MO 19: Chirality

Time: Thursday 11:00–12:45 Location: HS 3044

Invited Talk MO 19.1 Thu 11:00 HS 3044

Controlling the internal quantum states of chiral molecules — JuHyeon Lee, Elahe Abdiha, Boris Sartakov, Gerard Meijer, and •Sandra Eibenberger-Arias — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany

Controlling the internal quantum states of chiral molecules enantiomer-specifically has a wide range of fundamental and practical applications. The recently developed method of enantiomer-specific state transfer [1,2] holds great promise in providing the crucial ingredient for enabling the first experimental measurement of the long-predicted parity violation in chiral molecules. It also has the potential of enabling spatial separation of enantiomers in the gas phase and opening new avenues in chiral studies. For this to be possible, (almost) perfect enantiomer-specific state transfer is necessary. However, previous studies have been limited by thermal population in all involved quantum states for all currently accessible molecular temperatures. I will present recent efforts of our group targeted at increased state-specific enantiomeric enrichment and quantitative understanding thereof [3,4]. I will also give an outlook on future experimental directions. [1] S. Eibenberger, J. Doyle, D. Patterson, Phys. Rev. Lett. 118, 123002 (2017) [2] C. Pérez, A. L. Steber, S. R. Domingos, A. Krin, D. Schmitz, M. Schnell, Angew. Chem. Int. Ed. 56, 12512 (2017) [3] J.H. Lee, J. Bischoff, A. O. Hernandez-Castillo, B. Sartakov, G. Meijer, S. Eibenberger-Arias, Phys. Rev. Lett. 128, 173001 (2022) [4] J.H. Lee, J. Bischoff, A.O. Hernandez-Castillo, E. Abdiha, B. Sartakov, G. Meijer, Sandra Eibenberger-Arias, arxiv: 2310.11120 (2023)

MO 19.2 Thu 11:30 HS 3044

Towards perfect enantiomer-specific state transfer of chiral molecules — •Elahe Abdiha, Juhyeon Lee, Johannes Bischoff, Daniel Fontoura Barroso, Boris Sartakov, Gerard Meijer, and Sandra Eibenberger-Arias — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany

Chiral molecules are important in many chemical and biological processes and are also at the heart of some fundamental physics questions. Recently, enantiomer-specific state transfer (ESST) was experimentally demonstrated [1,2]. Here, the application of three mutually orthogonally polarized microwave fields yields enantiomer-specific population control in a chosen quantum state that is part of a triad of rotational states. I will present our recent work on ESST, where we largely overcome the previous limitation due to initial thermal population by combining ESST with optical methods [3]. By depleting the target state using resonant UV light prior to ESST we achieve state-specific enantiomeric enrichment in the order of 50%. Importantly, we quantitatively study ESST, explicitly including the role of spatial degeneracy. I will also discuss our recent study on the influence of microwave pulse conditions on ESST [4]. Extensions to our scheme will allow to create a molecular beam with an enantiomer-pure rotational level, holding great prospects for future spectroscopic and scattering studies.

[1] Eibenberger et al, PRL 118, 123002 (2017) [2] Pérez et al, Angew. Chem. Int. Ed. 56, 12512 (2017) [3] Lee et al, PRL 128, 173001 (2022) [4] Lee et al, arxiv: 2310.11120 (2023)

MO 19.3 Thu 11:45 HS 3044

Purcell effect in chiral environments — •Omar Jesus Franca Santiago[1], Claudio Salvador Rapp[1], Janine Christine Franz[2], and Stefan Yoshi Buhmann[1] — [1]Institute of Physics, University of Kassel, Germany — [2]University of Freiburg, Germany

The Purcell effect describes the modification of the spontaneous decay rate in the presence of electromagnetic media and bodies. In this work, we shed light on the dependencies and magnitude of this effect for chiral materials. Using the framework of macroscopic quantum electrodynamics [1,2] and Fermi's golden rule, we study a chiral bulk medium with and without local field corrections, an idealised chiral mirror and a chiral surface. The results imply that the chiral effect is greatest for large transition frequencies, molecules with large optical rotatory strength, and media with a strong cross-susceptibility. In the case of a surface, short distances from the molecule to the interface additionally enhance the effect.

[1] D.T. Butcher, S.Y. Buhmann, and S. Scheel, New J. Phys. 14, 113013 (2012).

