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Development of a high-resolution and high-sensitivity collinear resonance ionization spectroscopy system

Nuclear properties are closely connected to nuclear structure and nucleon-nucleon interactions, making them essential for exploring various novel phenomena that emerge in exotic nuclei. Laser spectroscopy is a powerful technique for investigating nuclear properties of unstable nuclei by probing the hyperfine structure (HFS) of their surrounding electrons. Such HFS effect contributes only about one part in a million of the total transition frequency, thus requiring high-resolution measurement techniques. Furthermore, studying unstable nuclei poses further challenges due to their short lifetimes, low production yields, and significant isobaric contamination. Collinear resonance ionization spectroscopy stands out as a premier technique for exotic nuclei research due to its high resolution and high sensitivity [1].

Through the recent implementation of a radio-frequency quadrupole cooler-buncher [2] and a multi-step laser ionization technique, we have successfully established a high-resolution and high-sensitivity collinear resonance ionization laser spectroscopy system named PLASEN (Precision LAser Spectroscopy for Exotic Nuclei) at Peking University [3]. The entire system was fully characterized using a bunched Rb ion beam at an energy of 30 keV by measuring the HFS spectra of the D2 line for ^{85,87}Rb isotopes. An overall efficiency exceeding 1:200 was achieved, along with a spectral resolution of approximately 100 MHz, which yields an experimental sensitivity sufficient for laser spectroscopy measurements of unstable nuclei at yields around 100 pps. The extracted properties of ^{85,87}Rb agree well with the literature values, further confirming the reliability of the system.

In this talk, the details of PLASEN system will be presented, together with the results from the offline commission experiment for ^{85,87}Rb isotopes. A planned online laser spectroscopy experiment using this setup at BRIF will also be discussed.

References:

[1] X. F. Yang, et al., Prog. Part. Nucl. Phys. 129 (2023) 104005.

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