Physics – Uspekhi **46** (12) 1291 – 1294 (2003)

CONFERENCES AND SYMPOSIA PACS numbers: 01.10.Fv, 05.70.Fh, 05.70.Jk, **64.60.–i**

Traditional international conference on phase transitions and related critical and nonlinear phenomena in condensed media (11 – 14 September 2002, Makhachkala, Dagestan, RF)

I K Kamilov, A K Murtazaev

DOI: 10.1070/PU2003v046n12ABEH001385

Abstract. A brief review is given of some results of the investigations presented at the International Conference "Phase Transitions and Related Critical and Nonlinear Phenomena in Condensed Media", held in Makhachkala under the auspices of the Institute of Physics of the RAS Dagestan Scientific Center on 11 – 14 September 2002. The programme of the conference was supplemented with the topics of the 5th International Seminar "Magnetic Phase Transitions", held simultaneously and dedicated to the memory of late K P Belov.

On 11 – 14 September 2002, the International Conference "Phase Transitions and Related Critical and Nonlinear Phenomena in Condensed Media" was held in Makhachkala under the supervision of the Institute of Physics of the Dagestan Scientific Center (DSC) of the Russian Academy of Sciences (RAS). The conference also included the 5th International Seminar "Magnetic Phase Transitions", dedicated to the memory of the distinguished magnetologist Professor K P Belov passed away in the year 2001.

Both the conference and the seminar were organized by the General Physics and Astronomy Division of RAS and the scientific board of RAS for the problem of "Magnetism" in collaboration with the RAS DSC Institute of Physics and Dagestan State University.

These scientific events were supported by the Russian Academy of Sciences, the Ministry of Industry and Technology of the Russian Federation, and the Russian Foundation for Basic Research.

The conference and seminar programme committees selected 145 presentations, of which 13 were plenary talks, 47 oral talks, and 85 poster presentations. There were participants from 18 cities of Russia and 12 foreign countries. More than 180 researchers took part in the conference. The scope of the conference covered almost all fields of the physics of condensed matter relating in one way or another to phase transitions (PT), critical phenomena (CP), and nonlinear phenomena. The conference saw the work of the following sections: 'Magnetic phase transitions', 'Simulation of phase transitions and critical phenomena', 'Critical phenomena in liquids', 'Phase transitions, chaos, and nonlinear phenomena in condensed matter', and 'Phase transitions and critical phenomena in ferroelectrics, HTSC, and manganites'.

The memorial seminar for K P Belov, a distinguished magnetologist, Professor of Moscow State University, was held on September 12. In the first two talks, the President of DSC of RAS and a Corresponding Member of RAS I K Kamilov and Professor S A Nikitin spoke about their reminiscences of K P Belov.

The aim of the conference was to discuss recent developments, the current situation, and novel ideas in the fields of research into phase transitions and critical and nonlinear phenomena in condensed matter.

One of the central problems discussed at the conference was that concentrating on magnet dynamics. In his plenary talk, Yu A Izyumov (Institute of the Physics of Metals, Ekaterinburg) reviewed theoretical and experimental studies of the dynamics of an isotropic Heisenberg ferromagnet within the whole temperature range of ferromagnetic ordering, with the exception of a narrow critical domain. The author pointed out several stages in this research: Bloch's linear theory, Dyson's theory of interacting spin waves, Tyablikov's mean field theory for retarded Green's functions, and the Vaks – Larkin – Pikin theory. He showed that for an isotropic ferromagnet there are satisfactory comprehension and agreement between the theoretical and experimental results on the dynamics of transverse spin components. The situation is quite different for the dynamics of longitudinal spin components — because of the strong nonlinearity of the corresponding theory, many results contradict to each other. Application of a special diagram technique for spin operators, which had been developed earlier by the authors, allowed them to sum up the infinite sequence of loop diagrams (generalized random phase approximation, GRPA) and to derive the expression for the dynamic longitudinal susceptibility. The dynamic structure factor of longitudinal fluctuations, obtained in the framework of this approximation, has in the general case a three-peak structure. As the Curie point is approached, the intensity of the central peak grows, and all three peaks can merge into a single broad distribution centered at zero frequency. It is possible that the existence of either a three-peak distribution or a single broad maximum, depending on the temperature and the system parameters, can explain the contradictory results produced in experiments. It should be emphasized that the GRPA theory developed by the authors is also valid beyond the bounds of the hydrodynamic approximation.

