(idw)
idw - Informationsdienst Wissenschaft
Nachrichten, Termine, Experten

Press release

Universität Greifswald
Jan Meßerschmidt

06/21/2018
http://idw-online.de/en/news698037

Research results
Physics / astronomy
transregional, national

UNIVERSITÄT GREIFSWALD
Wissen lockt. Seit 1456

# Thermal Radiation from Tiny Particles

**Researchers from Greifswald and Heidelberg have succeeded in performing time-resolved measurements of the internal energy distribution of stored clusters. The clusters investigated consisted of four cobalt atoms and an additional electron. Christian Breitenfeldt, a physicist at the University of Greifswald, presents, with his colleagues from the Max Planck Institute for Nuclear Physics in Heidelberg, the direct observation of the radiative heat exchange of these nanoparticles with their environment in the journal Physical Review Letters.**

You do not have to touch a hot stove to feel its heat. If it is hot enough, you can see it glow. But, even at lower temperature it still emits light – although not visible to the human eye, but in the form of infrared rays. We have known the radiation laws for the objects of daily life as well as for celestial bodies like our sun since the studies of Max Planck, for which he received the Nobel Prize for physics of 1918. Isolated atoms also emit electromagnetic waves, according to very different, but also well-known laws. However, the details of radiative cooling of clusters – nanoparticles made of just a few atoms or molecules – have still not been clarified completely.

This topic is being approached by researchers at the Max Planck Institute for Nuclear Physics in Heidelberg, (MPIK) in collaboration with the University of Greifswald. As part of his doctoral work, Christian Breitenfeldt, a member of the research group led by Prof. Lutz Schweikhard in Greifswald, used the electrostatic ion-beam trap CTF (Cryogenic Trap for Fast Ion Beams) at MPIK's scientific division led by Prof. Klaus Blaum, under the supervision of Prof. Andreas Wolf and Dr. Sebastian George.

The studies were performed with nanoparticles made of four cobalt atoms. These cobalt clusters were produced as negatively charged ions, i.e. with an additional electron, and captured in the CTF. Essentially, the trap consists of a pair of ion optical mirrors between which the stored ions bounce in an ultrahigh vacuum – which is very similar to a device that was developed in Greifswald and used extensively for precision mass measurements of exotic atomic nuclei at CERN. If a nanoparticle has some thermal energy, i.e. 'internal energy' stored in the vibration of its atoms, the energy can be transferred to the electron. This can lead to the emission of the electron – sooner or later, depending on the amount of internal energy. As the cluster is no longer electrically charged, it is also stored no longer. After leaving the trap, it can be traced by a detector. The aim of the experiments was to monitor the electron detachment in a time-resolved manner and to reconstruct the temporal development of the thermal distribution of the clusters' internal energy. To this end, the clusters were irradiated with laser light of various wavelengths, i.e. at different photon energies. The electron emission, as a function of laser wavelength, served as a probe for the energy distribution of the stored cobalt clusters.

The internal energy distribution was probed 20 times per second over periods of six seconds, i.e. each series consisted of 120 measurements. This allowed the researchers to monitor the temporal development of the clusters' thermal energy. It led to the reconstruction of the energy exchange by thermal radiation between the clusters and their environment, in this case the vacuum vessel, which was at room temperature. If the clusters had a high level of internal energy at the beginning of the storage time, cooling was observed. In contrast, when the clusters came from a particularly cold cluster ion source, which was contributed to these measurements by a research group from the University of Kaiserslautern, the clusters were observed to warm up over time. In both cases, the clusters tried to gain an equilibrium in the flow of thermal radiation, i.e. to reach the environmental temperature of the experimental setup.

Both cooling and heating by thermal radiation are important aspects with respect to the stability of nanoparticles in free space. Under space conditions – in the 'interstellar' medium between the stars – the environmental temperature can be very low. Thus, having gained these first results, follow-up experiments are currently being performed where these processes are being investigated at much lower temperatures, just a few degrees above absolute zero. To achieve this, the cryogenic storage ring CSR is being applied, which started work recently at the Max-Planck-Institute of Nuclear Physics. The experiments currently being performed – again using negative four-atomic cobalt clusters – have already shown that the energy exchange via thermal radiation slows down significantly at very low temperatures. The long storage duration of ions in the CSR (up to hours) are proving to be of particular advantage for the investigation of molecules and clusters under interstellar conditions.

The results on the radiative cooling and heating of small cobalt clusters were published in the journal Physical Review Letters 120, 253001 – Published 21 June 2018
Long-term monitoring of the internal energy distribution of isolated cluster systems
C. Breitenfeldt, K. Blaum, S. George, J. Göck, G. Guzmán-Ramírez, J. Karthein, T. Kolling, M. Lange, S. Menk, C. Meyer, J. Mohrbach, G. Niedner-Schatteburg, D. Schwalm, L. Schweikhard, A. Wolf
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.120.253001
DOI: https://doi.org/10.1103/PhysRevLett.120.253001
Extended press release in German: https://physik.uni-greifswald.de/ag-schweikhard/further-links/press-releases/

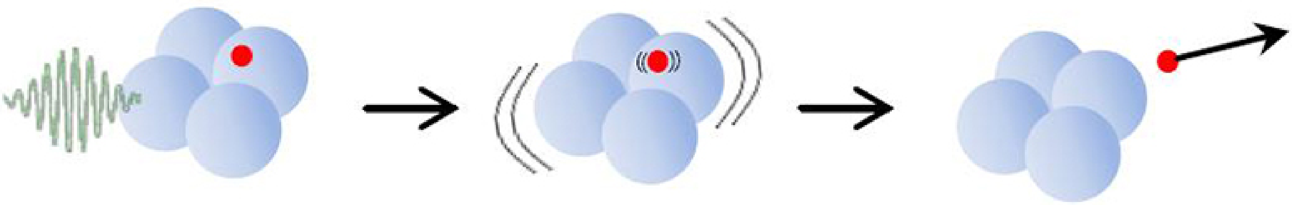
Contacts
Dr. Sebastian George
Institute of Physics, University of Greifswald
Research Group 'Atomic and Molecular Physics'
Felix-Hausdorff-Straße 6, 17489 Greifswald
Tel.: +49 3834 420 4700
sebastian.george@uni-greifswald.de
https://physik.uni-greifswald.de/ag-schweikhard/group-members/george/

Prof. Dr. Lutz Schweikhard
Institute of Physics, University of Greifswald
Research Group 'Atomic and Molecular Physics'
Felix-Hausdorff-Straße 6, 17489 Greifswald
Tel.: +49 3834 420 4700
lschweik@physik.uni-greifswald.de
https://physik.uni-greifswald.de/ag-schweikhard/
http://www.researchgate.net/profile/Lutz_Schweikhard

Prof. Dr. Andreas Wolf
Max-Planck-Institute for Nuclear Physics
Department 'Stored and Cooled Ions'
Saupfercheckweg 1, 69117 Heidelberg
Tel.: +49 6221 516 851

andreas.wolf@mpi-hd.mpg.de
https://www.mpi-hd.mpg.de/blaum/members/molecular-qd/wolf.de.html

Prof. Dr. Gereon Niedner-Schatteburg
Institute of Physical and Theoretical Chemistry,
University of Kaiserslautern
Erwin-Schrödinger-Straße 52, 67663 Kaiserslautern
Tel.: +49 631 205 2536
gns@chemie.uni-kl.de
https://www.chemie.uni-kl.de/gns/



Schematic of delayed electron emission after photoexcitation of a negatively charged four-atom cobalt cluster.
Drawing: Lutz Schweikhard