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A joint scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics of the USSR Academy of Sciences was held on January 21 and 22, 1981 at the P. N. Lebedev Physics Institute of the USSR Academy of Sciences. The following papers were presented:

January 21

1. *V. L. Pokrovskiĭ*, Phase transitions and solitons in two-dimensional crystals.
2. *Yu. S. Vedula, V. K. Medvedev, A. G. Naumovets, and A. G. Fedorus*, Experimental investigation of two-dimensional crystals.

January 22

3. *L. B. Okun'*, Present state and prospects of high-energy physics (a general review).

The content of the papers read on January 21 is presented below; the paper by L. B. Okun' has been published in the form of a review in this journal, **134**, 3 (1981); [**24**, 341 (1981)].

V. L. Pokrovskiĭ. *Phase transitions and solitons in two-dimensional crystals.* Two-dimensional crystals (TC) are now an object of physical experimentation as a result of progress in film technology. Here we shall discuss TCS that have been grown on a periodic base. These include sub-monolayer adsorbed atoms,[1-3] two-dimensional charge-density waves in chalcogenides of transition metals,[4] and the Abrikosov vortex lattice in a corrugated superconductive film placed in a transverse magnetic field.[5] With minor modification of the experiment, the Wigner electron crystal on the surface of liquid helium can also be classified as one of these systems.[6]

An incommensurable phase of special interest has been detected in all cases of periodic-base TCs that have been studied.[1,2,4,7] Theory[6,8] indicates that the extra atoms or holes over the commensurable phase are nonuniformly distributed and concentrate around certain lines, which we call soliton lines or simply solitons. The existence of the solitons was first demonstrated in Ref. 9 in a one-dimensional model. In the elementary model of Ref. 10, the adatoms are treated as particles joined by springs of equal length, and the base as a nonvarying periodic relief. The unit-length soliton energy ε_s depends on the initial incommensurability $\delta = (a - a_0)/a_0$, where a is the length of the unstretched spring and a_0 is the period of the potential. The soliton energy ε_s^0 will obviously be positive at $\delta = 0$. For arbitrary δ, we have $\varepsilon_s = \varepsilon_s^0 - C\delta$, where C is a positive constant. Generation of solitons becomes energetically favored at a critical value $\delta_c = \varepsilon_s^0/C$. This constitutes the transition to the incommensurable phase (C–I transition). Further multiplication of the solitons is brought to a stop by mutual repulsion. The smaller is $\delta - \delta_c$, the greater is the distance between solitons.

The soliton superstructure predicted by the theory[6,8] has been detected in structure measurements.[11-13] In accord with the theory,[6] the superstructure is found to be one-dimensional when the base is anisotropic.[11,13] There is no rigorous theory for isotropic bases (regular triangular lattices). The discrete lattice acts on a soliton as a periodic field. Attachment of a soliton to the lattice results in a number of physical consequences.[14] The C–I transition splits in two. As long as the average soliton density is low, the interaction between solitons is weaker than the energy of attachment. The solitons are firmly secured in this phase. As $\delta - \delta_c$ increases, the density of the solitons reaches a level at which their interaction becomes equal to and then greater than the attachment energy. Formation of a periodic soliton superstructure is favored. It is capable of movement as a whole with no energy change.[15,16] Generally, we may expect sharp changes in the kinetic coefficients. There are additional quasiacoustic vibration branches in a phase with unsecured solitons. The existence of these phonon branches has been demonstrated by A.G. Naumovets and A.G. Fedorus,[17] who measured the Debye-Waller factor of TCs.

The thermodynamics of a soliton system in a TC was constructed in Ref. 6. The phase diagram consists of alternating regions of commensurable and incommensurable phases. For each commensurable phase there is a critical temperature T_c above which this phase is absolutely unstable. For 1 : 1 commensurability, this temperature is of the order of the

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adatom interaction energy. For other types of commensurability, it decreases as N^{-2}, where N is the number of adatoms per unit cell for the given type of commensurability. The incommensurable phase exhibits the properties of a free TC.[18,19] Dislocation melting can (in principle) be observed in it.[20,21]

In their quantum and thermal motions, the solitons have the properties of Fermi particles.[6,22] Inclusion of the Fermi occupation energy changes the properties of the system significantly near the line of the $C-I$ transition. According to Ref. 6, the shift of the Bragg reflections is proportional to $(T-T_c)^{1/2}$ (or $\sqrt{\delta-\delta_c}$) and not to $[\ln(\delta-\delta_c)]^1$, as in the classical theroy.[9] The results of a recent experiment[13] (Xe atoms described by an anisotropic 110 surface of copper) are consistent with the $\sqrt{\delta-\delta_c}$ law. In the case of an isotropic surface (krypton on graphite), experiments[7,12] are accurately described by $(\delta-\delta_c)^{1/3}$, behavior that has not been explained theoretically.

The kinetics of the TC is determined by the number and mobility of the solitons. Thus, the sharp changes in the diffusion coefficient that were detected experimentally in Ref. 23 at concentrations near simple rational points can be interpreted qualitatively by treating the solitons as mass carriers.

If an external force F is applied to commensurable-phase particles, the commensurable phase becomes unstable at a certain critical force F_c. In the case of repulsion, instability arises earliest on the boundary, where the forces exerted on a given atom by other atoms do not cancel one another. A soliton forms at the boundary, enters the system, and transports mass, charge, etc.[24] The critical-current mechanism in a superconductor is of precisely this type (the Lorentz force plays the part of F). This mechanism makes it possible to explain the experimentally observed[5] form of the peaks of the critical current as a function of the magnetic field.

If the force exceeds F_c, the boundary becomes a source of solitons, which it releases into the system periodically. A dynamic soliton superstructure forms. It determines the volt-ampere characteristic, the nonstationary Josephson effect, and correlation dynamic properties.

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