Ultra-cold Polar Fermionic Molecules in Bilayers

A. Pikovski[a], M. Klawunn[b], A. Recati[b], G. Shlyapnikov[c,d], and L. Santos[a]

[a]Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstr. 2, 30169 Hannover, Germany
[b]INO-CNR BEC Center and Dipartimento di Fisica, Università di Trento, 38123 Povo, Italy
[c]Laboratoire de Physique Théorique et Modèles Statistiques, Université Paris Sud, 91405 Orsay, France
[d]Van der Waals-Zeeman Institute, University of Amsterdam, Valckenierstraat 65/67, 1018 XE Amsterdam, The Netherlands

Ultra-cold polar fermionic molecules in a bilayer geometry constitute a novel system with interesting physical properties. The long-range dipole-dipole interaction between molecules of different layers leads to the emergence of interlayer superfluids, even in the absence of tunneling between the layers. The superfluid regimes range from a BCS-like fermionic superfluidity to a BEC of interlayer dimers, exhibiting a BCS-BEC crossover. The peculiar inter-layer two-dimensional scattering results in interesting novel effects. In particular, we consider the case where molecules in each layer are initially prepared in different rotational states. It is shown that inter-layer interactions can lead in a two-body collision to a swap of rotational state of molecules in different layers, resembling spin-changing collisions in spinor gases. The rate of these state-changing collisions shows a non-trivial dependence with density, temperature and inter-layer separation. For optically trapped highly reactive molecules, like KRb, such state-changing collisions are accompanied by immediate losses, and hence the swapping collisions may be easily observed by monitoring the molecule number.