



Warsaw, 15 December 2021

Publication of physicists from the University of Warsaw in "Nature"

Scientists from the Faculty of Physics at the University of Warsaw led by dr hab. Michał Tomza together with the experimental group of prof. Tobias Schaetz from the University of Freiburg were the first to observe Feshbach resonances between a single ion and ultracold atoms. The results of their work have been published in "Nature". The article was additionally highlighted on the journal's cover.

The world at its foundations is of a quantum nature; however, we can't observe it on a daily basis. To reveal its non-classical character, it is helpful to significantly lower the temperature, which allows for phenomena such as superfluidity and superconductivity to occur. Ultracold gases of atoms cooled to a fraction of a degree above absolute zero are an example of quantum matter. Under such conditions, the interactions between atoms can be controlled using electromagnetic fields and the phenomenon of Feshbach resonances. Scientists from the University of Freiburg and the Faculty of Physics at the University of Warsaw were able to observe and explain such resonances between a single ion and ultracold atoms for the first time. The results of their many years of work have been published in "Nature", one of the most recognized scientific journals in the world. The article was additionally highlighted on the cover as the most important in the issue. The Polish team of theoretical physicists was composed of dr hab. Michał Tomza together with members of the Quantum Molecular Systems group led by him: PhD student Dariusz Wiater and Master's student Agata Wojciechowska, and dr Krzysztof Jachymski, leader of the Ultracold Atomic Systems group.

Microscale control

When the energy of molecular states is adjusted to the energy of colliding atoms, magnetic Feshbach resonances significantly increase the frequency of collisions. In the experiment they were observed as an increase in the probability of ion loss as a result of its reaction with pairs of atoms for specific values of the magnetic field. Scientists were also able to demonstrate an increase in the frequency of two-body collisions near the resonance, which effectively allows to cool the ion. The theoretical analysis of Polish scientists allowed to determine previously unknown interaction parameters and to predict the position of resonances, which were not initially detected in the experiment.

An open path for new experiments

Ultracold ion-atom systems have many potential applications in quantum computing and simulations. The results obtained by physicists open the path for the next generation of experiments in which the quantum state of the ion will be much easier to control. The lower energy and longer life of the ion will allow to explore new phenomena and to create interesting states of quantum matter, which on the one hand will help to better understand the quantum nature of the world, and on the other hand will be another fundamental element of emerging quantum technologies. It can be expected that in a short time Feshbach resonances between an ion and atoms will be observed for other combinations of elements.

Physics and astronomy at the University of Warsaw appeared in 1816 as part of the then Faculty of Philosophy. In 1825, the Astronomical Observatory was established. Currently, the Faculty of Physics at the University of Warsaw consists of the following institutes: Experimental Physics, Theoretical Physics, Geophysics, the Department of Mathematical Methods and the Astronomical Observatory. The research covers almost all areas of modern physics, on scales from quantum to cosmological. The Faculty's research and teaching staff consist of over 200 academic teachers, 81 of whom are professors. About 1,000 students and over 170 doctoral students study at the Faculty of Physics at the University of Warsaw.

SCIENTIFIC PUBLICATIONS:

P. Weckesser, F. Thielemann, D. Wiater, A. Wojciechowska, L. Karpa, K. Jachymski, M. Tomza, T. Walker, T. Schaetz, ***Observation of Feshbach resonances between a single ion and ultracold atoms***

<https://www.nature.com/articles/s41586-021-04112-y>

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RELATED WEBSITES WWW:

<http://quantmol.uw.edu.pl>

Website of the Quantum Molecular Systems group at the Faculty of Physics at the University of Warsaw

<https://www.fuw.edu.pl/faculty-of-physics-home.html>

Website of the Faculty of Physics at the University of Warsaw

<https://www.fuw.edu.pl/press-releases.html>

Press service of the Faculty of Physics at the University of Warsaw

GRAPHIC MATERIALS:

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https://www.fuw.edu.pl/tl_files/press/images/2021/FUW211215b_fot01.jpg

An artistic vision of a single ion surrounded by ultracold atoms (*author: Ella Marushchenko*)

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https://www.fuw.edu.pl/tl_files/press/images/2021/FUW211215b_fot02.png

Group photo of members of Quantum Molecular Systems group (*photo: Piotr Kulik*)