

Research Project

Precision molecular spectroscopy using a network for distribution of the Swiss primary frequency standard

Third-party funded project

Project title Precision molecular spectroscopy using a network for distribution of the Swiss primary frequency standard

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Status Completed

The goal of this project is to exploit recent progress in laser technology, frequency metrology and molecule optics to carry out ultra-precise measurements of energy intervals between electronic, vibrational and rotational states of molecules, in particular molecular ions. The present project aims to achieve a relative measurement accuracy in molecular-ion spectroscopy of order 10^{-14} – 10^{-15} , an improvement of several orders of magnitude in comparison to the present state of the art of 10^{-9} . These advancements will open up a new frontier in precision molecular spectroscopy which will pave the way for using molecules as new high-precision frequency standards and clocks, for addressing fundamental physical problems such as the proton-radius puzzle and a possible temporal variation of fundamental physical constants and for precision tests of quantum electrodynamics. All of these application will be explored in the present project.

The dramatic advancement in measurement accuracy targeted here will be enabled by the implementation of new spectroscopic methodologies based on quantum technologies, by the development of ultranarrow quantum-cascade laser sources tailored to the present needs, and in particular through the implementation of a fibre-optical network for the distribution of the Swiss primary frequency standard maintained by the Federal Institute of Metrology METAS to spectroscopy laboratories in Basel and Zurich. This network will enable the absolute stabilisation, calibration and frequency comparison of the laser sources employed in the present measurements at a level of up to 10^{-15} by their referencing to the Swiss primary standard. While several European countries have already set up similar national and international networks for precision frequency distribution, Switzerland thus far possesses no such facilities. For Switzerland not to lose contact and competitiveness in the key future scientific domain of frequency metrology, it is imperative for our country to establish similar infrastructures. The present project will establish and test a prototype network connecting ETH Zurich, the University of Basel and the Federal Institute of Metrology METAS in Bern/Wabern. This prototype is intended to form the nucleus of a Swiss national network for precision frequency- and time distribution linking a broad range of national laboratories and research groups involved in frequency metrology in the future.

These objectives can only be reached through the close collaboration of a highly interdisciplinary team involving physical chemists, laser physicists, metrologists and telecommunication-network engineers which are assembled in the present project.

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