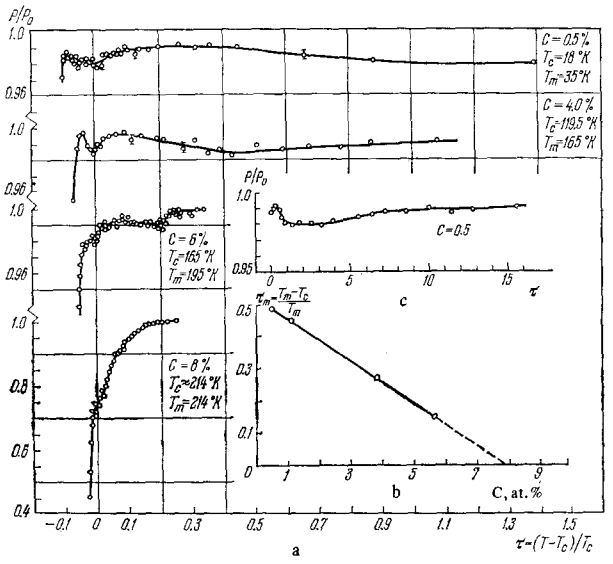

FIG. 2. Temperature dependence of the polarization of a neutron beam passed through a Pd-Fe sample with Fe concentrations from 0.5 at.% (a, c) to 8 at.% (a), and the shift of the high-temperature depolarization anomaly τ_m to $\tau = 0$ (b).

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.

[1]G. M. Drabkin, A. I. Okorokov, V. I. Volkov, and A. F. Shchebetov, ZhETF Pis. Red. 13, 3 (1971) [JETP Lett. 13, 1 (1971)].

[2]A. I. Okorokov and Ya. A. Kasman, Fiz. Tverd. Tela 14, 3065 (1972) [Sov. Phys.-Solid State 14, 2622 (1973)].

[3]G. P. Gordeev, G. M. Drabkin, I. M. Lazebnik, and L. A. Aksel'rod, Tezisy dokladov na Mezhdunarodnoĭ konferentsii po magnetizmu (Abstracts of Papers at International Conference on Magnetism), Nauka, Moscow, 1973.

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-

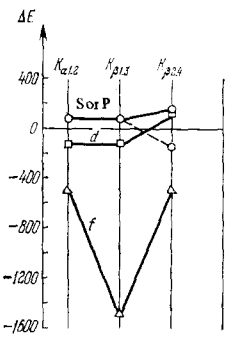

FIG. 1. Standard shift (in meV) vs. line ($K_{\alpha 1}$, $K_{\beta 1}$, $K_{\beta 2,4}$) relations observed on removal (incorporation into an ionic chemical bond) of one s (p), d, or f electron and serving as "facsimiles" of valence electrons in the range $30 \lesssim 75$.

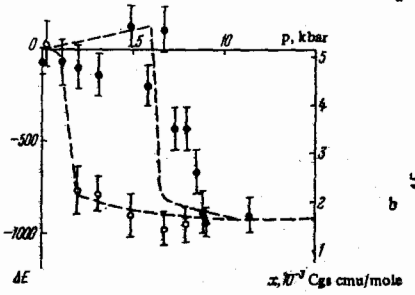

FIG. 2

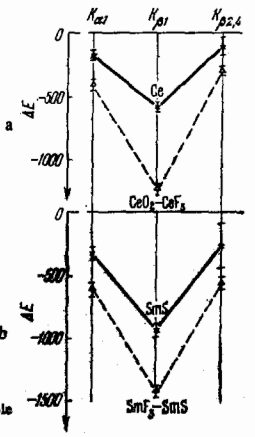

FIG. 3

FIG. 2. Shift (in meV) of K_{β_1} line of samarium in SmS as a function of pressure. The analogous relation for the magnetic susceptibility χ is indicated by the dashed curve.

FIG. 3. Shift (in meV) vs. line type relations for cerium (a) and SmS (b) (samples are compared before and after the phase transition). The analogous experimental relationships for the chemical compounds are indicated by the dashed lines.

perimental relations for the chemical compounds $C^{III} - Ce^{IV}$ and $Sm^{II} - Sm^{III}$ (the electron structure within each pair is known in this case and is distinguished by a single 4f electron) also makes it possible to determine the numbers of 4f electrons participating in the transition in cerium and SmS as 0.5 and 0.6 electron/atom, respectively.

The basic results were published in [2,3].

[1]E. V. Petrovich, Yu. P. Smirnov, V. Z. Zykov, A. I. Grushko, O. I. Sumbaev, I. M. Band, and M. B. Trzhaskovskaya, Zh. Eksp. Teor. Fiz. 61, 1756 (1971) [Sov. Phys.-JETP 34, 935 (1972)].

