Formation and velocity measurement of alow-energy Li^+ ion beam for precision laser spectroscopy

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This paper reports the formation and parameter analysis of a low-energy Li^+ beam (with natural isotope abundance) developed for optical and optical-microwave precision spectroscopy. Electrons emitted from a ring-shaped tungstenwire cathode ionize Li atoms by impact immediately when leaving the nozzle of an oven. Electrons and ions are accelerated to typically 300 eV by propagating counter to each other through the same electric field applied between cathode and oven orifice. A well-collimated ion beam, containing a ~10^{-3} fraction of ions in the metastable 1s2s $^3S_1$ state, is shaped by an electrostatic lens system. The 2 $^3S_1$–2 $^3P_{1,2,0}$ transition at the wavelength λ approximately 5485 Angström, representing the central target of numerous investigations in the helium-like Li^+ spectrum, provides a nondestructive access to kinematic beam parameters: The beam of a cw single-mode ring dye laser crosses the ion beam at an angle of roughly 12°. The Doppler shift of the 2 $^3S_1$, F = 5/2 - 2 $^3P_2$, F = 7/2 hyperfine structure component (the most prominent of the multiplet) with respect to the intrinsic transition frequency ν_0 and the Doppler profile are measured by frequency-tuning the laser over this line and registering the excitation profile with a photomultiplier via the reemitted fluorescence. The mean velocity β, the velocity distribution, and the divergence of the ion beam are derived from this measurement. The determination of β with an uncertainty of 4.5 x 10^{-3} has made it possible to perform at this ion-beam facility a measurement of ν_0 with a precision of about 2 x 10^{-9} and thus to provide a new independent value of this frequency.