HIGH PRECISION PHOTOASSOCIATION SPECTROSCOPY OF ULTRA-COLD ALKALIS.

EITE TIESINGA and PAUL JULIENNE, *Atomic Physics Division, National Institute of Standards and Technology, Gaithersburg, MD 20899*.

The ability to manipulate neutral atoms with lasers has brought new life to photoassociation spectroscopy. Photoassociation is the process whereby a photon binds two free atoms into an excited molecule. Previously the precision was limited by Doppler and/or collisional broadening caused by the high temperature of the gas of atoms but nowadays laser cooling can cool ^{2}S alkali atoms well below 1 mK. The collisional broadening is then comparable to the natural line broadening inherent to the excited ^{2}S+^{2}P alkali di-atom. Moreover, these ultra-cold temperatures favor the formation of long-range weakly-bound di-atoms. We developed a quantitative theoretical model that explains both the observed level structure and the shape and intensity of the lines. The success of the model crucially depends on the understanding of the interplay between hyperfine and fine structure interactions as well as rotational and vibrational motion of the di-atom. The excited molecules are so weakly bound that the vibrational spacings are comparable to hyperfine and rotational interactions. The line shape analysis enables us to extract the shape of the collisional wave function near the outer turning point of the di-atom and hence determines the zero-energy scattering length crucial for the understanding of the stability and shape of a Bose condensate of a weakly interacting gas of alkali atoms. We will present a comparison between theoretical and experimental spectra for Sodium and Potassium.