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Optical spectroscopy for nuclear and atomic science at JYFL

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High-resolution optical measurements of the atomic level structure readily yield fundamental and model-independent data on nuclear ground and isomeric states, namely changes in the size and shape of the nucleus, as well as the nuclear spin and electromagnetic moments [1]. Laser spectroscopy combined with on-line isotope separators and novel ion manipulation techniques provides the only mechanism for such studies in exotic nuclear systems.

This contribution will provide a status of the different activities connected with optical spectroscopy in Jyväskylä. In recent years an active program on the actinide elements has been initiated in collaboration with the University of Mainz and Vienna. This work has seen the realization of collinear laser spectroscopy of Pu, the heaviest element studied to date with this particular technique [2]. In addition, a multi-pronged approach towards accessing the lowest-lying isomeric state in the nuclear chart, namely ^{229m}Th, forms an active field of current research. Almost 40 years of research has been invested into efforts to observe the isomeric transition which, if found, may be directly accessed by lasers. In 2016, the community was given a tremendous boost with the unambiguous identification of the state by a group in Munich, providing a stepping stone towards a future realization of a "nuclear clock"[3].

The first optical spectroscopy of doubly-charged fission fragments has been performed in yttrium, motivated by access to alkali-like transitions in which the reliability of state-of-the-art atomic calculations can be accessed. This work saw the first use of application of a new off-line ion source, producing stable $^{89}Y^{2+}$, an isotope used as a reference in measurements of more exotic neutron rich isotopes. By merging both the reference beam and the low-energy neutron rich beams from IGISOL, optical isotope shifts have been studied and changes in mean-square charge radii extracted [4]. In 2018 we have started to implement an alkali-vapor charge exchange cell into the collinear beam line for future studies of neutralized atoms.

An exciting new research theme is now underway in collaboration with the University College London. A new atom trap has been installed at JYFL for the purpose of trapping ultra-cold samples of caesium isotopes and isomers. The ultimate goal is to achieve coherent gamma-ray emission via a Bose-Einstein Condensate of ^{135m}Cs isomers produced in fission [5]. The first results from this project will also be presented.

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[3] L. von der Wense et al., Nature 533 (2016) 47.

[4] L.J. Vormawah et al., submitted (2018).

[5]L. Marmugi, P.M. Walker and F. Renzoni, Phys. Lett. B 777 (2018) 281.

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