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Multichannel nature of elastic and inelastic three-body collisions

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For a thorough investigation of both elastic and inelastic three-body interactions, ranging from universal Efimov physics to non-univeral species-dependent collisions, one needs a three-body collision model that can handle all regimes of interaction strength. We developed a full three-body spin-dependent coupled-channels model in momentum space, with a very accurate expansion of the full pair-wise interaction potentials, which we implemented for several alkali atom species. Our model is numerically tractable, and we are able to investigate both elastic and inelastic three-body collisions to a high level of precision, for all regimes of the two-body interaction strength.

The full multi-spin nature of our method allowed us to identify an interesting and significant spin-exchange path in the three-body recombination process for ultracold lithium-7 atoms. This path requires one atom flipping its nuclear spin to allow the other two atoms to form a molecule with a large electronic singlet component, that enhances the recombination rate drastically.

We achieved a breakthrough on the lithium three-body puzzle, with a three-body parameter that deviates in opposite direction from universality compared to common finite range theory. We solved the puzzle by taking the full multichannel spin structure into account combined with the actual interaction potentials, and performing extremely heavy calculations by putting our model on a high-performance computing facility.

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