Experiments with cold, trapped Rydberg atoms and molecules

Stephen D. Hogan

Department of Physics and Astronomy, University College London
Gower Street, London WC1E 6BT, U.K.
E-mail: s.hogan@ucl.ac.uk

Atoms and molecules in Rydberg states of high principal quantum number can possess electric dipole moments greater than 1000 Debye. As a result, large forces can be exerted on samples in these states using inhomogeneous electric fields. The development of methods with which to exploit these forces to decelerate and trap beams of Rydberg atoms and molecules has led to the realisation of a new set of experimental tools, including mirrors [1], lenses [2] and traps [3,4] which have applications in several areas of research. These includ, e.g., the preparation of gas-phase molecular samples with translational temperatures below 1 K for low energy collision studies and precision spectroscopic measurements [5], the study of slow molecular decay processes, the investigation of the interactions of atoms and molecules with surfaces, and the manipulation of antihydrogen atoms [6].

In this talk the application of these techniques to the preparation of cold, electrostatically trapped samples of molecular hydrogen [5] will first be presented, before the extension of this work to the manipulation of samples of Rydberg atoms and molecules in the vicinity of surface-based electrical transmission lines will be discussed. It will be demonstrated that (i) these samples can be probed spectroscopically using microwave fields propagating along the transmission lines [7]; and (ii) beams of helium Rydberg atoms can be electrostatically guided in the static electric field distribution which can be generated in the vicinity of a transmission line of this kind.

[1] E. Vliegen and F. Merkt, *Phys. Rev. Lett.* **2006**, *97*, 033002.
[2] E. Vliegen, P. Limacher and F. Merkt, *Eur. Phys. J. D*, **2006**, *40*, 73.
[3] S. D. Hogan and F. Merkt, *Phys. Rev. Lett.* **2008**, *100*, 043001.
[4] S. D. Hogan, P. Allmendinger, H. Sassmannshausen, H. Schmutz and F. Merkt, *Phys. Rev. Lett.* **2012**, *108*, 063008.
[5] S. D. Hogan, Ch. Seiler and F. Merkt, *Phys. Rev. Lett.* **2009**, *103*, 123001.
[6] A. Kellerbauer et al., *Nucl. Instr. and Meth. in Phys. Res. B* **2008**, *266*, 351.
[7] S. D. Hogan J. A. Agner, F. Merkt, T. Thiele, S. Filipp and A. Wallraff, *Phys. Rev. Lett.* **2012**, *108*, 063004.