Progress on Ni^{12+} based highly charged ion clocks

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Abstract:

Highly charged ions (HCIs) have promising clock transitions with potential accuracy below 10^{-19}, Furthermore, they are sensitive to fine structure constant α and can be used to explore new physics beyond the standard physical model[1,2,3,4]. we utilized the Shanghai-Wuhan Electron Beam Ion Trap (SW-EBIT) [5] to perform a high-precision measurement of the M1 transition of Ni-HCI. Our approach involved an improved calibration scheme for the spectra, utilizing auxiliary Ar^+ lines for calibration and correction. Our final measured result of the M1 transition wavelength demonstrate a five-fold improvement in accuracy compared to our previous findings[6], reaching sub-picometer level accuracy[7]. In addition, High energy HCI bunches were slowed down[8] to the ion trap and cooled in a room temperature ion trap by means sympathetic cooling through the laser-cooled Be^+ ions. The Ni-HCIs temperature were decreased to hundred millikelvin level from megakelvin.

Table I. Error budget: The final result and main error sources to the wavelength measurement

Source of error	Shift (pm)	Error (pm)
Line centroid determination	511582.05	0.21
Calibration system	/	0.33
Isotope shift	0.06	0.06
Stark shift	/	<0.01
2^{nd} -order Zeeman effect	/	<0.01
Total	511582.11	0.40

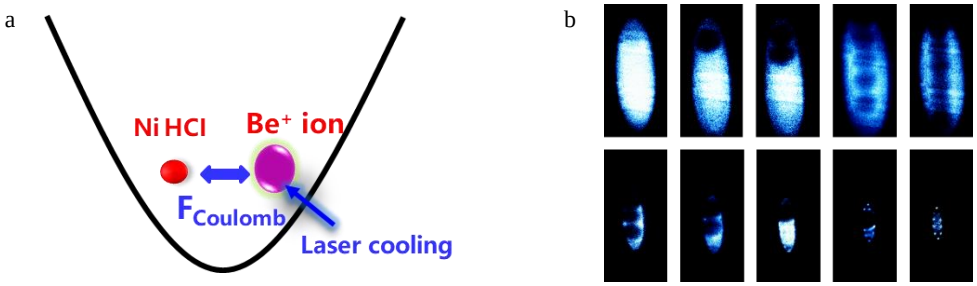

Fig. 1. The sympathetic cooling of HCIs. a: Sympathetic cooling Schematic Image; b: Coulomb crystal of Be^+ and Ni HCI(the dark circular shapes) --The process of HCI from being injected and trapped and subsequently lost one by one.

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