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In-gas-cell and in-gas-jet laser ion sources: Resonance ionization spectroscopy of radioactive atoms

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New approaches to perform efficient and selective step-wise Resonance Ionization Spectroscopy (RIS) of radioactive atoms in a gas cell and in supersonic gas jets are discussed.
In the ion source, the nuclear reaction products recoiling out of the thing target are thermalized and neutralized in a high pressure noble gas (helium or argon), then resonantly ionized by the laser beams in a two-step process, extracted from the ion source, accelerated and mass separated [1-3]. In this way isobaric and isotopic selectivity can be achieved. The laser ion source made it possible to perform ⊠-decay studies of nuclei that are produced in proton-induced fission of 238U and in light/heavy ion-induced fusion evaporation reactions.
A number of innovative techniques that were implemented to improve the performance of the laser ion source and also open new opportunities for high-precision laser spectroscopy of radioactive isotopes.
• In a dual chamber gas cell, the laser ionisation chamber is separated from the stopping chamber [4]. In this geometry the recombination of laser-produced ions due to the plasma created by the primary accelerator beam is reduced and allows to increase the ion source efficiency. This reduced plasma density opens the possibility to collect ions coming from the stopping zone with electrical fields thus increasing the ion source selectivity above 2000.
• High efficiency and selectivity of the ion source allows to perform in-gas cell resonance ionization spectroscopy of exotic atoms. Using this method the nuclear magnetic moments of copper and silver isotopes produced in heavy-ion-induced fusion-evaporation reactions have been measured [5].
• Implementation of resonance ionization in the supersonic gas jet [6,7] allows to increase the spectral resolution by one order of magnitude in comparison with in-gas-cell ionization spectroscopy. Properties of supersonic beams, obtained from the de Laval and the free jet nozzles that are important for the reduction of the spectral line broadening mechanisms in cold and low density environments are discussed. First results of high-resolution spectroscopy in the supersonic free jet are presented.

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