gap show very weak glow in the diode region; this glow is apparently due to evaporation of the adsorbed gas. They show also the bright glow of the plasma from the cathode flares at the tips. The intensity of this glow falls off rapidly in the radial direction. The region of visible glow penetrates not more than 5 mm into the interior of the gap (Fig. 2a). Our estimates show that at a voltage 10^6 V and at a current less than 100 A from one tip, the cathode plasma ceases to affect the switching in the accelerating gap if it reaches a dimension of 1 cm and more in the course of its expansion. The plasma concentration on the flare front becomes comparable with the concentration of the residual-gas particles. In this case, the duration of the current pulse is determined by the time of discharge of the pulse-generator capacitor into the diode resistance. It can be shown that this time is $\tau_{0.5} = 2.2\times10^5 Cd^2/S\sqrt{U_0}$, where $\tau_{0.5}$ is the current pulse duration at half height in seconds, C is the capacitance of the pulse generator in F, d is the interelectrode gap in cm, S is the cathode area in cm^2, and U_0 is the accelerating voltage in volts. The experimental results agree with this relation.

The structure of the beam (Fig. 2b) differs strongly from that obtained with this diode at 30 nsec pulse durations. Whereas in the former case it consists of individual rings obtained from each emitter, the microsecond pulses reveal irregularities that are probably due to the interaction between individual cathode flares.

The authors thank G. P. Smirnov and V. M. Paigin for help.

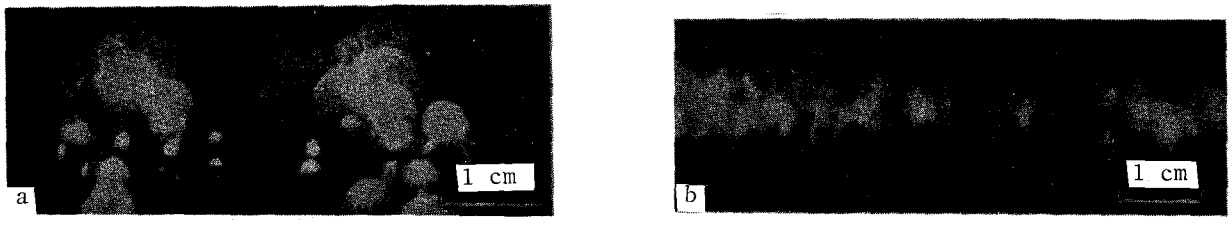

Fig. 3. Photograph of glow of near-cathode plasma: a) The cathode flares which are closer and farther from the focal plane seem to be diffused, owing to the small depth of focus of the lens. The focal plane is at the center of the photograph. b) Structure of electron current at the anode.

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PHASE TRANSITIONS IN DILUTE FERRIMAGNETS AND THE PROBLEM OF LIQUID INFILTRATION

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Submitted 6 June 1973
ZhETF Pis. Red. 18, No. 2, 85 - 89 (20 July 1973)

In the simplest two-sublattice ferrimagnet, the spine of the atoms situated in two nonequivalent crystallographic positions are ordered antiparallel, and the spontaneous moment is due to an excess of atoms in one of the positions. There have been numerous investigations of dilute ferrimagnets in which some of the magnetic atoms in one sublattice was isomorphically replaced by nonmagnetic atoms. Whereas at low dilutions the behavior of such a ferrimagnet can be described well by the Neel theory, there is still no incontrovertible physical model for the region of large dilutions [1 - 4]. We have therefore performed a neutron-diffraction study of two systems of dilute ferrimagnets:

$$\text{I. } \{Y_{3-x}Ca_x\}[Fe_{2-x}Zr_x](Fe_3)O_{12} \qquad (0 \leqslant x \leqslant 2);$$

$$\text{II. } \{Y_{3-y}Ca_y\}[Fe_2](Fe_{3-y}Si_y)O_{12} \qquad (0 \leqslant y \leqslant 3)$$

which are based on yttrium iron garnet (YIG). (The curly, square, and round braces denote, as usual, the dodecahedral, octahedral, and tetrahedral sites.) The magnetic properties of these systems were investigated in detail by Geller et al. [5] The purpose of our work was to obtain information on the character of the transition from the long-range ferrimagnetic order [6] in YIG (x, y = 0) to the long-range antiferromagnetic order [7, 6] in garnets containing Fe^{3+} ions in only one sublattice (x = 2; y = 3).

