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LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

THORIUM NUCLEAR CLOCK

Master Thesis Project

in the ERC Synergy Grant Project "ThoriumNuclearClock", at LS Parodi (in Garching), AG Thirolf

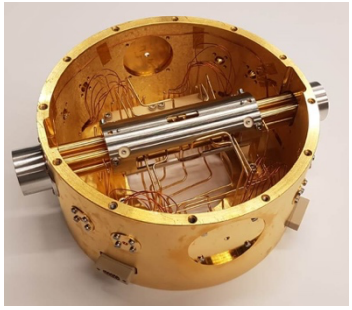
Building and characterizing external-cavity diode lasers (ECDL) for $^{229}Th^{3+}$ spectroscopy

Our group is exploring the properties of ^{229}Th, a very special nucleus that has an extremely low-lying isomeric state (denoted ^{229m}Th) which can be excited by laser light with a wavelength of 148.4 nm. Its long lifetime, and small sensitivity to external perturbations make ^{229}Th an ideal candidate for an **ultra-precise nuclear optical clock** that could outperform any state-of-the-art atomic optical clock. In addition to having a low systematic uncertainty (1.5×10^{-19}), the thorium nuclear transition is highly sensitive to variations of fundamental constants, and can be used for the search for Dark Matter. In our experiment, we trap thorium ions in the 3+ charge state (denoted $^{229(m)}Th^{3+}$) in a cryogenic Paul trap and sympathetically cool them by laser-cooled $^{88}Sr^{+}$ ions.
In the context of this experiment, we are looking for a highly motivated

MASTER STUDENT

to support our team in Garching.
We are setting up several ECDL for spectroscopy of $^{229(m)}Th^{3+}$, as well as for aligning the focus of the 148.4 nm laser light with single trapped $^{229(m)}Th^{3+}$ ions. For the latter, trapped $^{88}Sr^{+}$ ions will be used as detector. Within this project, **your tasks** will include characterization of diode properties, design of external cavities, assembly of all electrical and mechanical components, characterization of the complete laser systems, and finally spectroscopy of $^{88}Sr^{+}$ and/or $^{229(m)}Th^{3+}$ ions. The project can be started at the earliest convenience.

Previous knowledge in LabVIEW and MATLAB is beneficial, but not mandatory. A more important prerequisite is motivation and enthusiasm for experimental work.



Photograph of the cryogenic Paul trap

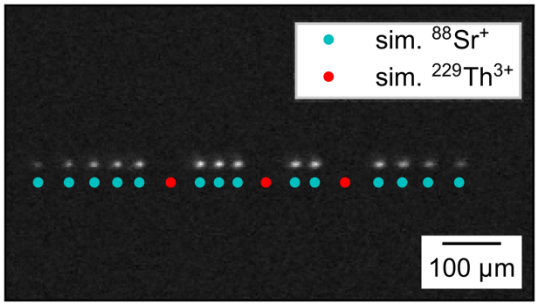


Image of trapped $^{88}Sr^{+}$ (bright) and $^{229}Th^{3+}$ (dark) ions

If you are highly motivated to work in a dynamic and internationally highly visible project, like practical, hardware-oriented work in the laboratory together with programming-related data analysis and experimental hands-on challenges, then you are encouraged to apply to join our team. If you want to know more about our research, you are always welcome to visit our lab in Garching for a lab tour and a chat in person.

Applications including a motivation letter, a CV, and transcripts of grades should be sent to:

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For further reading:

[1] L. v. d. Wense *et al.* Direct detection of the ^{229}Th nuclear clock transition. *Nature* **533**, 47 (2016).
[2] B. Seiferle *et al.* Energy of the ^{229}Th nuclear clock transition. *Nature* **573**, 243 (2019).
[3] K. Scharl *et al.* Setup for the Ionic Lifetime Measurement of the $^{229m}Th^{3+}$ Nuclear Clock Isomer. *Atoms* **11**, 108 (2023).