# FORMATION, DETECTION, AND SPECTROSCOPY OF ULTRACOLD GROUND-STATE KRb

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We use photoassociation (PA) of ultracold atoms to produce ultracold KRb molecules in high vibrational levels of the singlet ground state, $X\ ^1\Sigma^+$, and the triplet metastable state, $a\ ^3\Sigma^+$.[b] The heteronuclear PA takes place in overlapping "dark-SPOT" MOTs of $^{39}$K and $^{85}$Rb. Ultracold molecules that have radiatively decayed to the $X\ ^1\Sigma^+$ and $a\ ^3\Sigma^+$ states are detected via resonant two-photon one-color ionization by a pulsed dye laser. By scanning the detection laser, vibrationally resolved spectra are obtained for both the lower state (either $X$ or $a$) and the upper state (primarily the $4\ ^1\Sigma^+$ and $4\ ^3\Sigma^+$ states).[c] Analysis of these state-selective detection spectra also reveals the lower-state vibrational population distributions. We find that the $X\ ^1\Sigma^+$ and $a\ ^3\Sigma^+$ molecules reside predominantly in high-lying levels, bound by less than 30 cm$^{-1}$. As the PA laser is tuned farther below the asymptote, the PA process occurs at shorter range and the $X$ and $a$ populations shift to more deeply bound levels.

For higher resolution of selected spectral regions, we have used a cw laser to perform depletion spectroscopy of the ultracold KRb molecules. Here the pulsed detection laser is tuned to a transition from a specific high-$v$ level of the $X$ or $a$ state in order to monitor its population. As the cw laser is scanned, depletion dips are observed when rovibrational levels of the upper states are excited. Rotational resolution is thus obtained. We have recently completed an improved determination of the dissociation energy of KRb by combining our depletion spectroscopy results with earlier measurements of lower-$v$ levels using conventional laser spectroscopy. The result, $D_e = 4217.822 \pm 0.003$ cm$^{-1}$, is 140 times more accurate than prior determinations. In the future, we plan to use some of these transitions as part of a Raman transfer process from high-$v$ levels of the $X\ ^1\Sigma^+$ state to the absolute ground state, $v$=0, $J$=0.

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