[2]E. A. Shaburov, I. M. Band, A. I. Grushko, T. B. Mezentsova, E. V. Petrovich, A. E. Sovestnov, Yu. P. Smirnov, O. I. Sumbaev, M. B. Trzhaskovskaya, and I. A. Markova, Zh. Eksp. Teor. Fiz. 65, 1157 (1973) [Sov. Phys.-JETP 38, 573 (1974)].

[3]V. A. Shaburov, A. E. Sovestnov, and O. I. Sumbaev, ZhETF Pis. Red. 18, 425 (1973) [JETP Lett. 18, 249 (1973)].

G. M. Drabkin, V. A. Noskin, É. G. Tarovik, A. Z. Yagud, M. M. Agamalyan, and N. P. Zhuchenko. Investigation of Diffusive Mass Transport of the Isotope He^3 in Liquid He I with the Aid of Thermal Neutrons. The temperature dependence of the mass diffusion coefficient D_m was investigated in a liquid isotope mixture of He I and He^3 with the aid of thermal neutrons. The basic idea of the method was to use the large difference between the neutron absorption cross sections of the He^4 and He^3 atoms. The studies were made in the temperature range from $T_\lambda = 2.17°K$ to $T \approx 3°K$ for various concentrations of He^3 ($c \approx 1\%$ and 2%). To check for possible hydrodynamic effects on the measurement of D_m in specific diffusion-cell geometries, the experiments were performed with the latter filled in various ways, namely:

1) diffusion cell in the form of a 2-mm capillary 2 cm in length;

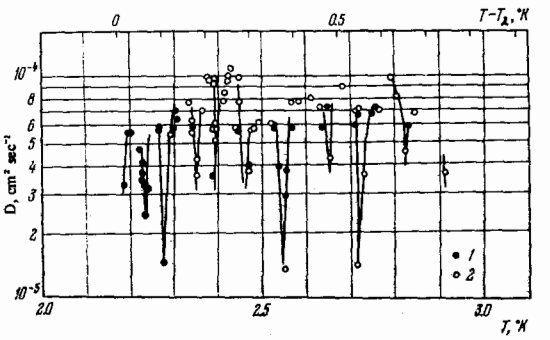

FIG. 1. Temperature dependence of mass diffusion coefficient. 1) Diffusion into a capillary filled with a porous packing having a characteristic pore dimension of 100 μm; 2) diffusion into a 2-mm capillary.

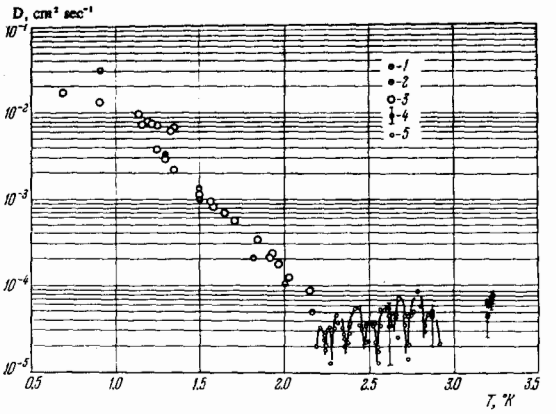

FIG. 2. Comparison of our results with those of other authors. 1) According to [1]; 2) [2]; 3) [3]; 4) [4]; 5) our results.

2) 2-mm capillary filled with a 41 200-μm capillary;

3) 2-mm capillary filled with a porous packing consisting of 100-μm stainless-steel balls sintered on a ceramic;

4) 2-mm capillary filled with porous teflon with a characteristic pore dimension ≈ 20 μm.

Diffusive mass transport was studied at each given temperature through the time variation of the intensity of a neutron beam passing through a diffusion cell filled with He^3 atoms. A further inference can be drawn as to the diffusive nature of mass transport on the basis of the observed time dependence, as illustrated in Fig.1.

That convective diffusion does not influence the process studied can be concluded from the nondependence of the corresponding diffusion coefficient D_m on the characteristic dimensions of the filler used in the diffusion cell.

The basic result of this study was to confirm the nonmonotonic temperature dependence of D_m in the temperature range investigated. Figure 2 presents the data of the present study in a comparison with the results of other authors.

The results have also been published in the following papers: G. M. Drabkin, V. A. Noskin, V. A. Trunov, A. F. Shchebetov, and A. Z. Yagud, Zh. Tekh. Fiz. 42, 180 (1972) [Sov. Phys.-Tekh. Phys. 17, 142 (1972); G. M. Drabkin, V. A. Noskin, and A. Z. Yagud, ZhETF Pis. Red. 15, 504 (1972) [JETP Lett. 15, 357 (1972)]; G. M. Drabkin, G. G. Tarovik, V. A. Noskin, and A. Z. Yagood, Phys. Lett. A43, 83 (1973).