Polarization Drag in a Gas of Molecular Superrotors

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When linearly polarized light is transmitted through a rotating dielectric, the polarization plane is slightly rotated—a phenomenon predicted by Fermi [1] in 1923 and first observed in mechanically rotated specimens more than fifty years after that [2]. For typical nonresonant dielectric materials, the measured polarization drag angle does not surpass several microradians. Recently, the rotary polarization drag was enhanced by about four orders of magnitude by using near-resonant slow light in a rotating solid ruby rod [10]. Up to now, the rotary polarization drag (also known as the mechanical Faraday effect) has never been observed in a gaseous medium, despite its potential importance in plasma physics and astrophysical applications. Compared to solids, the much lower density of gases presents a significant challenge for studying this effect in the laboratory.

Recently [4], we proposed an alternative approach for creating rotational polarization drag with an unprecedentedly high specific rotation level—four orders of magnitude higher than in the above record slow-light experiment [3]. Instead of mechanically rotating a bulky dielectric object as a whole, we suggested using short, strong laser pulses for exciting fast unidirectional rotation of individual microscopic constituent elements of the medium. This can be implemented in a gas of molecular super rotors, which are molecules excited to extremely high rotational states with strong laser pulses. The super rotors behave as tiny gyroscopes and retain their rotation through many collisions [5].

In our talk, we will discuss the physics behind the suggested approach and will present the results of the first observation [6] of the mechanical Faraday effect (rotary polarization drag) in various gases under ambient conditions (O_2, N_2, CO_2, and ambient air) excited with the help of an optical centrifuge [7].

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