I K Kamilov, A K Murtazaev DSC Institute of Physics,
Russian Academy of Sciences,
ul. M Yaragskogo 94, 367003 Makhachkala, Russian Federation
Tel. (7-8722) 62 89 60
E-mail: kamilov@datacom.ru

Received 16 December 2002
Uspekhi Fizicheskikh Nauk **173** (12) 1367 – 1370 (2003)
Translated by M V Chekhova; edited by A Radzig

Probably the most serious problem that challenges investigators of magnet dynamics is its behavior in the vicinity of the critical point. In spite of considerable efforts made for the development of critical dynamics theory, almost no new important results have been achieved in this direction. On the one hand, this is caused by serious difficulties arising in the study of dynamic effects near the critical point. On the other hand, even the static theory of critical phenomena is full of controversies and open questions. At the same time, it is well known that all modern theoretical approaches to critical dynamics are based on the advancements of the static theory of PT and CP.

A K Murtazaev (RAS DSC Institute of Physics, Makhachkala) presented a review of recent achievements in the PT and CP theories. In the first part of the talk, he made a thorough analysis of the static theory and described certain difficulties faced by the fundamental theory of PT and CP. He demonstrated several cases where the scaling hypothesis, which is one of the central statements of the static theory and forms the basis for the theory of PT and CP, is violated. Murtazaev also mentioned controversial problems that are intensely discussed in the scientific literature. He pointed out some questions that have no answers in the framework of current theoretical models and mentioned several novel theoretical approaches that have yet to be accomplished and tested in experiment. Obviously, the theory of critical dynamics presents even more problems, difficulties, and debatable questions.

In the present theory of critical dynamics, there are four basic approaches: the so-called conventional Van Hove theory, the theory of interacting modes, dynamical scaling, and the renormalization-group (RG) method. The speaker analyzed all these theories, pointed out their advantages and drawbacks, and discussed their agreement with existing experimental results. In relation to the problem of universality in dynamics, he stressed that dynamic universality classes are much narrower than those in static theory. The speaker presented a list of parameters that determine the universality class of dynamic critical behavior. He stressed that the list could be incomplete and there could exist certain characteristics making the universality classes even narrower. The author presented the well-known table by P C Hohenberg and B I Halperin showing the existing dynamic models and the corresponding values of z-index. The table was essentially expanded and supplemented with the most recent results.

The speaker demonstrated in a conclusive way that, although purely analytical methods have given no noticeable progress in the study of critical dynamics, a considerable breakthrough in this field is expected due to computing methods. He presented a simple and reliable scheme of calculating the most important parameters of critical dynamics, based on the combined employment of Monte Carlo and spin dynamics methods. The results of the dynamical critical z-index calculation for the Heisenberg models in various lattice types are quite convincing. After testing this method on well-known models, the authors used it in the calculation of the dynamical critical parameters for the models of Cr_2O_3, a complex multisublattice antiferromagnet. The results obtained and the calculation scheme demonstrate conclusively that the authors have developed a new efficient method for the study of critical dynamics. It should be stressed that their method can be applied to models of almost any complexity. One of the few drawbacks of this method seems to be its rather low accuracy, but this flaw will soon be eliminated due to the rapid progress in developing computer resources. All this makes one believe that numerical calculations will play the central role in the study of critical dynamics in the nearest future and probably provide considerable progress in this field.

Mutual relations between the dynamics of magnetic and structural phase transitions were considered in detail in the talk by N K Dan'shin (Institute of Physics and Technology of Ukrainian NAS, Donetsk). At present, vibrational spectra of magnetically ordered crystals are well studied. Here, much attention is paid to the neighborhood of orientational magnetic phase transitions. At the points of such transitions, the magnetic anisotropy energy turns to zero, and the magnet becomes practically isotropic. Fine dynamical interactions between the elastic, spin, and electromagnetic vibrational subsystems of the magnet are very difficult to observe and identify in experiment. This is only possible under the conditions that magnetic anisotropy gives no energy background. The experimental studies of orientational phase transitions in magnets mainly relate to the frequency gap in the spectrum of homogeneous spin waves and to anomalies in the speed and damping of sound.

