plemented to one degree or another in specific investigations. But their combined use promises a significant advance in the quite complex but important problem of creating new collective accelerators with energies of 1 – 10 GeV and up to 10^{15} particles per pulse, plans for which are now being elaborated[9]. Nor can we exclude the possibility of transition to accelerating-pulse repetition frequencies of 1 to 10 GHz. Even in the forseeable future, therefore, collective linear accelerators will become a necessary research tool in the nuclear physics of low and medium energies. Research should be continued to establish the feasibility of such accelarators in high-energy physics.

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G. M. Drabkin, G. P. Gordeev, E. I. Zabidarov, Ya. A. Kasman, A. I. Okorokov, and V. A. Trunov. Investigation of Magnetic Ordering and Phase Transitions in Magnets by a Polarized-Neutron Method. The present paper is devoted to magnetic ordering near the phase-transition point in nickel[11], yttrium iron garnet[2], MnF_2, and Pd – Fe alloys[3], and is a result of research done over the last five years on a VVRM [Modernized Water-Moderated Water-Cooled Reactor] using beams of polarized neutrons. The polarized beams are produced either by total reflection from a magnetized ferromagnetic mirror or by Bragg reflection from a magnetized Co – Fe crystal. The experiments employed vector analysis of polarization and spectral polarization analysis using three pyrolytic-graphite crystals and consisting of simultaneous measurement of the depolarization of three monochromatic lines and a beam with a broad spectrum. The magnetization of the sample was measured from the rotation of the polarization vector (Fig. 1). The critical magnetic fluctuation and domain parameters were determined from the depolarization. The periodic magnetic structure was studied by the spatial spin resonance method. The small-angle magnetic scattering of neutrons was investigated simultaneously with the polarization analysis.

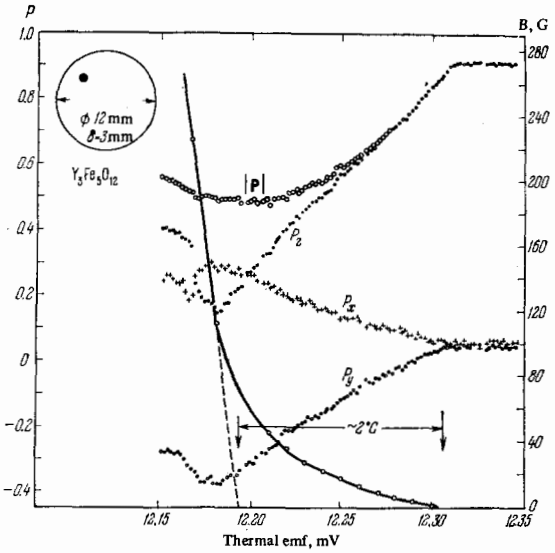

FIG. 1. Temperature dependence of the projections $P_{x,y,z}$ and the modulus |P| of the polarization of a neutron beam with a cross section of 1 mm² passed through a single crystal of iron-yttrium ferrite garnet near the Curie point. The solid curve is the temperature curve of induction in the specimen as reconstructed from these data. The heavy black dot in the circle indicates the point at which the beam passed through the circular specimen (diameter 12 mm and thickness 3 mm).

The spontaneous magnetization near T_C in Ni, determined from the depolarization of neutrons of various wavelengths, varies with temperature as $\tau^{1/2}$, where $\tau = (T_C - T)/T_C$, i.e., the critical exponent $\beta = 0.5$ in the relation $M \sim \tau^{\beta}$. Here the experiments indicate that, along with the small-scale inhomogeneity associated with the critical magnetic fluctuations and with the transition to the domain state, a large-scale inhomogeneity due to dipole interaction is observed in the transitional range.

The temperature superposition of the various phenomena complicates analysis of the experimental results and forces us to modify the experiments or to use narrow neutron beams for local study of the samples, or to conduct simultaneous investigations of the same sample by various methods. Such combined studies were made on samples of $Y_3Fe_5O_{12}$ by neutron, radio-frequency, and magnetic methods. Comparison of these data made possible more reliable establishment of T_C and more accurate determination of the critical transition exponents, which were found to depend on temperature. Thus, anomalously high values were found for the exponent β, which reaches 0.75 in the immediate proximity of T_C.

It was found possible to follow the dynamics of the observed phenomena as functions of the absolute value of the ordering parameter in a study of Pd – Fe alloys with variable concentrations of the magnetically active Fe atoms. Figure 2 presents experimental depolarization curves of neutrons passed through Pd – Fe alloys with iron concentrations from 0.5 to 8 at.%. Analysis of these data together with data on small-angle scatter-

