Quantum Li-Cr mixtures with tunable interactions

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Fermi–Fermi mixtures of ^{6}Li–^{53}Cr, uniquely realized in our laboratory, offer a promising platform for exploring novel quantum phenomena. The comparably large mass ratio ($M/m \sim 8.8$) is predicted to support exotic non-Efimovian few-body bound states, with potential impact on many-body physics [1–3]. Parallel to this, LiCr molecules are expected to exhibit both a large electric (3.3 Debyes) and a magnetic dipole moment (5 μ_B) [4], making this system a strong candidate to achieve the first quantum gas of paramagnetic polar molecules.

After a brief overview of the Li–Cr system [5, 6], I will present key technical advances in the experimental setup, including a major upgrade of the chromium laser system, which improved stability and enabled control across different isotopes and magnetic-field regimes. These developments allowed the production of new ultracold mixtures of ^{6}Li with bosonic chromium isotopes, leading to the realization of Bose–Einstein condensates of ^{52}Cr and, for the first time, ^{50}Cr, as well as the corresponding degenerate Fermi–Bose mixtures.

I will then discuss the characterization of interspecies and intraspecies interactions via Feshbach loss spectroscopy. The identification of resonances using different isotopic combinations, together with the knowledge of the Feshbach resonances already characterized [5, 7], allowed us to extract information on the Li–Cr and Cr–Cr interaction potentials, including the exact number of bound states, in agreement with theoretical predictions [4]. On top of that, a broad low-field resonance in the ^{50}Cr system provides a convenient tool for interaction tuning.

Finally, I will present ongoing work on the phase-space density of weakly-bound bosonic and fermionic LiCr molecules. Together with previous results on LiCr molecular samples [4], these studies represent a significant step toward the realization of a quantum gas of paramagnetic polar molecules.

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