The neutron-diffraction measurements were made at 4.2°K in the absence of an external field. The presence of any particular long-range magnetic order could be assessed from the appearance of the corresponding magnetic reflections on the neutron diffraction patterns. All the Magnetic reflections of YIG coincide with the nuclear ones. The contribution made to the reflections 211, 220, and 422 by the long-range ferrimagnetic order is proportional to m_d^2, $(2m_a - m_d)^2$, and $(2m_a + m_d)^2$, respectively, where m_a and m_d are the magnetizations of the octahedral and tetrahedral sublattices, respectively. The neutron diffraction pattern of the garnet with Fe^{3+} ions only in the tetrahedral sublattice contains magnetic reflections with one even and two odd indices. Some of these reflections (110, 310,...) do not coincide with the nuclear ones. The magnetic order in the garnet having Fe^{3+} ions in the octahedral sublattice only leads to the appearance of a number of additional reflections (111, 311,...) with all odd indices.

It is seen from Figs. 1 and 2, which show the concentration dependences of the intensities of some of the magnetic reflections, that the long-range ferrimagnetic order vanishes from both systems long before complete dilution takes place. The critical concentrations of the magnetic atoms amount to 0.40 ± 0.02 for the system I (p = 1 - x/2) and 0.25 ± 0.02 for the system II (p = 1 - y/3). Long-range antiferromagnetic order is established in system I at $0.2 > p > 0.1$ and in system II at $0.25 > p > 0.17$. In system I there exists a region of concentrations $0.4 > p \geq 0.2$ where there is no long-range magnetic order at all.

At realistic ratios of the exchange parameters ($|J_{aa}|$, $|J_{dd}| \ll |J_{ad}|$; J_{aa}, J_{dd}, $J_{ad} < 0$), which characterize the intrasublattice (J_{aa}, J_{dd}) and intersublattice (J_{ad}) interactions, the observed changes of the magnetic order can be explained in the following manner: The magnetic atom placed in an unfilled sublattice of an-iferromagnetic garnet will orient the spins of all its neighbors parallel to one another, i.e., it will upset the antiferromagnetic order. The

