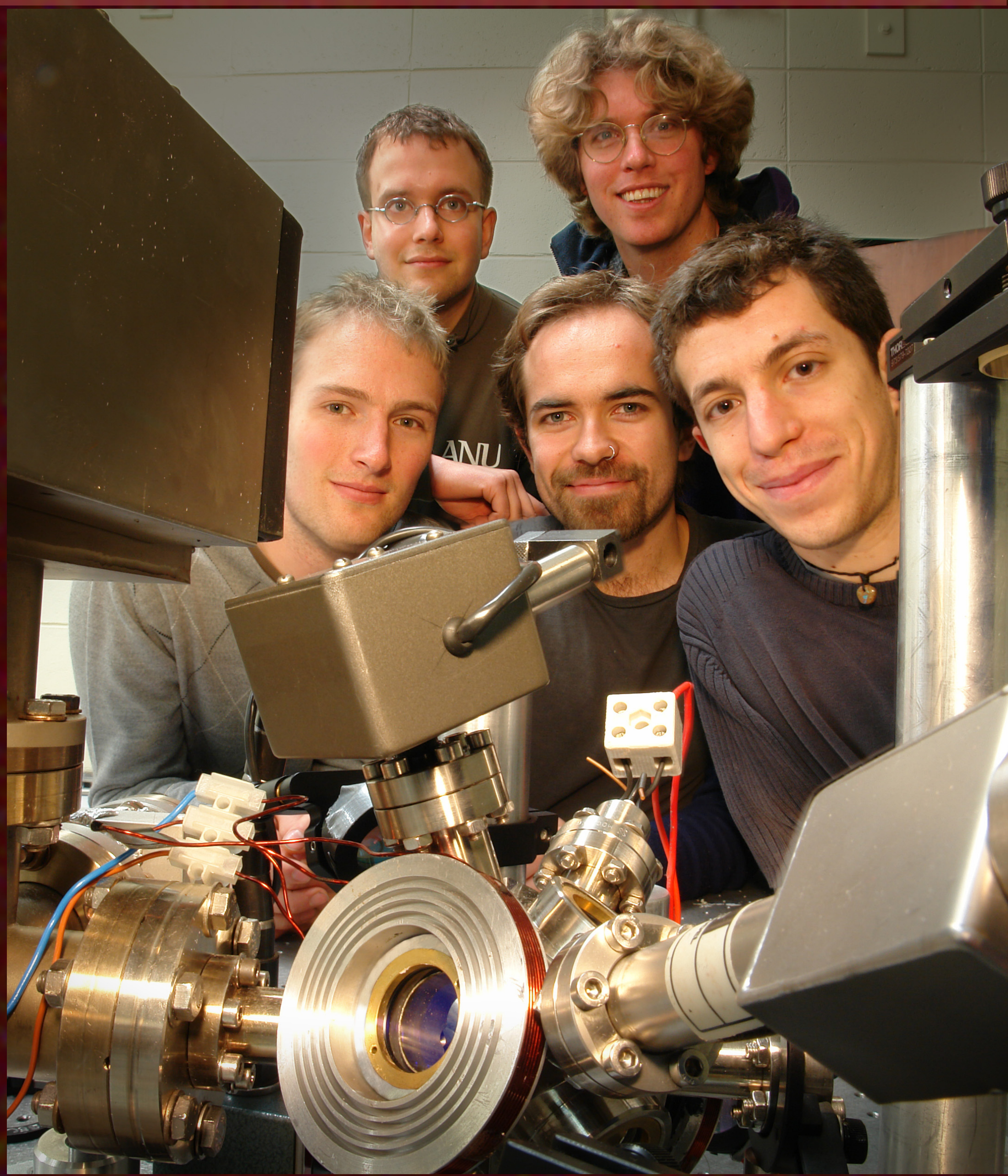
THE AUSTRALIAN NATIONAL UNIVERSITY

ANU ACHIEVES WORLD FIRST IN ATOMIC LASER

Nick Robins, Julien Dugue, Paul Summers, Matthew Jeppesen, Oliver Topic, Cristina Figl & John Close.

