

Chiral asymmetry in elastic scattering of vortex electrons by molecules

Tuesday 28 October 2025 14:45 (15 minutes)

Photoelectron circular dichroism (PECD) [1] is a well-known phenomenon resulting in asymmetry in the angular distribution of photoelectrons produced in the ionization of randomly oriented chiral molecules in a gas by circularly polarized light relative to the direction of light propagation. Recent advances have extended this concept to vortex electrons, where the ejected photoelectron has a certain projection of its angular momentum on a given vortex axis [2].

We consider an elastic scattering of vortex electrons by chiral molecules. Using an exact theoretical framework implemented for the zero-range potential model [3] of a chiral D-glyceraldehyde molecule ($C_3H_6O_3$), we demonstrate that the angular distribution of scattered electrons depends on the handedness of both the incident electron vortex and the target molecule. This effect persists after averaging over molecular orientations and is absent in conventional plane-wave electron scattering. The predicted chiral asymmetry is quantitatively described by the coefficients $b_L^m(\theta_q)$, which determine the observable orientation-averaged angular distribution of the scattered electrons:

$\langle w_{mq\theta_q}(\Omega_r) \rangle = \frac{1}{4\pi} \sum_{L=0}^{\infty} b_L^m(\theta_q) P_L(\cos \theta_r)$, where θ_q is the vortex opening angle and θ_r is the scattering angle of the outgoing electron. Specifically, for a chiral molecule, the relation $\tilde{b}_L^m(\theta_q) = b_L^{-m}(\theta_q)$ holds, where \tilde{b}_L^m denotes the coefficients for the enantiomer. This relation leads to a measurable difference in the distribution of scattered electrons for vortices with opposite orbital angular momentum projections. Our result suggests that scattering of vortex electrons could provide a new method for studying the electronic structure and properties of chiral materials.

This work was supported by the Russian Science Foundation (Grant No. 24-12-00055).

References:

- [1] B. Ritchie, Theory of the angular distribution of photoelectrons ejected from optically active molecules and molecular negative ions, Phys. Rev. A 13, 1411 (1976).
- [2] K. V. Bazarov and O. I. Tolstikhin, Chiral asymmetry in the photoeffect with vortex photoelectrons, Physics Letters A 556, 130818 (2025).
- [3] Y. N. Demkov and V. N. Ostrovskii, Zero-Range Potentials and Their Applications in Atomic Physics (Plenum Press, New-York, 1988)

Authors: KOLOVERTNOVA, Valentina (MIPT); Mr V. BAZAROV, Kirill (MIPT); Dr I. TOLSTIKHIN, Oleg (MIPT)

Presenter: KOLOVERTNOVA, Valentina (MIPT)

Session Classification: Theoretical Physics

Track Classification: Theoretical Physics