Towards a High Sensitivity Atom Accelerometer for Exploring Physics Beyond the Standard Model

D. O. Sabulsky¹, I. J. M. Barr¹, G. Barontini¹, Y.-H. Lien¹, and E. A. Hinds¹

¹Centre for Cold Matter, Blackett Laboratory, Imperial College London, Prince Consort Road, London SW7 2AZ, United Kingdom

Presenting Author: d.sabulsky@imperial.ac.uk

Theories of dark energy usually invoke a screening mechanism to explain why their scalar fields do not produce observable long range fifth forces; a primary example of this mechanism is the so-called chameleon field. However, it is now known, from [1,2], that individual atoms are not massive enough and large enough to screen the chameleon field inside a large vacuum chamber under UHV. We present the design for an atom interferometer experiment that will place strong new constraints on the chameleon and other similar scalar fields [1].

Figure 1: Contour plot showing acceleration of rubidium atoms, normalized to the acceleration of free fall on earth \( g \), due to the chameleon force outside a sphere of radius \( R_A = 1 \) cm and screening factor \( \lambda_A = \frac{3M_A \phi_{\text{bg}}}{\rho_A R_A^2} \). The \( L - M \) area above the heavy solid line will be excluded by a first atom interferometer experiment measuring \( 10^6 \) \( g \). With modest attention to systematic errors, this can move down to the heavy dashed line. For \( \Lambda \geq 10 \) meV, atom interferometry could sense chameleon physics up to the Planck mass \( M_P \). We calculate that measurements on atoms and neutrons near surfaces, (a)-(e), already exclude the top-left corner, as indicated by the light-weight lines.

References