Research Highlights

THE AUSTRALIAN NATIONAL UNIVERSITY

Research School of Physical Sciences and Engineering

Reversing the Roles of Light and Matter

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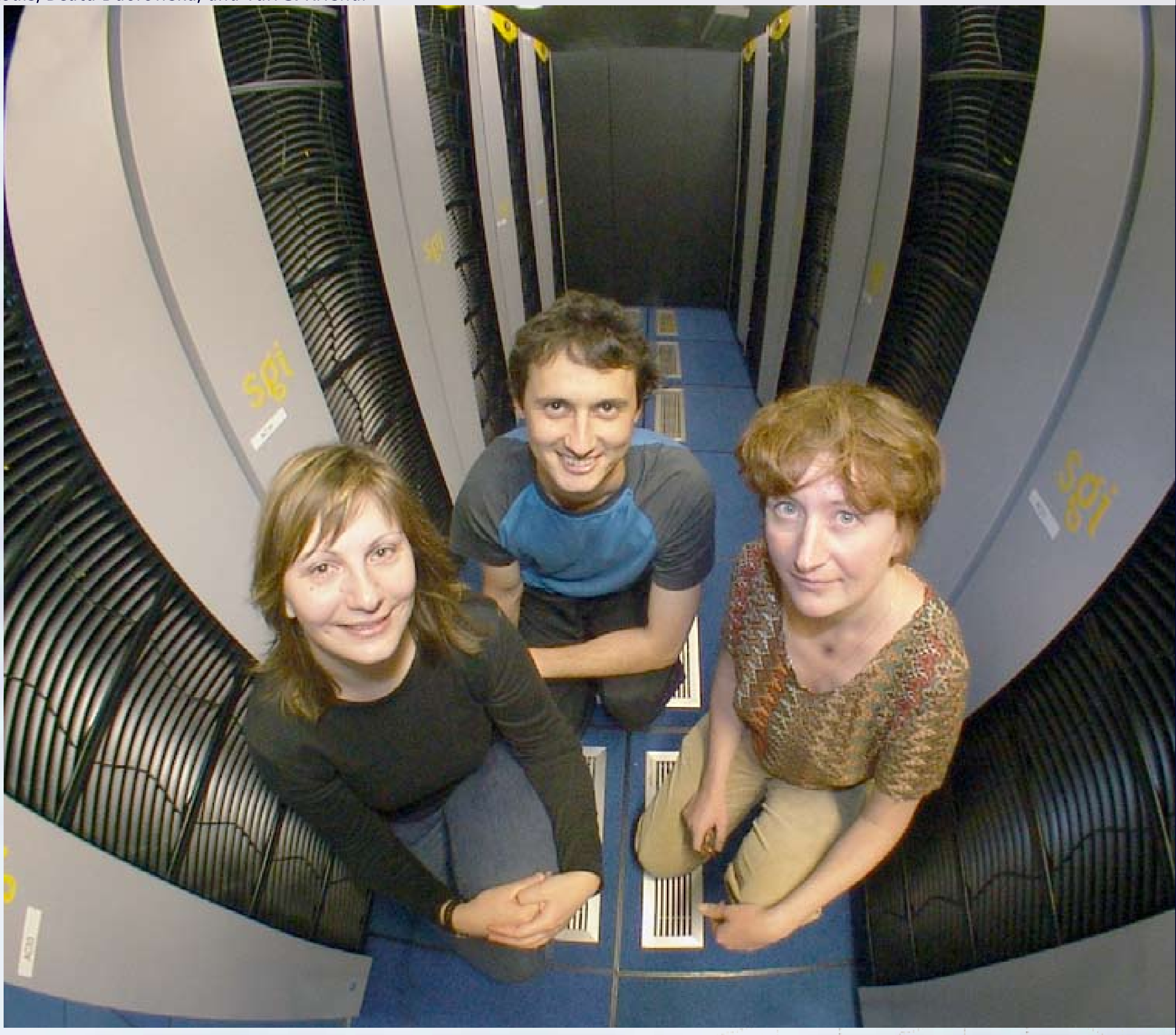
For years physicists have studied the interaction of laser light with the regular atomic lattices of crystals. But what happens when the roles are reversed and the laser beam is made of atoms and the crystal is made of light? This is exactly the question that Scientists at the ANU are currently exploring.

The laser beam of atoms is created by cooling a gas to almost absolute zero. This causes its atoms to undergo a transition into a single quantum state known as a Bose-Einstein condensate (BEC). Such BECs can behave like giant coherent matter waves or laser beams composed of atoms. A fascinating feature of the atom laser beam is its inherent nonlinearity; due to atom-atom interactions it can display focusing or defocusing behaviour even in vacuum. To make the light crystal, scientists combine multiple coherent light beams so that the interference pattern forms an optical lattice - perfectly periodic and stationary arrays of microscopic high and low intensity regions that attract or repel the ultracold atoms.

One of the most intriguing predictions of the new ANU theoretical model is the existence of so called atomic gap solitons - stable localisations of the defocusing atomic beam within the light lattice that are induced by the combination of nonlinearity and nontrivial scattering of the matter wave. The theory has recently been given a boost by the first experimental observation of these atomic gap solitons in Konstanz, Germany. Other fascinating and counter intuitive prediction of the theory is that even a "square" optical lattice can trap and sustain circular currents in condensates, BEC vortices. The lattice fragments the BEC into a regular array of condensate droplets but maintains the common circular particle flow.

The physics of BECs in optical lattices opens up novel possibilities of control and micro manipulation of matter waves by optical laser beams. It contributes into the foundation of amazing emerging technologies based on the principles of new cutting-edge science - quantum-atom optics.



Members of the research team with the ANU Supercomputer on which modeling calculations are performed