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New developments in resonance laser ionization for radioactive beams

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Multi-step resonance photo-ionization is completely element selective as it exploits the unique electronic energy level structure of the chosen element. When incorporated into the Isotope Separator On-Line (ISOL) process of ion beam production, element selective laser ionization complements the subsequent charge-to-mass ratio selection, performed by an electromagnetic spectrometer, thereby greatly increasing the isotope purity of the ion beam that reaches the experiment.
Crucial to the application of resonance laser ionization at radioactive ion beam facilities is an optimization of the laser-atom interaction region so that it is well adapted to specific requirements imposed by the isotope production environment. The physical and chemical properties of the isotope of interest must be considered, as well as the nature and abundance of non-laser ionized impurities. Due to the diversity of existing and planned ISOL facilities there is no universal laser ion source design and a variety of implementations have been conceived.
At thick-target ISOL facilities, the hot-cavity surface ion source is a commonly used, convenient and effective laser ionization environment but simultaneous extraction of surface-ionized isobaric contaminants often limits the achievable ion beam purity. Several supplementary techniques may be employed to reduce this problem: selective in-target production; chemical separation before the ion source; reduced surface ionization efficiency; and active suppression of surface ions. The suitability of these methods will be summarized along with an outlook towards promising ongoing developments, particularly the exploitation of the time structure of the laser-ion bunch and laser/atom interactions inside a FEBIAD-type ion source.
At thin-target ISOL and projectile fragmentation facilities a gas cell, used to capture nuclear reaction products, can be an effective laser ionization volume. Design modifications have greatly improved the laser-ion survival whilst also enabling active suppression of impurities. For resonance ionization spectroscopy applications the pressure broadening and shifts of the atomic spectral lines are problematic and must be well characterized. This issue is largely avoided if ionization takes place outside of the gas cell, within a high-velocity collimated gas jet. A comparison of these methods will be presented along with a summary of the progress in achieving compatibility with projectile fragmentation facilities.

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