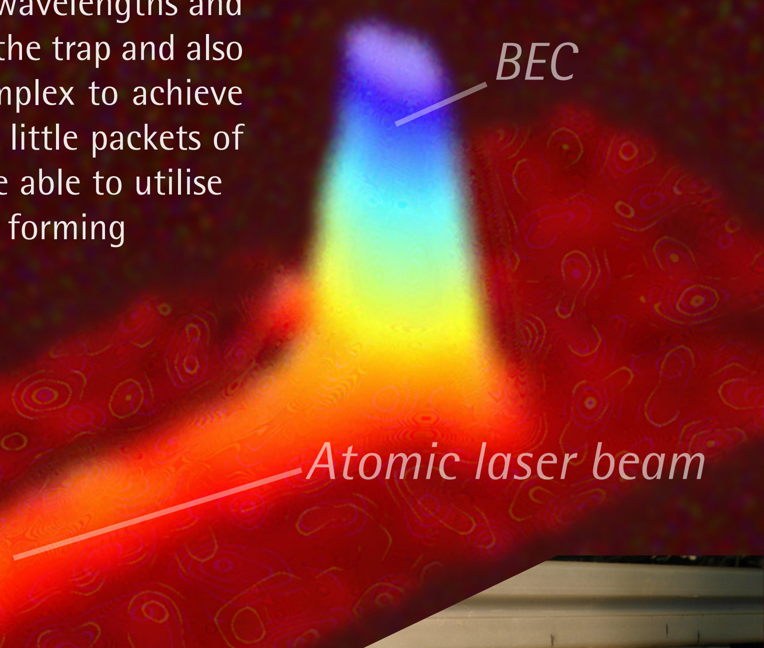
Department of Physics, Faculty of Science

An optical laser beam consists of a stream of identical photons each with the exact same wavelength and phase. But the physics of lasers isn't restricted to photons; you can also make a laser from a stream of identical atoms. So-called atomic lasers begin with a super cold cloud of atoms known as a Bose-Einstein condensate or BEC. The atoms in a BEC are so cold that they take on an entirely new state of matter, each adopting identical quantum properties to the others, just like the individual photons in an optical laser. In principle, by slowly releasing atoms from a BEC in a steady stream, it is possible to generate an atomic beam with all the coherence properties of an optical laser. However as with so many things in science, the practice is a lot more difficult than the principle.



To achieve a BEC in the first place, scientists use optical lasers to slow or cool atoms to almost absolute zero. At such low temperatures the atoms become sensitive to the pull of magnetic fields and it becomes possible to trap them in a carefully designed magnetic cell. As the atoms cool further in the magnetic trap, they begin to condense into a BEC. To release atoms from the BEC a radio frequency pulse is used to flip their Zeeman state, making them less sensitive to the magnetic trapping field and allowing them to tumble from the trap under gravity. However to make a really good bright atom laser, it's better if they all travel in a single direction with more enthusiasm than a mere tumble.

For almost a decade now theorists have been proposing a clever way of achieving atom release from a BEC by using two photons of light to induce a double transition. With the angles, wavelengths and energy all just right, the effect is to flip an atoms' Zeeman state thus freeing it from the trap and also to give it a little kick using the momentum of one of the photons. This is very complex to achieve in practice, and until recently had only been done using very short pulses to release little packets of atoms. However, scientists at ANU recently became the first group in the world to be able to utilise this double photon process to create a continuous steady release of atoms from a BEC forming a bright and highly coherent atomic laser.



Because of their inherent physical properties, bright atomic lasers offer the potential to revolutionise many sensing applications. For example the theoretical limit to the accuracy of a rotation sensor using an atomic laser is 100,000,000,000 times as high as the same limit for an optical laser based system. Atomic beams also offer major improvements in the time keeping vital to global positioning systems and to super quiet sensing used in gravity wave detection.