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Spin-orbit-coupled Bose-Einstein Condensate as playground to explore quantum collision and chemistry

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Abstract: In this talk I will describe our recent experiments studying spin-dependent quantum transport/collision as well as chemical reactions in a Bose-Einstein condensate (BEC) of ultracold (^{87}Rb) atoms subject to optically-generated “synthetic” spin-orbit coupling (SOC). By performing a “quantum quench” (suddenly reducing the optical Raman coupling that generates the synthetic SOC and gauge fields), we induce head-on collisions between two (dressed) spinor BECs (so called “spin dipole mode”) and study how such spin transport is affected by SOC, revealing rich interplay between quantum interference, many-body interactions, and (im)miscibility between (dressed) spinor condensates [1]. We also demonstrate a new approach of quantum control of (photo) chemical reactions (photoassociation of molecules from atoms) – a “quantum chemistry interferometry” – by preparing reactants in (spin) quantum superposition states and interfering multiple reaction pathways [2]. Time permitting, I may briefly discuss our recent realization of a BEC on a “synthetic” cylinder (by cyclicly couple spin states based “synthetic dimensions”) with a synthetic radial magnetic flux, giving rise to a symmetry protected topological band crossings and quantum transport mimicking motion on a Mobius strip in momentum space [3]. Our experimental system can be a rich playground to study physics of interests to AMO physics, quantum chemistry, condensed matter physics, and even high energy/nuclear physics.

[1] C. Li et al. “Spin Current Generation and Relaxation in a Quenched Spin-Orbit Coupled Bose-Einstein Condensate”, *Nature Comm.* 10, 375 (2019)

[2] D. Blasing et al. “Observation of Quantum Interference and Coherent Control in a Photo-Chemical Reaction”, *PRL* 121, 073202 (2018)

[3] C. Li et al., “A Bose-Einstein Condensate on a Synthetic Hall Cylinder”, arXiv:1809.02122

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