MAR10-2009-007523

Abstract for an Invited Paper
for the MAR10 Meeting of
the American Physical Society

Collision dynamics of molecules and rotational excitons in an ultracold gas confined by an optical lattice[1]

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This talk will focus on two problems: (i) inelastic collisions of ultracold molecules confined by optical laser forces; and (ii) dynamics of rotational excitons in an optical lattice of ultracold polar molecules. Optical laser forces can be used to restrict the motion of ultracold particles in one dimension to produce a quasi-2D gas. I will discuss the general features of inelastic scattering and chemical reactions in ultracold quasi-2D gases of molecules. I will demonstrate that the cross sections for inelastic and chemically reactive collisions are suppressed by the confinement forces. This suppression is generally more significant than the effect of the laser confinement on the probability of elastic scattering. The elastic-to-inelastic collision ratios are therefore enhanced in the presence of a laser confinement. Our results thus suggest that applying laser confinement in one dimension may stabilize ultracold systems against reactive collisions. I will show that the threshold energy dependence of cross sections for both elastic and inelastic collisions in quasi-2D gases can be tuned by varying the laser confinement forces and an external magnetic field. Optical laser forces can also be used to generate periodic lattice structures of ultracold molecules. Rotational excitation of molecules in the lattice structures gives rise to rotational excitons. I will show that a combination of an optical confinement and an external dc electric field can be used to induce scattering resonances in collisions of the rotational excitons with lattice impurities. These resonances are analogous to Feshbach resonances in atomic collisions. An external dc electric field can be used to control dynamics of the rotational excitons, leading to localization of excitons by multiple collisions with impurities. The system of ultracold molecules I will describe can thus be used for the detailed study of fundamental physical phenomena such as Anderson localizations.

[1]Work supported by NSERC of Canada