



## Electrons Meet Helium



*Dr. Keiya Shirahama meets Sir Martin Wood*

Dr Keiya Shirahama, is the winner of the 2001 Sir Martin Wood Prize. Sponsored by Oxford Instruments Superconductivity, the Millennium Science Forum annually awards the Sir Martin Wood Prize to a young Japanese scientist carrying out his/her research in Japan, who has performed outstanding research in Condensed Matter Science. Dr Shirahama's prize winning research using 2D electron systems is presented below.

### Liquid $^3\text{He}$ Free Surface Probed by the Wigner Crystal

**Two-dimensional (2D) electron systems have contributed greatly to developments in fundamental physics, for example, in the discovery of the Quantum Hall effect. Electrons trapped on a free surface of liquid helium (He) offer an excellent high mobility 2D electron system.**

Since the free surface of liquid He is extremely smooth, the mobility of electrons increases enormously at low temperatures. Due to this highly mobile nature, the electrons are very sensitive to elementary excitations, which disturb electron transport, and can be a powerful probe for the study of the He surface.

Due to strong Coulomb repulsion, surface electrons undergo a phase transition to a crystalline state called the Wigner crystal, predicted theoretically by the famous American physicist, Eugene Wigner, in 1934.

The Wigner crystal is one of the possible ground states of strongly correlated electron systems.

### Quantum Liquids

The Wigner crystal on liquid He has a unique feature; the electrons localised within the lattice put pressure on the liquid surface resulting in periodic corrugations (Figure 1). This is called the "dimple" structure. Not only does the dimple structure play a key role in the dynamic properties of the Wigner crystal, but it can be used as a tool for understanding liquid He, the fascinating quantum liquid.

The free surface of liquid He is an intriguing object of study. In particular, we have been interested in the surface of superfluid  $^3\text{He}$ . The superfluid  $^3\text{He}$  is a typical *anisotropic* Fermi superfluid, in which the Cooper pairs have nonzero spin- and orbital- angular momenta. Near the boundaries of the liquid, the