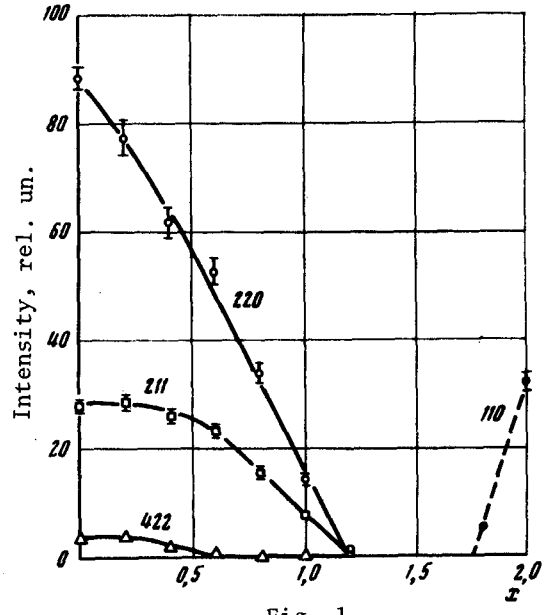

Fig. 1

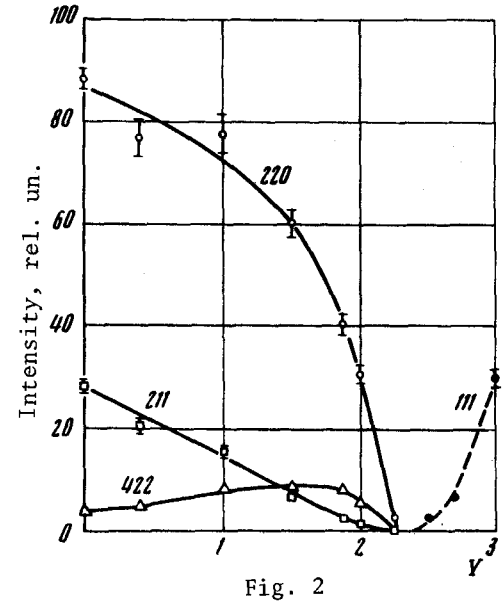

Fig. 2

Fig. 1. Intensities of magnetic reflections 211, 220, 422, and 110 vs the Zr^{4+} content in the octahedral sites (system I).

Fig. 2. Intensities of magnetic reflections 211, 220, 422, 11 vs the Si^{4+} content in the tetrahedral sites (system II).

long-range antiferromagnetic order is fully destroyed when the concentration of the magnetic atoms in the unfilled sublattice is of the order of $1/z$, where z is the coordination number. The spins of two, three, etc. neighboring atoms in the unfilled sublattice turn out to be coupled by the strong intersublattice interaction J_{ad} and form configurations close to ferrimagnetic. The average dimension of such ferrimagnetic clusters will increase as the sublattice becomes filled. Obviously, at such an arbitrarily low temperature, the necessary condition for the onset of long-range ferrimagnetic order is the formation of a continuous network of atoms that penetrates through the entire crystals. These atoms are coupled by the interaction J_{ad} and form a cluster of infinite size.

Mathematical statistics deals with two different problems concerning the size distributions of the clusters; these problems were formulated by Hammersley as the problem of penetration of liquid through a periodic lattice in which the sites (bonds) that transmit the liquid are disposed in random fashion. In these problems one calculates the critical probability of the transmitting sites (bonds), which then reached enables a liquid fed to one site to penetrate through the entire lattice. Domb and Sykes [10] called attention to the fact that the problem of penetration of a liquid through a lattice with randomly disposed sites is the mathematical analog of a dilute ferromagnet. It is easy to note that the problem of penetration of a liquid through a lattice with randomly distributed bonds is the analog of a dilute two-sublattice ferrimagnet in which the magnetic atoms from the dilute sublattice can be regarded as bonds for the non-diluted sublattice. The critical probability of the bonds corresponds to that concentration the nagmetic atoms in the dilute sublattice must reach to give rise to long-range ferrimagnetic order.

The critical probabilities of penetration were calculated for certain lattices by the Monte Carlo method in [1]. It turns out here that different lattices with identical coordination numbers have the same critical probability. In particular, at $z = 4$, the critical probability of the bonds amounts to 0.388 ± 0.010 in the quartz lattice and 0.390 ± 0.011 in the diamond lattice. These values coincide within the limits of error with the critical concentration of the magnetic atoms in the octahedral sublattice of the garnet, which are bonds for the tetrahedral sublattize ($z = 4$). The critical probability of the bonds 0.254 ± 0.013 in the primitive cubic lattice ($z = 6$) and the critical concentration of the magnetic atoms in the tetrahedral sublattice of the garnet, which form the bonds for the octahedral sublattice ($z = 6$) are in equally good agreement.

The observed phase transitions explain the differences between the magnetic behaviors of systems at small and large dilutions [5]. A long-range ferromagnetic order and a macroscopic spontaneous moment exist when the dilution is less than critical, whereas at dilutions larger than critical the magnetization is the result of the alignment of the individual ferrimagnetic clusters in the external field. It should be noted that this important circumstance was not taken into account in any of the papers [1 - 4].

In conclusion, we wish to thank G. M. Drabkin, I. Ya. Korenblit, and G. A. Smolenskii for a discussion of the results.

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