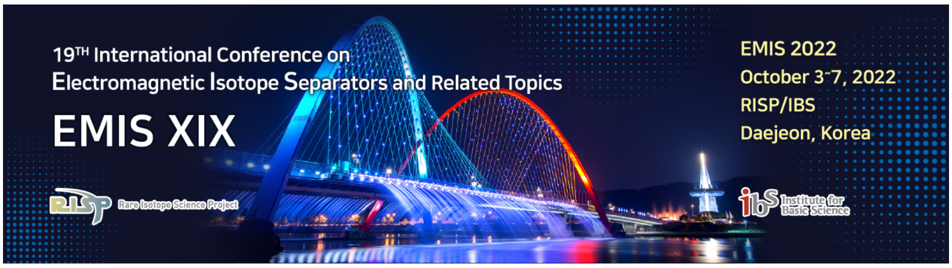

Contribution ID: **84** Type: **Oral Session**

Laser Spectroscopy of the Heaviest Elements at SHIP at GSI

Friday, 7 October 2022 09:00 (20 minutes)

Laser spectroscopy is a versatile tool to unveil fundamental atomic properties of an element and information on the atomic nucleus. Up to the chemical element fermium (Z=100), a limited number of long-lived isotopes can be produced in macroscopic amounts through irradiation of actinide samples in reactors where they undergo neutron capture and successive beta decay. Heavier elements and more exotic isotopes of the lighter elements are only accessible through fusion-evaporation reactions at minute quantities and at high energies, hampering their study by optical spectroscopy. However, the heaviest elements are of particular interest as their electron shell is strongly influenced by electron-electron correlations and relativistic effects changing the electron configuration and thus, the chemical behavior [1,2]. Furthermore, subtle changes in the atomic transition for different isotopes of the same element allow fundamental nuclear information to be inferred.
An exploration of the region of the heaviest elements with laser spectroscopy became possible with the RAdiation Detected Resonance Ionization Spectroscopy (RADRIS) technique. Here, recoils from fusion-evaporation reactions, which were transmitted by the velocity filter SHIP at GSI Darmstadt, are stopped in high-purity argon gas and collected onto a thin filament. After re-evaporation, the released neutral atoms are probed by two-step resonance laser ionization. The so created photo-ions were then guided to a detector where they were identified by their characteristic alpha decay. After the first identification and characterization of a strong atomic ground-state transition in ^{254}No [3] detailed studies on further nobelium isotopes were performed [4].
Here, we will present advancements and recent results of the RADRIS technique along with future prospects for laser spectroscopy of the heaviest elements. This includes the application on decay-daughter products of nobelium enabling the study of the fermium isotopes $^{248-250}$Fm, and with a dedicated detector setup also the long-lived isotope ^{254}Fm ($T_{1/2}$=3.24 h). The setup's performance was furthermore optimized with respect to the filament increasing the total efficiency for the search of atomic levels in heavier elements such as lawrencium (Z=103). A first experimental campaign for the search of an atomic level in ^{255}Lr was recently performed. Next steps include the extension of the RADRIS method to more exotic isotopes and the continuation of the level search in lawrencium (Z=103) as well as developments for higher spectral resolution spectroscopy. For the latter a dedicated setup was recently commissioned combining the efficient stopping and neutralization from the RADRIS technique with the high resolution of in-gas-jet spectroscopy [5,6]. Laser spectroscopy in the low-density and low-temperature regime of the jet enables higher resolution in the spectroscopy while the continuous operation and swift evacuation of the gas cell using electrical fields will allow us to address shorter-lived isotopes and isomers as, e.g., the lower lying 266 ms K-isomer in ^{254}No.

1. E. Eliav, S. Fritzsche, U. Kaldor, Nucl. Phys. A 944, 518 (2015).
2. P. Schwerdtfeger, et al., Nucl. Phys. A 944, 551 (2015).
3. M. Laatiaoui, et al., Nature 538, 495 (2016).
4. S.Raeder et al. Phys. Rev. Lett. 120.23, 232503 (2018).
5. Kudryavtsev, Yu, et al. Nucl. Instrum. Meth. Res. B 297, 7-22 (2013)
6. S. Raeder et al., Nucl. Instrum. Meth. Res. B, 463, 272-276. 272-276, (2020).