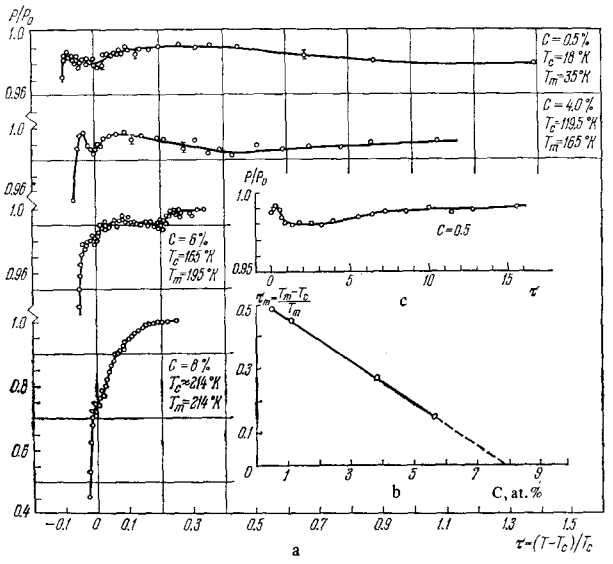

FIG. 2. Temperature dependence of the polarization of a neutron beam passed through a Pd-Fe sample with Fe concentrations from 0.5 at.% (a, c) to 8 at.% (a), and the shift of the high-temperature depolarization anomaly τ_m to $\tau = 0$ (b).

ing and polarization of the scattered neutrons permitted the conclusion that there exist three temperature ranges in which substantially different phenomena unfold.

Ferromagnetic domains or "quasidomain formations" predominate at the low-temperature end, in the range of the sharp drop in polarization. This range is characterized by a depolarization hysteresis that decreases with increasing average magnetization of the alloy. Considerable magnetostriction was observed in the same range. The second range (with a depolarization anomaly at $\tau \approx 0$) is characterized by the development of critical fluctuations. The third range (broad minimum of P at positive τ) has not yet been definitely interpreted, but may be related either to the dimensions of Pd-matrix polarization clouds due to polarization by the Fe atoms or to some sort of spin excitation. As the iron concentration increases, all the ranges are compressed in temperature toward $\tau = 0$, and they practically merge at 8 at.% Fe. Figure 2b shows the trend of this displacement for region III.

The existence of the previously predicted weak ferromagnetism was observed experimentally on measurement of the depolarization of neutrons by single-crystal and polycrystalline MnF_2 specimens.

The results are a strong stimulus to more thorough further investigation—both experimental and theoretical—of the phase-transition problem.

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O. I. Sumbaev, V. A. Shaburov, I. M. Band, A. E. Sovestnov, E. V. Petrovich, Yu. P. Smirnov, and M. B. Trzhaskovskaya. Investigation of the Electronic Mechanism of Isomorphic Phase Transitions Using the "Chemical" Shifts of X-Ray Lines. Study of the shifts of the fundamental x-ray lines ($K_{\alpha 1,\ 2}$, $K_{\beta 1,\ 3}$, $K_{\beta 2,\ 4}$) that occur on changes in the valence shells of an atom participating in a chemical bond has revealed (see, for example,[1]) a strong dependence of the nature of the shifts on the "species" (s, p, d, or f) of the valence electron. Standard shift vs. line type dependences are represented in Fig. 1. They remain approximately constant (characteristic) in a broad range of Z, can be reproduced satisfactorily in theoretical calculations (Hartree-Fock and Hartree-Fock-Slater models), and can act as a kind of "facsimile" of valence electrons, making it possible in many cases to establish with certainty the quantum numbers of the electrons participating in formation of the chemical bond in a given specific compound. The relation for 4f electrons in rare-earth elements is particularly revealing and different from the others (see the V-shaped curve in Fig. 1).

The object of the present paper is to outline briefly the results of studies in which this method was first used to investigate reversible electron realignments that occur on phase transitions in crystals. Specifically, we shall be concerned with the so-called first-order isomorphic phase transitions in metallic cerium and SmS. The establishment, back in the 1940's, of the experimental fact that the crystal-lattice symmetry of metallic cerium remains unchanged on the phase transition (hence the term isomorphic) initiated by cooling or application of pressure enabled Pauling and Zachariasen (1950) to advance the hypothesis that the events are unfolding at the atomic level in this case and involve partial transition of one of the localized 4f electrons into the conduction band.

If this is indeed the case, such phase transitions should be accompanied by a strong reversible temperature or pressure dependence of the x-ray line energies (primarily (see Fig. 1) that of the $K_{\beta 1,\ 3}$ line). Figure 2 shows the relationship that we observed for the $K_{\beta 1}$ energy of samarium in SmS as a function of pressure. It is a typical hysteresis curve that agrees with the one previously known, for example, for the magnetic susceptibility (dashed line in Fig. 2).

Figure 3 shows shift vs. line-type relations for SmS and cerium (specimens before and after the phase transition are compared). We observe the V-shaped "facsimiles" that are characteristic for 4f electrons. Comparison of these facsimiles with the analogous ex-

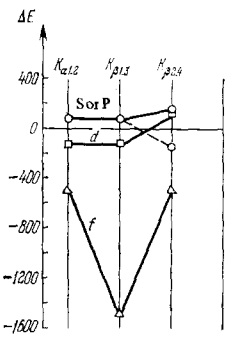

FIG. 1. Standard shift (in meV) vs. line ($K_{\alpha 1}$, $K_{\beta 1}$, $K_{\beta 2,4}$) relations observed on removal (incorporation into an ionic chemical bond) of one s (p), d, or f electron and serving as "facsimiles" of valence electrons in the range $30 \lesssim 75$.