COLD MOLECULAR IONS AT THE QUANTUM LIMIT

2nd COMIQ Training Event

Thank you

Thank you all for four inspiring days at Schloss Reisensburg 1–4 June 2015. It was a great pleasure to experience such a vibrant atmosphere of creative people contributing with beautiful posters and great talks.

Mid-term Review

As you all know the Mid-term Review Meeting took place at the same time as the 2nd COMIQ Training Event and we passed the review in the best possible way. This had not been possible without your contributions, thank you!

Upcoming COMIQ Event

Next Training Event will take place in the Spring of 2016 in France hosted by the two CNRS-nodes Laboratoire Kastler-Brossel and Laboratoire Aimé Cotton (Prof. Hilico and Prof. Dulieu).

Thank you for four inspring days at Schloss Reisensburg

From left to right: Lorenzo Petralia, Humberto da Silva jr., Johannes Hecker Denschlag, Stephan Schiller, Milán Negyedi, Celia Haldan Voetmann, Michael Köhl, József Fortágh, Karin Fisher, Olivier Dulieu, Stefan Willitsch, Franco Gianturco, Ibrokhim Iskandarov, Tim Softley, Steffen Meyer, Jacob Esmann Poulsen, Julian Glässel, Amir Mahdian, Jan Christoph Heip, Richard Maulini, Artjem Krükow, Mike DePalatis, Johannes Heinrich, Joschka Wolf, Ilia Sergachev, Chunyan Shi, Ken Brown, Ivan Kortunov, Michael Drewsen, Kaveh Najafian, Alexander Dörfler

COMIQ FELLOWS

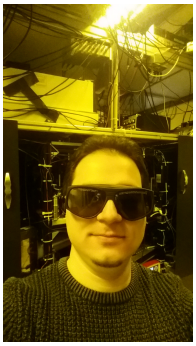
The following ESR positions have been filled.


Johannes Heinrich

Johannes Heinrich, CNRS/ LKB

Johannes Heinrich joined Laboratoire Kastler-Brossel on 1 October 2014 under the supervision of Prof. Laurent Hilico.

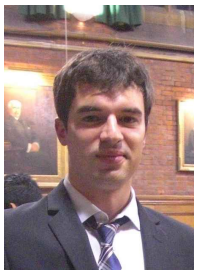
Johannes Heinrich graduated from Julius-Maximilians-University in Würzburg with a degree in physics in 2013. Having worked on frustrated magnetism under supervision of Prof. Hanke, he joined briefly the department of technology and innovation at the SGL Group in Meitingen, where he was tasked with simulating instabilities in the Hall-Héroult process. After a stay at the university of Ulm under supervision of Prof. Hecker-Denschlag he now joins Prof. Hilico's group at the LKB in order to work on spectroscopy of captured and cooled hydrogen molecular ions.


Amir Mahdian

Amir Mahdian, UULM

Amir Mahdian joined the group of Prof. Johannes Hecker Denschlag in Ulm on 1 October 2014.

Amir Mahdian received his Master's degree in physics from University of Tehran, Iran where he investigated the conversion of methane to higher valued hydrocarbons by means of a repetitive pulsed-plasma. Joining the COMIQ network under the supervision of Prof. Hecker Denschlag in Ulm, Amir investigates the elastic and inelastic collision processes between ions and atoms in a hybrid atom-ion experiment.


Leonardo Carcagnì

Leonardo Carcagnì, UBO

Leonardo Carcagni joined the group of Prof. Michael Köhl at University of Bonn for 8 months starting 1 November 2014.


Ivan Kortunov

Ivan Kortunov, UDUS

Ivan Kortunov joined the group of Prof. Stephan Schiller in Düsseldorf for 32 months starting 1 March 2015.

My name is Ivan Kortunov. I have graduated from the Moscow State University Department of Quantum Electronics as a Specialist in Physics physicist. It is my pleasure take part in the COMIQ network and develop methods for high-efficiency preparation of a single quantum state of a molecular ion and a high-precision spectroscopic determination of a fundamental mass ratio with the group of Professor S. Schiller at Heinrich-Heine University Düsseldorf.

