Study on the development of resonance ionization scheme of strontium with high isotope selectivity

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Abstract:
The resonance ionization spectroscopic (RIS) isotope selectivity of strontium has been studied in terms of alternatively found triplet transition for isotope selectivity enhancement. We have investigated the isotope selectivity of strontium at prospective Rydberg state (n=39) ionization transition scheme (689 nm – 487 nm – 393 nm).

Keyword: Resonance Ionization, Strontium, Isotope Selectivity

1. Introduction

The tracing radioactive isotopes are being interested with its importance of precise monitoring of radioactive isotopes, such as ^{90}Sr. It is not easy to monitor due to its low isotopic abundance with isobaric interference by the equal mass isotopes. To present the high isotopic selectivity, we presented the resonance ionization spectroscopic technique for the enhancement of isotopic selectivity of strontium. We have studied to find out the alternative optical excitation transition scheme for the isotopic selectivity enhancement by applying narrow linewidth transition at 689.4 nm ($5s^2\ ^1S_0$ – $5s5p\ ^3P_1^{\circ}$, natural linewidth is ~7.4 kHz) [1-3].

2. Experimental

To perform the multi-step RIS, we prepared three diffraction grating used Littrow angle external cavity diode lasers (ECDLs) at 689 nm, 487 nm and 393 nm, respectively. We separated the output beam into three parts such as main beam for the resonance ionization, the wavelength monitoring, and the computational wavelength control by digital fringe offset frequency locking system. Figure 1 shows the energy level scheme of 3-step RIS for the Rydberg state (n=39); the left is 460 nm – 655 – 426 nm reported by Miyabe [3], and the right is 689 nm – 487 nm – 393 nm used in this work. Figure 2 presents the Voigt fitted spectrum of ^{88}Sr at 689 nm. The Lorentzian component of the spectrum width was 1.7 MHz, which is narrower than the natural width (~32 MHz) of the 460 nm line [3]. It means that the 689.4 nm line is effective for the isotope selectivity enhancement. Further, the isotope shifts at the 487 nm and the 393 nm have been evaluated for the first time.

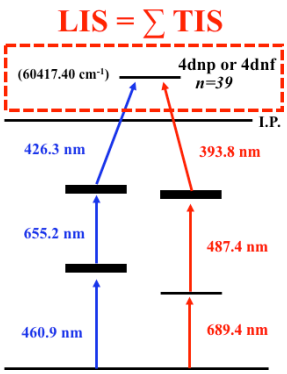

Figure 1. Energy level diagram of resonance ionization.

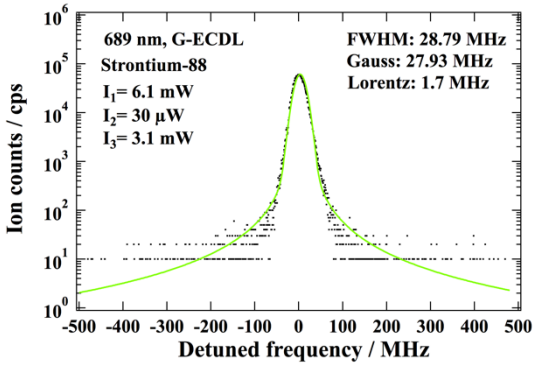

Figure 2. Voigt profile of ^{88}Sr spectrum at 689.4 nm.

3. Conclusion

We have applied novel resonance excitation scheme for the optical isotope selectivity enhancement. The isotope selectivity evaluation of strontium has been performed at 689.4 nm – 487.4 nm – 393.8 nm ($5s^2\ ^1S_0$ – $5s5p\ ^3P_1^{\circ}$ – $5s5d\ ^3D_2$ – 4dnp or 4dnf, n=39). The Lorentzian component linewidth of the 689.4 nm spectrum has been experimentally proven to be narrower than the natural width of the 460 nm transition. Regarding the optical isotope selectivity relation with the natural linewidth of transition [1, 3], it is able to expect the selectivity of strontium isotope can be enhanced with our experimental results (>$10^{7\sim8}$).

References

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