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Cruising through the Quantum world

A new method for controlling the bound states of ultracold molecules has been developed by research teams led by professor Johannes Hecker Denschlag and professor Rudolf Grimm at the Institute of Experimental Physics at the University of Innsbruck. It allows them to quasi navigate through various bound states of the molecules. The Innsbruck quantum physicists report their findings in the science journal *Nature Physics*.

One of the most exciting areas of physics today is the study of atoms and molecules at extremely low temperatures near absolute zero (-273.15 degrees Celsius). The Innsbruck quantum physicists in the working group of Wittgenstein laureate Rudolf Grimm are world leaders in this field. Within his group, the team of Johannes Hecker Denschlag has developed a new method for studying these particles in more depth.

Navigating through bound states

The binding energy of a molecule can take on several discrete values. These quantized bound states are of great interest to experimental physicists. “In the longer term we want to experiment with transferring an ultracold molecule into the ground quantum state,” Johannes Hecker Denschlag explains. “What has long become routine with atoms nobody has yet achieved with molecules, because molecules are much more complex forms, which makes them much more difficult to control.” The new method allows the transfer of molecules from one quantum state to a neighbouring quantum state by dynamically applying magnetic fields and carrying out a radio-frequency transition. “In this way we can “cruise” through the different levels of binding energy fairly freely. For physicists these levels are indeed a kind of “road network”. In our experiment, for instance, we transferred a very weakly bound molecule of two rubidium atoms across nine crossings into a more strongly bound state,” recalls Hecker Denschlag, who clearly enjoys this elegant way of “taming” molecules.

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Potential for complex molecules

It has indeed been possible before to transfer molecules into certain quantum states in a controlled fashion. The advantage of the new technique is the fact that it allows navigating through different energy levels and thus transferring the molecules into ever new bound states. “In our experiment with ultracold molecules we have now opened up completely new possibilities”, enthuses Rudolf Grimm. These possibilities include ever more precise measurings, an exploration of particle collision and a controlled transfer of molecules into any bound state. Such research blazes a trail towards chemistry at total zero temperatures. Of his hopes for the future, Johannes Hecker Denschlag says, “One day it will be possible to apply this method to very complex molecules, which could be interesting for progress in nano- and biotechnology.” The current project was developed at the Institute of Experimental Physics of the University of Innsbruck with support from the Austrian Science Fund FWF.

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You can find pictures on: http://www.iqoqi.at/media/download/

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