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Towards ultracold RbSr ground-state molecules

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A current challenge in quantum gases is to produce trapped clouds of ultracold ground-state molecules having both an electric and a magnetic dipole moment. These would form a novel platform for investigations of few- and many-body physics, quantum simulation, quantum information and quantum-controlled chemistry. A promising route to achieve this is to combine ultracold alkali and closed-shell atoms. Our group has focused on the combination Rb-Sr. Ground-state RbSr molecules have an electric dipole moment of around 1.5 debye (in the molecular frame) and a magnetic dipole moment of ~1 bohr magneton (from the unpaired electron). We have observed magnetic Feshbach resonances with this combination [1]. Such resonances are typically at high fields (~kG) and are very narrow (mG widths). We have developed a magnetic field control system with ppm-level stability [2], in order to investigate such narrow resonances in detail. Current experiments focus on the combination of (bosonic) ^{87}Rb and (fermionic) ^{87}Sr. This combination has a large interspecies scattering length (~$1500a_0$ [3]), and rather strong three-body losses at and near quantum-degeneracy. We have identified and detected a promising Feshbach resonance, at 521 G magnetic field, for producing weakly-bound molecules of this combination. Because of the nuclear spin of ^{87}Sr ($I = 9/2$), this resonance actually splits up in 10 separate Feshbach resonance features, one for each nuclear spin component, similar to the recent observations in the Cs-Yb combination [4]. We plan to load the ^{87}Rb and ^{87}Sr jointly in an optical lattice with the aim of reducing three-body losses. This will also open an interesting alternative route to molecule formation, namely sweeping through a confinement-induced resonance by ramping the lattice depth. Our latest results will be presented at the conference.

[1] V. Barbé et al, Nature Physics 14, 881 (2018)
[2] M. Borkowski et al, Rev. Sci. Instr. 94, 073202 (2023)
[3] A. Ciamei et al Phys. Chem. Chem. Phys. 20, 26221 (2018)
[4] T. Franzen et al, Phys. Rev. Res. 4, 043072 (2022)

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