

Technical Developments for Precision Spectroscopy of light Isotopes in Collinear Laser Spectroscopy (IS449)

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The aim of proposal IS449 is the determination of charge radii of the beryllium isotopic chain $7,9,10,11\text{Be}$. For a precise extraction of charge radii, a precision of laser spectroscopy on the order of 1 MHz is needed. We have now used for the first time collinear laser spectroscopy to measure the isotope shift of radioactive isotopes to the accuracy required to extract charge radii by overcoming the uncertainty in the acceleration voltage of the ions.

In collinear laser spectroscopy with a fixed-frequency laser, the ions are Doppler-tuned across the resonance with the laser light by accelerating or decelerating them by applying an offset potential to the optical fluorescence detection region. The sensitivity of the measured transition frequency to the applied total acceleration voltage, the so-called Doppler-coefficient for 7Be is about 40 MHz/V at typical ISOLDE ion beam energies of about 50 keV. This would require knowledge of the ion acceleration potential of better than 1 ppm to obtain isotope shifts with the required accuracy. This hindered precision laser spectroscopy of light isotopes with collinear spectroscopy so far.

In this talk we report about a new technique to overcome this limitation which we applied for laser spectroscopy in Beryllium but can be generally applied for highest precision laser spectroscopy of light nuclei at COLLAPS. Applying two laser beams in collinear and anti-collinear geometry to the ion beam, we determined the resonance frequencies in parallel and anti-parallel direction. Multiplication of both frequencies then yield the transition frequency at rest, independent of any uncertainties in the voltage or ion beam energy determination. To fully exploit the precision provided by this approach, we applied frequency locking of the laser system to a frequency comb.

This technique was tested on stable 9Be beam time employing 8 shifts for test of systematic limitations and uncertainties of this approach. After the successful test 12 shifts have been used to perform on-line spectroscopy on the beryllium isotope chain which will be reported in another contribution. In these runs we achieved an uncertainty in the absolute frequency determination of about 800 kHz and an uncertainty of about 1 MHz in the isotope shift determination.

As a spin-off of our studies we could detect an offset between the ISOLDE high-voltage dividers ASTEC-1 and ASTEC-2 and recalibrated those by the result of the laser spectroscopic measurement and an electronic measurement with a 1 ppm voltage divider from the KATRIN collaboration.

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