Report of April Meeting
Royal Society
Southern Highlands Branch

Speaker: Professor Kenneth Baldwin
Deputy Director: Research School of Physical Sciences and Engineering and the Australian Research Council Centre of Excellence for Quantum Atom-Optics, ANU

Topic: Weirdness in the Quantum World: When light and matter behave as both particles and waves.

The Southern Highlands Branch meeting of 15 April was held at 6.30pm in the Drama Theatre, Frensham School, Mittagong. The lecture attracted a 48-strong audience.

Professor Baldwin is a laser physicist based at the Australian National University. He is a Past-President of the Australian Optical Society, and is the first Australian to be elected to the Board of Directors of the Optical Society of America. He is also Past-President of the Australian Scientific and Technological Societies (FASTS). In 2004 he won the Australian Government Eureka Prize for Promoting Understanding of Science for his role in initiating and championing "Science meets Parliament". He has 81 refereed publications, 183 conference papers and has given 17 invited/postdeadline conference talks.

Kenneth Baldwin introduced his audience to the dual behaviours of light as both particles and waves using practical demonstrations. He showed the wave behaviour of light using double - slit diffraction patterns from a laser beam, and the particle behaviour of the same beam with a photometer. He then used these basic experiments, along with numerous accompanying video presentations, as a platform to describe the type of research that he and his teams are conducting in order to develop new laser technologies.

According to the laws of quantum mechanics that govern conditions in the microcosmos, what we normally term a particle can sometimes behave like a wave. This is well known and is used in e.g. the electron microscope. As early as 1924, de Broglie postulated the existence of matter waves and expressed their wavelength in terms of an inverse relationship with the momentum of the particles. The more slowly the particle moves, the less its momentum and the longer the de Broglie wavelength. According to the kinetic theory of gases, low particle velocities correspond to low temperatures. If a sufficiently

dense gas of cold atoms can be produced, the matter wavelengths of the particles will be of the same order of magnitude as the distance between them. It is at that point that the different waves of matter can 'sense' one another and co-ordinate their state, and this is Bose-Einstein condensation. It is sometimes said that a "superatom" arises since the whole complex is described by one single wave function exactly as in a single atom.

Kenneth Baldwin described many aspects of his research interests. He talked of his research into atom optics, where lasers can be used to create nanostructures for better microchips, and showed how lasers can be used to cool atoms to the lowest temperatures in the universe, at which point they behave more like waves than particles. A large part of the presentation dealt with the physics of the wavelengths generated, many examples being chosen to demonstrate the relationship between the achieved wavelength and the momentum of the particle involved. One practical application of this wave behaviour is the generation of sensitive detectors of, for example, changes in the earth's gravitational field to enhance mineral exploration.

It was clear from Kenneth Baldwin's presentation that his field of quantum atom-optics is advancing at an unprecedented pace. One only has to consider the recent spate of Nobel prize winners in that field.

At the conclusion of this extraordinary lecture, Professor Baldwin answered as many audience questions as time allowed. The vote of thanks was given by Anne Wood.

Anne Wood