In order to describe dynamic interaction between different vibrational subsystems in the magnet, one should solve a system of three equations, including the elasticity equation, the equation of motion of the magnetic moment, and the full set of the Maxwell equations. The energy gap in the spectrum of the soft magnetic resonance mode has been shown to be a sum of additive contributions from different coupled vibrations. At the same time, the decrease in the velocity of sound and anomalies in the sound damping coefficient are due to the dynamic interaction between the elastic subsystem and other vibrational subsystems of a magnet. This pattern of spontaneous orientational transitions in magnetically ordered crystals is extended to objects that have no ordered spin systems but experience spontaneous structural transitions of the 'order – disorder' type.

Of considerable interest was the talk by A I Sokolov (St.-Petersburg State Electrotechnical University 'LETI', St.-Petersburg) who studied chiral transitions in magnets with planar or vector ordering and a 'floating' fixed point (focus). In the literature, available data on the critical behavior of the N-vector chiral model are still contradictory, although this model is very interesting for the study of phase transitions in helicoidal magnets, antiferromagnets with triangular lattices, and some other systems. According to the idea of the authors, such an inconsistent situation is caused by the existence of an unusual mode in the critical behavior of the N-vector chiral model in the physically important cases of $N = 2$ and $N = 3$. In order to verify this idea, the authors have analyzed the critical behavior of 2D and 3D chiral models in five-loop and six-loop RG approximations for a space of the fixed dimension and found the structure of RG trajectories for the cases $N = 2$ and $N = 3$. During the calculations, the authors utilized a new technique of series resummation. This technique turned out to be quite efficient, even close to the phase space boundaries, where usual RG trajectories diverge and the series lose their Borel summability. It was shown that the critical behavior of chiral models with planar and vector ordering can be described by a stable fixed point constituting a focus type attractor for spiral RG trajectories. When approaching the fixed point nonmonotonously, one can observe crossover transitions from one trajectory to another in the vicinity of the critical point. Because of these

transitions, there is a wide spread between the critical parameters observed in numerous laboratory and computer experiments. Supplementary calculations based on Padé–Borel–LeRoy summation technique confirmed the conclusion about the type of the fixed point.

As at previous conferences, several interesting papers were submitted by the RAS Institute of Radio and Electronic Engineering (RAS IREE, Moscow). V V Koledov presented the results obtained for newly discovered alloys that manifest both thermoelastic memory and ferromagnetism effects. Of most interest among them are intermetallic compounds based on the Geissler alloy, viz. Ni_2MnGa. In these alloys, a magnetic field can cause a thermoelastic martensite transformation and induce the shape memory effect at constant temperature. This process is accompanied by 'colossal magnetostriction' of the samples, i.e., magnetically induced strains in the range 1–10%. The author investigated the stress–strain relations at various temperatures and strengths of the external magnetic field. He demonstrated the effects of unilateral magnetomechanical memory, 'colossal magnetostriction' under a stress, and magnetically controlled bilateral shape memory requiring no external stress. He also put forward a theory of 'colossal' magnetomechanical effects, based on Landau's thermodynamic theory of phase transitions and taking into account the model of twin structure transformation.

As before, much attention is attracted to the region of incommensurate phase transitions in ferroelectrics. Of utmost interest are the critical properties of ferroelectric materials in the vicinity of the transition point between symmetrical and incommensurate phases. Still, high-precision experimental studies of specific heat in this region have been performed only for very few ferroelectrics. S N Kallaev (RAS DSC Institute of Physics, Makhachkala) presented the results of heat capacity measurements for ferroelectric $SC(NH_2)_2$ using AC calorimetry. The critical index α calculated from these data is in qualitative agreement with the theoretical value obtained for the XY model, as well as with the results of some other papers where α was determined indirectly.

The pressure effect on the magnetic, magnetically ordered, and magnetocaloric properties of rare-earth elements (REE), as well as their alloys and compounds, in the region of magnetic phase transitions was considered in the talk by S A Nikitin (Moscow State University, Moscow). Using the experimental evidence, the author calculated bulk magnetostriction and various contributions to the dependence of magnetization on the pressure (the $\Delta\delta$ effect). The effect was shown to be due to the dependences of saturation magnetization, magnetic anisotropy, and exchange interactions on pressure. Transformation of magnetic phase transitions under the influence of magnetic field and pressure was studied. The author presented very interesting results for the effect of magnetization on the Young modulus for REE in the region of magnetic phase transitions. Using these results, he showed that the dependence of the Young modulus on the magnetization and its anomalies near the magnetic phase transition temperature could be understood in the framework of an approach based on the theory of second-order phase transitions. It was also shown that anisotropic single-ion contributions to field-induced magnetostriction are comparable with isotropic exchange contributions. Finally, the author found that the shift of magnetic phase transitions is also determined by the dependence of both exchange and magnetocrystalline interactions on the interatomic distances.

