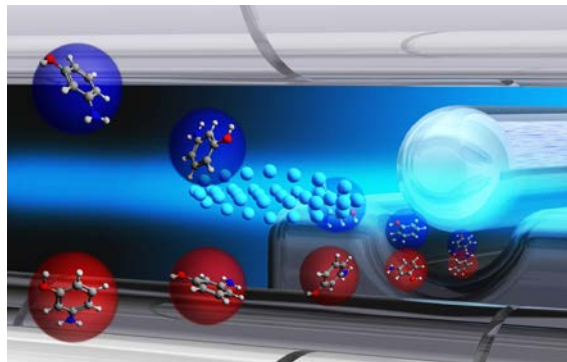


Dynamics and reactivities of cold and controlled molecules

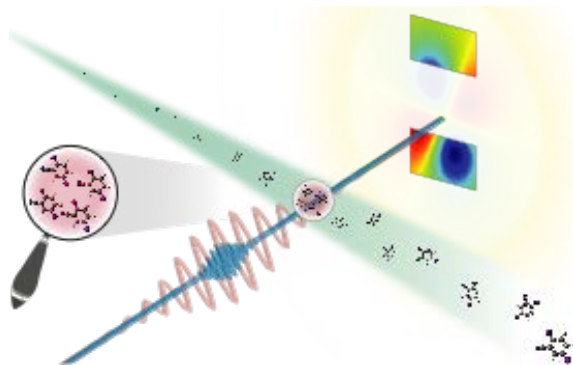
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The structure function relationship is still a largely open area of molecular sciences. On the one hand there is vast evidence for structural influence in chemistry and biology, with highly successful abstractions even at the textbook level. On the other hand, there is very little direct experimental evidence for the details of this structure-function relationship. We have demonstrated a new approach toward the investigation of the influence of conformational details in the molecular structure on the reactivity of gas-phase reactions. The next challenge is the disentangling of the chemical dynamics of individual molecular species with temporal and spatial atomic resolution. The recording of these so-called “molecular movies” is within reach. Cor-



responding modern experiments in the molecular sciences range from the investigation of ultrafast electron dynamics in small molecules to the coherent diffractive imaging of nanocrystals or viruses of biological samples. The successful filming will often rely on strongly controlled molecular samples. This includes the separation of individual structural isomers or even single quantum states of complex molecules, the ability to strongly fix molecules in space, and to deliver them to the interaction point of the probe experiment. These include, for instance, modern table-top laser systems, free-electron lasers, or electron beams.



In this presentation I briefly review our endeavors to get complex molecules under control, including the spatial separation of different species and the one- and three-dimensional alignment and orientation. I will discuss the chemical reactivities of conformers and discuss future possibilities to study the structure-function relationship in molecular reactions. Moreover, the controlled samples of such many-body quantum systems have been successfully employed in various benchmark experiments toward the recording of molecular movies and I will discuss the current status and future possibilities.

Overview

Y.-P. Chang, D. Horke, S. Trippel, and J. Küpper, “Spatially-controlled complex molecules and their applications”, *Int. Rev. Phys. Chem.* **34**, 557 (2015); DOI: [10.1080/0144235X.2015.1077838](https://doi.org/10.1080/0144235X.2015.1077838), arXiv:1505.05632 [physics]

Short biography

Jochen Küpper ist Gruppenleiter am Center for Free-Electron-Laser Science, DESY, Hamburg und Universitätsprofessor an der Universität Hamburg. Er studierte mit Hauptfach Chemie an der Heinrich-Heine-Universität Düsseldorf und wurde dort mit Schwerpunkt in der ultra-hochauflösende Spektroskopie promoviert. Als Feodor Lynen Stipendiat der Alexander von Humboldt-Stiftung an der University of North Carolina in Chapel Hill arbeitete er an der Erzeugung von "Raketentreibstoffen" in superflüssigen Heliumtröpfchen. Anschließend entwickelte er am FOM-Institut für Plasmaphysik "Rijnhuizen" in den Niederlanden und als Forschungsgruppenleiter am Fritz-Haber-Institut der Max-Planck-Gesellschaft Methoden um die Bewegung großen Moleküle zu manipulieren. Damit konnten einzelnen Quantenzustände und Strukturisomere dieser Systeme räumlich getrennt werden. 2009 wurde er an der Freien Universität Berlin in Experimentalphysik habilitiert. Seit 2010 in Hamburg hat er die Kontrolltechniken um starke Ausrichtung und Orientierung der Moleküle erweitert und verwendet diese kontrollierten Proben um zeitlich und räumlich hochaufgelöste bildgebende Verfahren zu implementieren. Zudem werden die Kontrollmethoden auf die Manipulation sehr großer (Bio-)Moleküle und Nanoobjekte erweitert. Jochen Küpper hat unter anderem den Nernst-Haber-Bodenstein-Preis der Deutschen Bunsen-Gesellschaft für Physikalische Chemie sowie einen *Consolidator Grant* des Europäischen Forschungsrates erhalten und ist *Fellow of the Royal Society of Chemistry*.

CV is available at https://www.controlled-molecule-imaging.org/team/jochen_kuepper