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State-to-state chemistry for three-body recombination in an ultracold rubidium gas

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Experimental investigation of chemical reactions with full quantum state resolution for all reactants and products has been a long-term challenge. We have recently developed an experimental method for detecting molecules in a quantum state resolved way with unprecedented resolution, which we can use to study chemical reactions. As a benchmark reaction, we investigate three-body recombination of ultracold Rb atoms, where two atoms combine to form a Rb2 molecule while the third atom carries away part of the released binding energy. Initially the atoms are prepared in a well-defined internal quantum state. After the reaction we state-selectively ionize the produced molecules with a resolution of about 5 MHz such that most molecular quantum states can be spectroscopically distinguished. Our results allow for formulating propensity rules for the distribution of products. Furthermore we have developed a theoretical model that predicts many of our experimental observations. The scheme can readily be adapted to other species and opens a door to detailed investigations of inelastic or reactive processes.