atoms and molecules. Secondly, although we cannot use a measurement of the DC phase shift, ϕ_{iDC} , to determine atomic polarizabilities, as discussed in section 3, we can use it to estimate the number of molecules in the beam. Molecule fractions greater than 10% would produce DC phase shifts inconsistent with what we expect from the phase choppers at a given position and voltage. Finally, the quality of the least-squares fit to the chopper data noticeably decreases when the molecule fraction rises above 10%.

We tested phase chopper velocity measurements against less precise velocity measurements using diffraction from a nanograting. We found no discrepancy between the two methods. However, as described in [1], we must account for a small difference between the velocity distribution of the entire beam (as measured by diffraction) and the velocity distribution of the atoms detected in the interferometer (as measured by phase choppers). The difference exists because the dispersive nature of the nanogratings, combined with detector size and beam width, leads to a velocity distribution in the atom interferometer that depends on the position of the detector. For precision measurements, it is preferable to directly measure the velocities of atoms that contribute to the detected interference pattern and thus avoid the correction (0.25% in v_0) and its associated uncertainty (0.1%). In this respect, phase choppers are better than nanograting diffraction for measuring beam velocity in an atom interferometer.

We also tested the phase choppers by measuring the static ground state polarizability of cesium using beams with three very different flow velocities on three different days. Each day we alternated between measurements of beam velocity and polarizability every hour to account for small changes in velocity ($<0.5\%$) over the course of a day due to instability in beam source temperature. The statistical error of each measurement of velocity was less than 0.1%. To measure polarizability, we used a third electric field gradient region that will be described in a future publication. We find the cesium polarizability (stat. unc.) to be 59.84(4), 59.71(7) and 59.85(8) \AA^3 at flow velocities of 925, 1345 and 1680 m s^{-1} . These polarizability measurements are subject to a systematic correction due to the third gradient region, but the consistency of the polarizability measurements provides strong evidence that our velocity measurements using phase choppers are reproducible at the 0.1% level.

Finally, we have also modeled and tested the phase choppers in the $\phi_{iDC} = +\pi$ and $\phi_{2DC} = +\pi$ mode. In the limit of an infinitely sharp velocity distribution ($r \rightarrow \infty$), there is no difference between the $+\pi, +\pi$ configuration and the $+\pi, -\pi$ configuration. However, the finite velocity spread and the fact that ϕ_{iDC} never exactly equals $\pm\pi$ results in the $+\pi, -\pi$ configuration yielding slightly more precise results than the $+\pi, +\pi$ configuration.