PRACTICAL ISSUES

We have the following mailing lists available within the network:

comiq.fellows@maillist.au.dk (fellows)
comiq@maillist.au.dk (group leaders)
comiq.all@maillist.au.dk (fellows + group leaders)

The student wiki is available at: http://comiq.au.dk
and the Zotero group at: https://www.zotero.org/groups/comiq
as well as the Facebook Group at: https://www.facebook.com/groups/733547676698388/

COMIQ news will be posted at our **website**: http://itn-comiq.eu

Important tasks in relation to publications:

1. Make sure to **acknowledge COMIQ**: "This work was supported by the European Commission under the Seventh Framework Programme FP7 GA 607491 COMIQ."
2. Send the publication to celia@phys.au.dk (**doi number** is sufficient)

FROM SCIENCE

First ESR publication within the COMIQ network by Ilia Sergachev, Alpes Lasers SA.

An easy way of laser frequency noise suppression was developed in Alpes Lasers in cooperation with the University of Neuchâtel.

The method is based on observations that laser frequency fluctuations are highly correlated to voltage fluctuations measured on laser contacts in constant current mode. Therefore fast corrections of current calculated so that laser is kept in constant electrical power mode lead to frequency noise suppression.
The only additional components used for this method are voltage preamplifier and FPGA which calculates instant current corrections required to keep laser electrical power constant.
Different wavelength QCLs were used to demonstrate few times frequency noise suppression and linewidth narrowing. However, the technique can be generalized for other types of lasers and even other electrical devices where constant electrical power mode is preferable.

Ilia Sergachev, Richard Maulini, Alfredo Bismuto, Stéphane Blaser, Tobias Gresch, Yves Bidaux, Antoine Müller, Stéphane Schilt, and Thomas Südmeyer. **All-electrical frequency noise reduction and linewidth narrowing in quantum cascade lasers.** Optics Letters **39**, 22 (2014).
DOI: 10.1038/NPHYS3085

ESR publication by Humberto da Silva jr., CNRS Laboratoire Aimé Cotton.

ESR Humberto da Silva jr. publishes in New Journal of Physics reporting on the formation of molecular ions by radiative association of cold trapped atoms and ions.

Radiative emission during cold collisions between trapped laser-cooled Rb atoms and alkaline-earth ions (Ca+, Sr +, Ba+) and Yb+, and between Li and Yb+, are studied theoretically, using accurate effective core potential based quantum chemistry calculations of potential energy curves and transition dipole moments of the related molecular ions. Radiative association of molecular ions is predicted to occur for all systems with a cross section two to ten times larger than the radiative charge transfer one. Partial and total rate constants are also calculated and compared to available experiments. Narrow shape resonances are expected, which could be detectable at low temperature with an experimental resolution at the limit of the present standards. Vibrational distributions are also calculated, showing that the final molecular ions are not created in their ground state level.

Humberto da Silva Jr, Maurice Raoult, Mireille Aymar and Olivier Dulieu. **Formation of molecular ions by radiative association of cold trapped atoms and ions.** New Journal of Physics **17**, 045015 (2014).
DOI: 10.1088/1367-2630/17/4/045015

Prof. Stefan Willitsch, University of Basel publishes in Nature Physics

The COMIQ node at University of Basel reports the direct oberservation of dipole-forbidden, electric-quadrupole-allowed infrared (IR) transitions in a molecular ion.

Spectroscopic transitions in atoms and molecules that are not allowed within the electric-dipole approximation, but occur because of higher-order terms in the interaction between matter and radiation, are termed dipole-forbidden. These transitions are extremely weak and therefore exhibit very small natural linewidths. Dipole-forbidden optical transitions in atoms form the basis of next-generation atomic clocks and of high-fidelity qubits used in quantum information processors and quantum simulators. In molecules, however, such transitions are much less characterized, reflecting the considerable challenges to address them. Here,we report direct observation of dipole-forbidden, electric-quadrupole-allowed infrared (IR) transitions in a molecular ion. Their detection was enabled by the very long interrogation times of several minutes afforded by the sympathetic cooling of individual quantum-state-selected molecular ions into the nearly perturbation-free environment of a Coulomb crystal. The present work paves the way for new mid-IR frequency standards and precision spectroscopic measurements on single molecules in the IR domain.

M. Germann, X. Tong and S. Willitsch. **Observation of electric-dipole-forbidden infrared transitions in cold molecular ions.** Nature Physics **10**, 820 (2014).
DOI: 10.1038/NPHYS3085