Rotational Control of Helium Dimers in Superfluid Helium

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I will discuss our recent results on coherent excitation and coherent control of metastable helium dimers (He_2^*) inside bulk superfluid helium by means of shaped ultrashort laser pulses. I will present an experimental study of the laser-induced rotation of helium dimers inside the superfluid ^{4}He bath at variable temperature. The coherent rotational dynamics of He_2^* is initiated in a controlled way by ultrashort laser pulses, and tracked by means of time-resolved laser-induced fluorescence. We detect the decay of rotational coherence on the nanosecond timescale and investigate the effects of temperature on the decoherence rate. The observed temperature dependence suggests a non-equilibrium evolution of the quantum bath, accompanied by the emission of the wave of second sound [1].

I will also report on the experimental demonstration of the rotational control of helium dimers by a periodic sequence of linearly polarized femtosecond pulses (a pulse train). We show that the degree of rotational excitation of He_2^* can be enhanced or suppressed by varying the period of the pulse train, whereas the directionality of molecular rotation can be controlled by the relative angle between the polarization vectors of pulses in the train [2].

[1] Milner A. A., V. A. Apkarian, Milner V., "Dynamics of molecular rotors in bulk superfluid helium", *Science Advances*, **9**, eadi2455 (2023).
[2] Milner A. A., MacPhail-Bartley I., Preocanin K., Dasgupta S., Peng X., Milner V., "Coherent control of molecular rotation in superfluid helium", *Phys. Rev. A*, **109**, 013110 (2024).