BCS-to-BEC crossover with ultracold fermionic molecules: a polaron perspective

Eugen Dizer[1,†], Xin Chen[1], Richard Schmidt[1], Arthur Christianen[2,†]

[1]Institute for Theoretical Physics, Heidelberg University, D-69120 Heidelberg, Germany
[2] Institute for Theoretical Physics, ETH Zürich, Zürich, Switzerland
† achristianen@phys.ethz.ch

Degenerate gases of ultracold molecules are expected to exhibit rich many-body physics due to their strong and field-tunable dipolar interactions. For fermionic molecules, a key question is how dipolar interactions influence Cooper pairing and superfluidity, and in particular the BCS-to-BEC crossover. In molecular (hyperfine) mixtures, both s-wave and p-wave pairing and their competition can be explored. Starting from the population-imbalanced limit, polaron spectroscopy offers a useful and experimentally feasible probe of these phenomena. In our theoretical work, we study a single dipolar impurity in a Fermi gas and examine how dipolar interactions shape the polaron spectrum. We show how the polaron energy directly follows from the underlying scattering phase shifts. Near a scattering resonance, we find clear signatures of both the s-wave and p-wave bound states in the polaron spectrum. Remarkably, these states hybridize through the medium, highlighting the role of complex few-body physics in the phase diagram of degenerate dipolar many-body systems.