Development of Tapered Amplifier Coupled ECDL System for Resonance Ionisation

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We describe the development of a laser system that targets the third step transition in a resonance ionisation scheme that selectively ionises the ^{41}Ca isotope from a mixed sample. We intend for this technique to be used for improved spectroscopy leading to novel isotope identification and separation methods.

Keywords: calcium, reactor concrete, decommissioning, spectroscopy, ECDL, resonance ionisation

1. Introduction

The disposal of waste from the decommissioning of nuclear sites remains a laborious task, involving as it does the measurement of radionuclide radioactivity and calculation of its time variance in order for appropriate sorting into the various waste streams to take place. Of particular note is the large amounts of concrete surrounding reactors, acting as the biological shield. These represent a great proportion of the overall low and intermediate disposal considerations. One important radionuclide present in the concrete is ^{41}Ca (half-life 1.04×10^5 years, decay mode: EC to ^{41}K), neutron activated from the majority abundance ^{40}Ca compounds of cement [1]. In order to perform spectroscopy on the ^{41}Ca isotope, with the aim of production of novel techniques for identifying or indeed, isolating ^{41}Ca from decommissioning wastes; we construct an external cavity diode laser (ECDL) – tapered amplifier laser system in order to target a third step transition in the resonance ionisation scheme. In our research, once ionised, the calcium can then be trapped for spectroscopic study [2].

2. Isotope Selectivity and Laser System

The justification for targeting the third step transition is to greatly improve isotope selectivity. Previously, the majority of calcium resonance ionisation schemes made use of only two steps. This produces selectivity of 2×10^4 over ^{40}Ca detection. The addition of a third step to the resonance ionisation narrows the window for non-targeted photon absorption/ionisation, thereby improving the isotope selectivity [1,3].

In order to precisely achieve a coherent laser beam for this transition, we utilise the wavelength selective properties of an ECDL to finely tune the laser system to the third step transition. This ECDL beam is then amplified using a tapered amplifier (TPA) to achieve an intensity appropriate for the cross section of the third step transition.

3. Summary

We report on the construction and characterisation of an external cavity laser diode coupled tapered amplifier laser system for the third step resonance photoionisation of calcium. This transition is intended to improve isotope selectivity therefore making techniques for highly accurate radioisotopic (notably ^{41}Ca) spectroscopy accessible, while the amplifier increases its power to functional levels. The technique is highly adaptable for the study of other isotopes and elements, and has possible further applications in nuclear engineering, astrophysics and biomedicine.

References

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