Quantum Colloquium

Ultrafast molecular chirality: a topological connection

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An object is said to be chiral if it cannot be superimposed on its mirror image by any rotation. The two mirror images of the same chiral molecule are called enantiomers and are often referred to as “left”- and “right”-handed. While the physical properties of the two enantiomers of the same chiral molecule are nearly identical, the geometric property of chirality leads to vastly different chemical properties of the two enantiomers. The need for rigorous selection of a specific enantiomer, a now standard requirement in drug design, is one of the many reasons behind the ever-greater need for improving sensitivity of chiral sensing.Yet, standard optical methods of chiral detection still use the same principles as the method discovered by Louis Pasteur in the XIX century: the linear interaction between chiral molecules and light, which becomes chiral-sensitive due to the magnetic field component of the light wave.Ultrafast non-linear spectroscopies promise to increase the enantio-sensitive signal by three orders of magnitude [1] by removing the need to rely on the interaction with the magnetic field component of light. The second important feature of non-linear light-matter interactions is the opportunity to imprint topological properties of light on matter, presenting an opportunity to achieve topologically robust enantio-sensitive observables.I will describe our very recent results [2,3] on marrying chiral and topological properties in ultrafast electronic response of chiral molecules in the gas phase, enabling highly efficient and robust chiral observables. I will present three vignettes where topological connection appears in optical or electronic chiral response:Chiral topological light: a new concept enabling chiral-sensitive and topologically robust properties of high harmonic emission, generated by such light in chiral molecular gases [2]Geometry of temporal chiral structures: a concept encompassing the emergence of geometric fields in electronic response of chiral molecules [3]Enantio-sensitive exceptional points: chiral topology in non-Hermitian chiral systems [4] References:[1] “Ultrafast chirality: the road to efficient chiral measurements” D Ayuso, A F Ordonez, O Smirnova, (Perspective) Phys. Chem. Chem. Phys., 2022, 24, 26962-26991, (2022)[2] “Chiral topological light for detecting robust enantio-sensitive observables” N Mayer, D Ayuso, M Ivanov, M. Khokhlova, E Pisanty, O Smirnova, Nature Photonics 2024, https://doi.org/10.1038/s41566-024-01499-8[3] Geometry of temporal chiral structures, A. F. Ordonez, A. Roos, P. Mayer, D.Ayuso, O. Smirnova, arXiv preprint arXiv:2409.02500, 2024[4] “Enantiosensitive exceptional points” N Mayer, N Moiseyev, O Smirnova, arXiv preprint arXiv:2306.12293, 2023

Tuesday, December 17, 2024 11:00am - 12:00pm

Office Building West/Ground Floor/Heinzel Seminar Room

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