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Laser spectroscopy - optical probes for radioactive nuclei

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The study of exotic nuclear matter and related radioactive ion beam technologies is at the forefront of modern subatomic physics. Atomic physics techniques - more specifically, high resolution optical measurements of the atomic structure - readily yields fundamental and model-independent data on the structure of ground and isomeric nuclear states. The competition and balance between nuclear shell and collective effects results in a spectacular range of shapes and sizes within nuclear systems. Such shapes and structures perturb the atomic energy levels of atoms and ions at the ppm level and although this is a small absolute effect it is readily probed and measured by modern laser spectroscopic methods. These techniques are particularly suitable for the study of short-lived radionuclides with lifetimes as short as a few milliseconds, and production rates often only a few hundred isotopes/isomers per second.

In recent years, resonant laser ionization has become a mature technique, playing a key role in the selective production of radioactive nuclides at on-line isotope separator (ISOL) facilities. More recently, spectroscopy is being performed in-source, complementing the high-resolution collinear beams method by offering a means to probe even more weakly produced nuclei, with rates as low as a few atoms per second, albeit with lower resolution. In order to increase the resolution of these techniques new laser systems are being developed and different environments are being utilized which offer the most attractive perspective from the point of view of reduced atomic line broadening mechanisms. In this sense, gas jet laser spectroscopy is a novel technique yielding first promising results in its early stages of development.

In this talk I will review some of the recent progress in the field of laser spectroscopy at facilities such as ISOLDE, CERN, and at IGISOL-4, Jyväskylä. I will also discuss some of the most novel developments in the field of laser ionization and will conclude with a look at the current gaps in our knowledge and where the field of laser spectroscopy is proceeding in the future.