Measurement of the He-McKellar-Wilkens and Aharonov-Casher topological phases by atom interferometry

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We describe measurements of the He-McKellar-Wilkens (HMW) and Aharonov-Casher (AC) topological phases by atom interferometry. These two phases are measured in a single experiment with our lithium atom interferometer [1]. The interferometer arms spatial separation (about 100 micrometers) is sufficient to apply opposite electric fields on the two arms. In order to suppress stray effects present in our first experiment [2], we optically pump the ^{7}Li atoms in their F=2, m_F=+2 (or -2) ground state sublevel. The measured phase shift is the sum of the HMW phase and of the AC phase: we separate these two contributions thanks to their different m_F-dependence. Both phases have been measured for different lithium beam velocities and the results are independent of the atom velocity, as expected for topological phases. Figure 1 presents our results for the HMW phase.

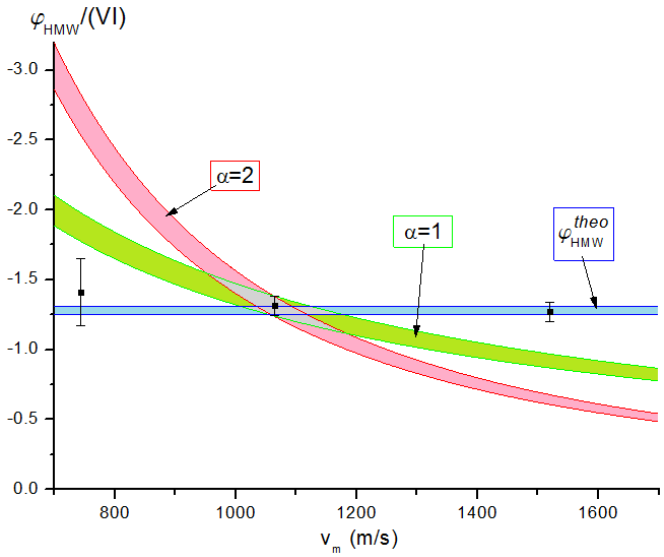

Figure: Plot of the HMW phase $\varphi_{HMW}/(V\ I)$ (in units of 10^{-6} rad/VA) as a function of the mean atom velocity v_m. The HMW phase shift, which is proportional to the product of an electric field and a magnetic field, is proportional to the product of the capacitor voltage V by the current I in the coils producing the magnetic field. 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 α =1 (green) or α= 2 (pink).

References:

[1] A. Miffre, M. Jacquey, M. Büchner, G. Trénec, and J. Vigué, Eur. Phys. J. D **33,** 99 (2005).
[2] S. Lepoutre, A. Gauguet, G. Trénec, M. Büchner, and J. Vigué, Phys. Rev. Lett. **109**, 120404 (2012).