Nonlinear effects in condensed matter were among the main topical problems of the conference. One of the most interesting presentations on this subject was the talk by A B Borisov (Institute of the Physics of Metals, Ekaterinburg) about the structure and properties of spiral vortices in ferromagnets. At present, it is securely established that under certain conditions the effect of self-organization of magnetization vector distribution shows itself in thin magnetic films with strong transverse anisotropy of 'easy axis' type. A harmonic or monopolar pulsed magnetic field can cause the formation of leading centers from labyrinth domain structure. These centers can be target-like structures, spiral domains, and domain structures with high translational and orientational ordering.

Typical features of such magnetic structures are their static stability and significant nonlinearity. In addition, they possess rather long lifetimes. Therefore, target-like magnetic structures and spiral domains can be considered as magnetic defects that are excited by the energy pumping into a magnetically ordered media and undergo slow relaxation to thermodynamic equilibrium. The speaker showed that exchange interaction is already responsible for formation of spiral vortex type structures in 2D ferromagnets. Borisov found a broad class of new exact solutions to the corresponding equations and studied the structure and interaction of spiral vortices. The influence of other interactions on the structure of a spiral vortex was qualitatively studied.

Nonlinear phenomena and chaos in semiconductor systems are intensely studied at the RAS DSC Institute of Physics in Makhachkala. K M Aliev (RAS DSC Institute of Physics, Makhachkala) reported the results of experimental studies for p-Ge(Au) specimens with specially chosen parameters. The specimens were obtained through the injection of carriers from contacts under simultaneous illumination of p^+-n-p^+ samples of length $l = 1-3$ mm. Using extensive experimental material, the speaker demonstrated that within the chosen range of parameters the system could manifest three regimes of behavior. It was discovered that the current–voltage characteristic of the system had the second S-switch section. The authors supposed that it was caused by a noise-induced nonequilibrium phase transition. Physical mechanisms were suggested to explain the results obtained, and the experimental data were compared with the predictions of the posed one-dimensional theoretical model.

As a rule, a considerable number of talks at such conferences are devoted to the study of thermophysical and critical properties of liquids. One should specially mention the talks by G V Stepanov, S M Rasulov, and G M Ataev (all from the RAS DSC Institute of Physics, Makhachkala), E G Rudnikov (Kiev National University, Kiev, Ukraine), G G Petrik (RAS DSC Institute of Geothermometry Problems, Makhachkala), R A Gafiatulin (Bashkirian State University, Ufa), and some others. It is clear from the talks that current investigations of PT and CP in liquids mostly consist of the collection, accumulation, and processing of experimental data for simple and complex liquids.

As a rule, this conference attracts a large number of young participants. Among the talks delivered by young researchers, let us mention interesting presentations by K Sh Khizriev, M A Magomedov, M Sh Ramazanov, and A S Kovalev (all from the RAS DSC Institute of Physics, Makhachkala), I Yu Lamakina (Bashkirian State University, Ufa), and M A Borich (Institute of the Physics of Metals, Ekaterinburg). The talks presented by young authors not only

demonstrate their high professional level but also show that the flow of talented young people to science is still strong, at least in the provinces. The conference was organized in such a way that young participants had an opportunity to communicate with well-known scientists. This stimulated the interest of young people in science and promoted the generation of new ideas.

In this brief summary of several talks delivered at the conference and the seminar, we tried to cover the main subjects and problems discussed at these scientific events.

Analyzing the results reported at the conference and the seminar, one can see that despite the difficult financial situation in fundamental science, there is evident progress in the physics of phase transitions and critical phenomena. In nearly all fields, there are new findings that are level with the highest world standards. The flow of young people to science did not discontinue.

As a part of the cultural program, the Organizing Committee suggested an interesting trip to Sulak Canyon, including an excursion to a unique hydraulic structure, the 'Chirkeĭskaya' hydroelectric power station. Some participants of the conference also visited mountainous Gunib.

The planned programme of the conference and the seminar was completely implemented.