Atom interferometry measurements of the He-McKellar-Wilkens and the Aharonov-Casher geometric phases

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We present measurements of the He-McKellar-Wilkens (HMW) and Aharonov-Casher (AC) geometrical phases by atom interferometry. Our atom interferometer working with ^{7}Li allows the spatial separation between the two interferometer arms of about 100 μm [1]. We apply opposite electric fields, proportional to a voltage V, on the two arms and a homogenous magnetic field, proportional to a current I. We prepare the ^{7}Li atoms in their $F = 2$, $m_F = \pm 2$ ground state sublevel by optical pumping. This preparation allows the suppression of stray phases and the measurement of both the HMW and the AC phase shift in one experiment. The HMW phase shift does not depend on the magnetic hyperfine state, while the AC phase shift changes sign with m_F and we use these different behaviours to separate both phases. We measured these phases for three different atom velocities v_m, the results are in good agreement with the predicted values and are independent of v_m [2,3]. This independence is an important characteristic of a geometric phase. Fig. 1 and 2 summarize our results for the HMW and the AC phases, resp.

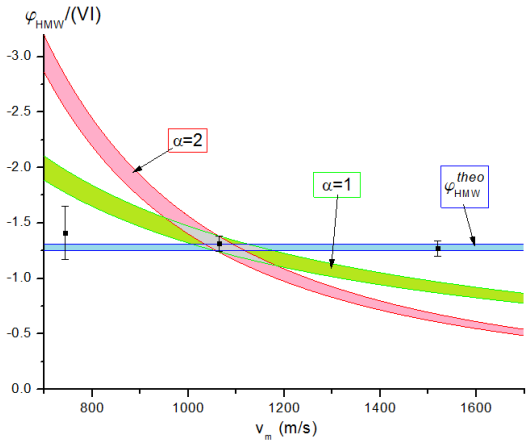

Figure 1: *Plot of the slope of the HMW phase $\varphi_{HMW}/(V\ I)$ (in units of 10^{-6} rad/VA) as a function of the mean atom velocity v_m. The experimental results are compared to the theoretical value, represented with its error bar by the blue horizontal band. The shaded areas represent what would be the phase if, starting from its value at 1062 m/s, the HMW phase was varying like $1/v^\alpha$ with $\alpha = 1$ (green) or $\alpha = 2$ (pink).*

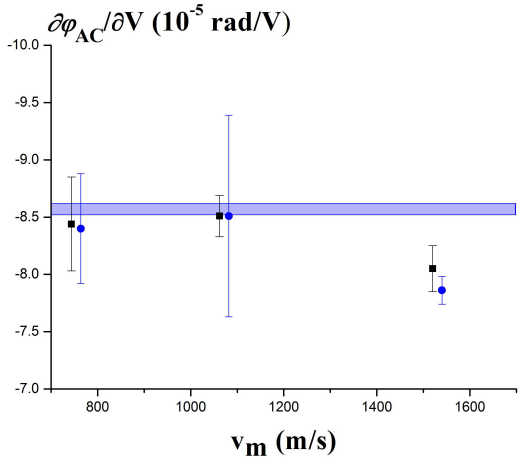

Figure 2: *Plot of the slope of the AC phase $\varphi_{AC}/(V)$ as a function of the mean atom velocity v_m. The experimental results are compared to the theoretical values calculated with the assumption of a perfect optical pumping, represented with its error bar by the blue horizontal band, and to the corrected theoretical ones, taking into account the limited optical pumping efficacy.*

References

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[3] J. Gillot, S. Lepoutre, A. Gauguet, J. Vigué and M. Büchner, submitted to Eur. Phys. J. D, `http://arxiv.org/pdf/1312.3453.pdf`