Millimeter-wave precision spectroscopy of d-d transitions in potassium Rydberg states\(^1\) HUAN BUI, CHARLES CONOVER, Colby College

— We measure two-photon millimeter-wave transitions between nd\(_j\) and (n+1)d\(_j\) Rydberg states for 30 \(\leq n \leq 35\) in \(^{39}\)K to an accuracy of 5\(\times\) 10\(^{-8}\) to determine high-n d-state quantum defects and absolute energy levels. \(^{39}\)K atoms are magneto-optically trapped and cooled to 2-3 mK, and excited from ground state 4s\(_{1/2}\) to nd\(_{3/2}\) or nd\(_{5/2}\) by frequency-stabilized 405 nm and 980 nm external-cavity diode lasers in succession. The magnetic-field insensitive nd\(_j\) \(\rightarrow\) (n+1)d\(_j\) \(\Delta m = 0\) transitions are driven by a 16 \(\mu\)s-long pulse of mm-waves before the atoms are selectively ionized for detection. The (n+1)d population is measured as a function of mm-wave frequency. Static electric fields in the MOT are nulled in three dimensions to eliminate DC Stark shifts. The two-photon transitions exhibit small but measurable AC Stark shifts in the resonance frequencies. We determine the field-free intervals both by extrapolating a sequence of measurements made as a function of mm-wave power to zero and directly without extrapolation by applying Ramsey’s separated oscillating fields method. Our results give quantum defects for the high-n states that are an order of magnitude more accurate than earlier measurements of these quantities.

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Huan Bui
Colby College

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