SYSF 1 Superfluidity 1

Time: Monday 09:45–11:15 Room: HSZ 04

Invited Talk SYSF 1.1 Mon 09:45 HSZ 04

Rotons and superfluidity — •Sebastien Balibar — Laboratoire de Physique Statistique, Ecole Normale Superieure, 75231 Paris cedex 05, France

Fritz London understood that quantum mechanics shows up at the macroscopic level, and proposed in 1938 that superfluidity was a consequence of Bose-Einstein condensation. However, Lev Landau could not believe in London's ideas; instead, he introduced quasiparticles to explain the thermodynamics of superfluid 4He and its critical velocity. One of these quasiparticles was his famous "roton" which he considered as an elementary vortex. In 1946, London criticized Landau's "theory based on the shaky grounds of imaginary rotons". Despite their rather strong disagreement, Landau was awarded the London prize in 1960. Today, we know that London and Landau had both found part of the truth: BEC takes place in superfluid 4He, and rotons exist.

In my early experiments on quantum evaporation, I found direct evidence for the existence of rotons which play the role of photons in the photoelectric effect. But rotons are now considered as particular phonons which are nearly soft, due to the local order of superfluid 4He. In our recent studies of nucleation, rotons show their importance again: by using acoustic techniques, we have extended the study of liquid 4He up to very high pressures where the liquid state is very dense and metastable. We now wish to demonstrate that, at high density, the vanishing of the roton gap destroys superfluidity and triggers an instability towards the crystalline state.

Invited Talk SYSF 1.2 Mon 10:15 HSZ 04

Disorder determined phase of the p-wave superfluid 3He — •Igor Fomin — P. L. Kapitza Institute for Physical Problems, Kosygina 2, 119334 Moscow, Russia

For p-wave Cooper pairing several superfluid phases can exist. Two pases - ABM and BW are realized in the superfluid 3He. The order parameters of both phases are minima of the conventional Ginzburg and Landau free energy, obtained as a regular expansion in powers of the order parameter. Introduction of impurities in a form of high porosity aerogels in the superfluid 3He changes expression for its free energy. Singular terms appear in this expression. The singular terms dominate in a near vicinity of the transition temperature. As a result new phase can appear at cooling of liquid 3He from the normal phase in the superfluid. The order parameter of the new quasi-isotropic, or "robust" phase is found and suggested as a candidate for the experimentally observed A-like phase. Some properties of the suggested phase are discussed.

Invited Talk SYSF 1.3 Mon 10:45 HSZ 04

From superfluids to vacuum of relativistic quantum fields — •Grigory Volovik — Low Temperature Laboratory, Helsinki University of Technology, P.O.Box 2200, FIN-02015 HUT, Finland — Landau Institute for Theoretical Physics, 119334 Moscow, Russia

The phenomenon of emergent physical laws, which is manifested in most of the condensed-matter systems, is becoming the paradigm of the modern physics. We hope that this phenomenon can be also applicable to the high energy physics and gravity. The encouraging fact comes from universal properties of the ground states of quantum liquids, which play the role of the quantum vacua in particle physics. The role of matter is played by the fermion zero modes and by the bosonic collective modes of the liquid. There are only two basic universality classes of quantum vacua, which support the topologically stable gapless (massless) fermions. The more common class contains the vacua whose fermionic excitations live in the vicinity of the Fermi surface. Fermionic excitations in vacua belonging to the second class live near Fermi points – points in momentum space where the energy of excitation is zero. Near Fermi points, excitations behave as relativistic massless Weyl fermions, while the bosonic collective modes interacting with them simulate the gauge and gravitational fields. In this universality class the gauge fields, chiral fermions, Lorentz invariance, gravity, relativistic spin, and other features of Standard Model gradually emerge. The condensed-matter vacua demonstrate the possible solution of the cosmological problem: the huge contribution of zero point energy of quantum fields is cancelled without any fine tuning by microscopic degrees of freedom above the Planck cut-off.