

# RAPID-ADIABATIC-PASSAGE CONTROL OF RO-VIBRATIONAL POPULATIONS IN POLYATOMIC MOLECULES

EMIL J ZAK, *Department of Physics and Astronomy, University College London, Gower Street, London WC1E 6BT, United Kingdom*; ANDREY YACHMENEV, *Center for Free-Electron Laser Science (CFEL), Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany*.

We present a simple method for control of ro-vibrational populations in polyatomic molecules in the presence of inhomogeneous electric fields [1]. Cooling and trapping of heavy polar polyatomic molecules has become one of the frontier goals in high-resolution molecular spectroscopy, especially in the context of parity violation measurement in chiral compounds [2]. A key step toward reaching this goal would be development of a robust and efficient protocol for control of populations of ro-vibrational states in polyatomic, often floppy molecules. Here we demonstrate a modification of the stark-chirped rapid-adiabatic-passage technique (SCRAP) [3], designed for achieving high levels of control of ro-vibrational populations over a selected region in space. The new method employs inhomogeneous electric fields to generate space- and time- controlled Stark-shifts of energy levels in molecules. Adiabatic passage between ro-vibrational states is enabled by the pump pulse, which raises the value of the Rabi frequency. This Stark-chirped population transfer can be used in manipulation of population differences between high-field-seeking and low-field-seeking states of molecules in the Stark decelerator [4]. Appropriate timing of voltages on electric rods located along the decelerator combined with a single pump laser renders our method as potentially more efficient than traditional Stark decelerator techniques. Simulations for  $\text{NH}_3$  show significant improvement in effectiveness of cooling, with respect to the standard 'moving-potential' method [5]. At the same time a high phase-space acceptance of the molecular packet is maintained.

- [1] E. J. Zak, A. Yachmenev (submitted).
- [2] C. Medcraft, R. Wolf, M. Schnell, *Angew. Chem. Int. Ed.*, 53, 43, 11656–11659 (2014)
- [3] M. Oberst, H. Munch, T. Halfman, *PRL* 99, 173001 (2007).
- [4] K. Wohlfart, F. Grätz, F. Filsinger, H. Haak, G. Meijer, J. Küpper, *Phys. Rev. A* 77, 031404(R) (2008).
- [5] H. L. Bethlem, F. M. H. Crompvoets, R. T. Jongma, S. Y. T. van de Meerakker, G. Meijer, *Phys. Rev. A*, 65, 053416 (2002).