Bouncing atoms : a coherent nanoprobe

N. Westbrook, V. Savalli, V. Josse, L. Cognet, P. Featonby,
D. Stevens, C. Westbrook and A. Aspect

Laboratoire Charles Fabry de lInstitut dOptique,
BP 147, 91403 Orsay CEDEX, France
Tel: +33 (0)1 69 35 88 32 Fax: +33 (0)1 69 35 87 00 E-mail: david.stevens@iota.u-psud.fr
Website: http://atomoptic.iota.u-psud.fr

For several years now, many workers have been studying atom mirrors. Experimental geometries have included both flat and curved surfaces, fiber-like waveguides as well as more complex structures [1]. The evanescent wave mirror, based on the force between a laser field and an induced atomic dipole, is in principle quite simple, but the behavior of real atoms in real evanescent waves has yielded several surprises. The same can be said of the magnetic mirror, which is based on the interaction of a permanent magnetic moment with a periodically magnetized structure. Our group in Orsay has spent considerable effort in elucidating this behavior and this talk will summarize some of our recent results.

First we discuss an effect due the fact that the internal structure of the atom is more complicated than is assumed in a naive model. For an atom with a non-degenerate ground state, it is possible to create coherent superpositions of internal states which do not follow the same trajectories in the mirror potential. Interference between the states leads to fringes, quite analogous to well known Stueckelberg oscillations in collision physics. These collisions can provide a sensitive measurement of potential seen by the atom at the surface of the mirror including the van der Waals atom wall potential.

The second subject of the talk will focus on the effect of the roughness of the dielectric surface supporting the evanescent wave. When we were first experimenting with evanescent wave mirrors, we were surprised to observe that the atoms appeared to be sensitive to an rms surface roughness of order 0.1 nm . Later theoretical work led to an explanation of this effect in terms a rough dipole potential created by the interference of the evanescent wave with the light scattered by the surface. An important prediction of this understanding is that, for a spatially coherent deBroglie wave, and a roughness small compared to the deBroglie wavelength, the transverse momentum distribution of the atoms should contain a perfectly reflected specular peak and a pedestal due to the potential roughness whose width is a few times the recoil velocity. Our first experiments were not sufficiently well resolved to observe this effect. We present here recent measurements using velocity selective Raman transitions to improve the transverse velocity resolution of our reflection measurement to much better than the recoil velocity, an order magnitude improvement over our previous results.

[1] For recent reviews, see J. Dowling and J. Gea-Banaloche, Adv. At. Mol. and Opt. Phys, **37**, 1 (1996), N. Westbrook, et al., Phys. Scripta, **T78**, 7 (1998), V. Balykin, Adv. At. Mol.Opt. Phys, **4**, 181 (1999), and E. Hinds and I. Hughes, J. Phys. D: Appl Phys. **32**, 119 (1999).