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Effect of Spin-Orbit Coupling to Interacting Ultracold Atoms[1]

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The recent realization of spin-orbit (SO) coupling in neutral atoms has opened up new directions to explore novel SO effects in a diversity of new physical settings. In this talk, I shall discuss two important effects of SO coupling to interacting ultracold atoms. First, the presence of SO coupling will inevitably induce mixed scatterings and interference between different partial-waves, and as a result it could significantly affect the validity of widely-used pseudo-potentials. Explicitly, the s-wave pseudo-potential alone is approximately valid under more stringent conditions, while the p-wave pseudo-potential alone can no longer be used even near p-wave resonance. These results indicate a fundamental change of short-range physics for interacting atoms in high orbits, due to destructive interference with lower ones. Second, the presence of SO coupling will induce exotic scattering between spin-1/2 bosons confined in a quasi-one-dimensional waveguide, and lead to a Tonks gas with unique properties that have not been unveiled before. Explicitly, SO coupling will break the magnetization conservation during the scattering process, and also induce a sequence of scattering resonances (or Tonks limit) simultaneously in all scattering channels. Unlike the usual Tonks gas of identical bosons, the Tonks gas here, with strong spin-orbit entanglement, exhibits rich textures in spin and density distributions. These features can be directly observed in current cold atom experiment.

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