日本物理学会北陸支部特別講演会

講演題目：2D electrons on the liquid helium - on the way to quantum computing devices

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場　　所：金沢大学 角間キャンパス　自然科学 5 号館講義棟 2F　第 5 講義室

講演概要：

The concept of making a computational machine where calculations are based on the quantum physics laws - quantum computer is one of the biggest challenges in modern physics. Despite on the serious obstacles on the way to reach this ultimate goal, the efforts of many scientists on this field disclosure the new way of understanding the mystery of the quantum world.

A lot of different physical systems have been proposed as a candidate for the main unit of this computer (qubit), and intensively studied in the experiments. Rydberg and spin states of electrons floating on the surface of liquid helium was suggested [1-3] as a promising two-level system for realizing a qubit. One of the main architectural attribute required for this physical system (as a quantum computer) is the ability to manipulate with individual electrons. Here we demonstrate a precise control of the quasi-1D electrons configuration by varying the confinement in the microchannel type device by transport measurements. Transport properties of surface state electrons (SSE) formed on liquid helium and confined in a 7 μm-wide microchannel was studied in unprecedented details. Quasi-1D confinement was created by applying voltages to Bottom-Gate (Vbg) and top Split-Gate (Vsg) electrodes. By varying voltages on these electrodes allows us to precise control of the confinement parameters: the potential depth, which controls the density of the electron system, and the effective width of the channel. The electric current was measured as a function of voltages applied to these electrodes. Under certain temperature and confinement conditions SSE form an ordered state, known as a Wigner crystal. The phase transition was observed as a drop of the electric current due to the emergence of a specific bound state of electrons with ripplons (surface capillary waves), which effectively increases the mass of the electron system in the ordered state.

The observation of a unique behavior of interacting systems in confinement - reentrant melting (observed as a current oscillation at the boundary of phase transition) allows us to identify the number of electron rows formed in the microchannel (from a single chain up to 20 electron rows). The ability to control the number of electron rows opens doors to build mesoscopic devices, similar as in the semiconductor physics (quantum wires, Aharonov-Bohm rings, microdevices for spin manipulations etc.), to study the physics of interacting electrons in reduced dimensionality.

1. PM Platzman and MI Dykman, Science 284, 1967 (1999).
2. S. Lyon, Physical Review A 74, (2006).
3. D.I. Schuster et al., Physical Review Letters 105, 040503 (2010).

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