[2] S. Y. Buhmann, Dispersion Forces II: Many-Body Effects, Excited Atoms, Finite Temperature and Quantum Friction, (Springer, Berlin Heidelberg, 2012).

MO 19.4 Thu 12:00 HS 3044

Silicon 2p inner-shell photoelectron circular dichroism in sec-butyl trimethylsilylether — •Emilia Heikura, Christina Zindel, Lutz Marder, Catmarna Küstner-Wetekam, Niklas Golchert, Johannes Viehmann, Denis Kargin, Rudolf Pietschnig, Andreas Hans, and Arno Ehresmann — University of Kassel, Heinrich-Plett-Straße 40, 34132 Kassel

Photoelectron circular dichroism (PECD) is one of the most powerful methods for investigating molecular chirality in the gas phase. PECD is a forward-backward asymmetry of emitted photoelectrons from chiral molecules after interaction with a circularly polarized light. The asymmetry can be observed even in randomly oriented chiral molecules. Site-selectivity of inner-shell photoelectrons enables the investigation on chirality as a function of a distance from a stereocenter. It is still unknown how the magnitude of PECD is affected by the distance of the emission site from the stereocenter. To be able to investigate this phenomenon, a series of specifically synthesized molecules was created. In sec-butyl trimethylsilylether and it's derivatives the distance between stereocenter and a marker atom can be increased by inserting additional CH_2 groups while otherwise the structure of the molecule stays intact.

MO 19.5 Thu 12:15 HS 3044

Control of circular dichroism in ion yield of 3-methyl cyclopentanone using femtosecond laser pulses — •Sagnik Das, Jayanta Ghosh, Sudheendran Vasudevan, Hangyeol Lee, Nicolas Ladda, Simon Ranecky, Tonio Rosen, Till Stehling, Fabian Westmeier, Arne Senftleben, Thomas Baumert, and Hendrike Braun — Institut für Physik, Universität Kassel, Heinrich-Plett-Strasse 40, 34132 Kassel, Germany

Circular dichroism in ion yield (CDIY) is the difference in ion yield from left and right circular polarised light interacting with an enantiomer of a chiral molecule. The cyclic ketone 3-methyl cyclopentanone (3-MCP) has long been studied for its large circular dichroism in the $\pi^* \leftarrow n$ transition. We used femtosecond laser pulses tuned in wavelength around one of the vibrational modes in the $\pi^* \leftarrow n$ band to study the effect of pulse parameters like linear chirp and peak intensity on the CDIY. In the 3-photon resonance enhanced multiphoton ionization (1+1+1) of 3-MCP, we observed an enhancement of CDIY for chirped pulses. At the same time, almost no change in CDIY was detected for variation of the peak intensity of bandwidth-limited pulses. Not only the magnitude of the chirp but also its sign influences the CDIY, indicating more than the pulse duration or peak intensity as the underlying cause. It highlights the role of frequency ordering in the observed enhancement of CDIY for chirped pulses. Moreover, the progression of the CDIY with regard to the applied linear chirp sensitively depends on the central wavelength of the laser pulses.

MO 19.6 Thu 12:30 HS 3044

Photoelectrons from transiently populated nonresonant states — •Simon Ranecky, Sudheendran Vasudevan, Han-gyeol Lee, Till Stehling, Nicolas Ladda, Tonio Rosen, Fabian Westmeier, Sagnik Das, Jayanta Ghosh, Hendrike Braun, Arne Senftleben, and Thomas Baumert — Universität Kassel, Institut für Physik und CINSaT, D-34132 Kassel

When an intense laser pulse induces a two-photon electronic transition from one state to another, all other states are populated transiently with various proportions during the interaction time. This transient population in nonresonant states can absorb further photons and then become ionized so that these states become visible in the photoelectron spectrum. This effect was already observed for Sodium atoms [1].

Here, we report the observation of the same ionization mechanism for the first time on molecules using Fenchone and fs- to ns-lasers around 400 nm. The main ionization scheme for this molecule at this wavelength is 2+1 resonance-enhanced multiphoton ionization. And besides the photoelectrons from resonant s- and p-states, we could see photoelectrons from further, nonresonant states.

With this study, we want to encourage spectroscopists to have a close look at the background of their photoelectron spectra. Doing this for Fenchone and observing the weak signals from transiently populated, nonresonant states, we were able to determine the energies of these states.

[1] Krug et al. N.J. Phys. 11 (2009) 105051