Light Polarization And Quantum Interference Effects In Unresolvable Atomic Lines Applied To A Precise Measurement Of The ^{6,7}Li D_2 Lines

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Abstract. Precise measurement of the isotope shift of the lithium 2s→3s and 2s→2p (D) lines has been proposed [1] and subsequently used [2] as a sensitive probe of nuclear charge radii, including halo nuclei in unstable isotopes. Despite this success, large discrepancies have remained among observations of D lines of the stable isotopes. We find that when the excited state splittings are of order the excited state natural linewidths, as is the case for the D_2 line of lithium, light-polarization-dependent quantum interference modifies the lineshape and represents an overlooked but significant systematic effect. We present expressions for the corrected line shapes and demonstrate that they yield consistent line centers for arbitrary polarization of the excitation laser.

In our experiment Doppler free spectra were collected using a tunable single-frequency diode laser referenced to a frequency comb [3]. We analyze spectra of the ^{6,7}Li D_2 lines taken at various excitation laser polarizations and show that failure to account for the quantum interference changes the inferred line strengths and shifts the fitted line centers by as much as 1 MHz, a systematic effect large enough to account for discrepancies between previous measurements. We obtain revised values for the absolute transition frequencies of the unresolvable ^{6,7}Li D_2 features. Combining these with our previous results for the D_1 lines [3], we derive the ^{6,7}Li excited state fine structure intervals, the 2s →2p isotope shift, the splitting isotope shift and the relative nuclear charge radii [4]. This analysis should also be important for precise spectral measurements in a number of other species including partially resolved D_2 lines in hydrogen, lithium, potassium, francium, and singly-ionized beryllium and magnesium.

PACS: 32.10.Fn, 32.30.Jc, 32.70.Jz, 42.50.Gy, 42.62.Ehs, 42.62.Fi, 21.10.Ft

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