Primary authors: RAGGIO, Andrea (University of Jyväskylä); RAEDER, Sebastian (GSI Helmholtzzentrum für Schwerionenforschung GmbH); Dr MISTRY, Andrew (GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany); DE ROUBIN, Antoine (KU LEUVEN); CLAESSENS, Arno (KU LEUVEN); Dr SULIGNANO, Barbara (Irfu/CEA, Saclay, France 11IJCLab Orsay, France); CHEAL, Bradley (University of Liverpool); Dr ANDELIC, Brankica (GSI Damstadt, KVI-CART, Groningen, The Netherlands); DEVLIN, Charlie (University of Liverpool); DÜLLMANN, Christoph E. (Department of Chemistry –TRIGA Site, Johannes Gutenberg University Mainz, GSI Helmholtzzentrum für Schwerionenforschung GmbH Darmstadt, Helmholtz Institute Mainz); Mr MÜNZBERG, Danny (1GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany, Johannes Gutenberg-Universität, Mainz, Germany); ACKERMANN, Dieter (GANIL); ROMERO, Elisa Romero (Johannes Gutenberg-Universität, Helmholtz-Institut, GSI); RICKERT, Elisabeth (Johannes Gutenberg-Universität, Helmholtz-Institut, GSI); Mr REY-HERME, Emmanuel (Irfu/CEA, Saclay, France 11IJCLab Orsay, France); KIM, EunKang (Helmholtz Institute in Mainz); IVANDIKOV, Fedor (KU Leuven - IKS); Dr GIACOPPO, Francesca (GSI Darmstadt); SAVAJOLS, Herve (GANIL); Dr FRITZ-PETER, Hessberger (GSI Darmstadt); MOORE, Iain (JYU FINLAND); ROMANS, Jekabs (KU LEUVEN); Dr LANTIS, Jeremy (Johannes Gutenberg-Universität, Mainz, Germany); WARBINEK, Jessica (GSI Helmholtzzentrum fur schwerionenforschung, Darmstadt, Germany. Helmoltz Institute Mainz, Mainz, Germany); WENDT, Klaus (JGU MAINZ); KAJA, Magdalen Anna (Institute of Physics, Johannes Gutenberg University Mainz); Dr VANDEBROUCK, Marine (Irfu/CEA, Saclay, France 11IJCLab Orsay, France); Mr STEMMLER, Matou (Johannes Gutenberg-Universität, Mainz, Germany); BLOCK, Michael (Johannes Gutenberg-Universität, Helmholtz-Institut, GSI); LAATIAOUI, Mustapha (Johannes Gutenberg-Universität, Helmholtz-Institut); LECESNE, Nathalie (GANIL/CNRS); Dr KALEJA, Oliver (Ernst-Moritz-Arndt-Universität, Greifswald, Germany , GSI Darmstadt); CHAUVEAU, Pierre (GANIL); VAN DUPPEN, Piet (KU Leuven - Instituut voor Kern- en Stralingsfysica); CHHETRI, Premaditya (KU Leuven); FERRER-GARCIA, Rafael (KU Leuven - IKS); KRAEMER, Sandro (KU Leuven, Instituut voor Kern- and Stralingsfysica); SELS, Simon (KU LEUVEN); Dr NOTHHELFER, Steven (GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany); Prof. WALTHER, Thomas (TU Darmstadt, Germany); KIECK, Tom (Helmholtzzentrum für Schwerionenforschung GmbH & Helmholtz Institute Mainz); MANEA, Vladimir (IJC lab); Dr LAUTH, Werner (4Johannes Gutenberg-Universität, Mainz, Germany)

Presenter: RAEDER, Sebastian (GSI Helmholtzzentrum für Schwerionenforschung GmbH)

Session Classification: Session 15