RESONANCE-ENHANCED PHOTOASSOCIATIVE FORMATION OF GROUND-STATE Rb_2 AND SPECTROSCOPY OF MIXED-CHARACTER EXCITED STATES

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We describe experimental and theoretical studies of the effects of resonant electronic state coupling on the formation of ultracold ground-state $^{85}\mathrm{Rb}_2$. The molecules are formed by photoassociation of ultracold atoms in a MOT into the 0_u^+ state converging to the $5S + 5P_{1/2}$ limit, followed by radiative decay into high vibrational levels of the ground electronic state, $X\ ^1\Sigma_g^+$. The populations of these high-v ground-state levels are monitored by resonance-enhanced two-photon ionization (R2PI) through the $2\ ^1\Sigma_u^+$ state. We find that the populations of vibrational levels v''=112-116 are far larger than can be accounted for by the Franck-Condon factors for $0_u^+ \leftarrow X\ ^1\Sigma_g^+$ transitions. Further, the total number of ground-state molecules formed by this process exhibits oscillatory behavior as the PA laser is tuned through a succession of 0_u^+ state vibrational levels. Both of these effects are explained by a new calculation of transition amplitudes that includes the resonant character of the spin-orbit coupling between the two 0_u^+ states converging to the $5P_{1/2}$ and $5P_{3/2}$ limits. The resulting enhancement of more deeply bound ground-state molecule formation will be useful for future experiments on ultracold molecules.

We also describe evidence from our R2PI spectra for extensive singlet-triplet mixing between excited states of Rb_2 at intermediate internuclear separations, apparently also induced by spin-orbit interactions. In particular, the $3\ ^1\Sigma_g^+$ and $1\ ^1\Delta_g$ states converging to $5s + 4d$ have been observed in excitation from the $a\ ^3\Sigma_u^+$ state,[a] and the $2\ ^3\Pi_u$ state has been observed in excitation from the $X\ ^1\Sigma_g^+$ state.

[a] J. Lozeille, A. Fioretti, C. Gabbanini, Y. Huang, H. K. Pechkis, D. Wang, P. L. Gould, E. E. Eyler, W. C. Stwalley, M. Aymar, and O. Dulieu, Eur. Phys. J. D **39**, 261 (2006).