EFFECT OF PRESSURE ON THE ANTIFERROMAGNETIC TRANSITION TEMPERATURE OF CHROMIUM

F. F. VORONOV

Institute of High-pressure Physics, Academy of Sciences, U.S.S.R.

Submitted to JETP editor July 29, 1964

J. Exptl. Theoret. Phys. (U.S.S.R.) **47**, 1999-2001 (November, 1964)

THE temperature and pressure dependences of the velocities of propagation of elastic waves have pronounced anomalies, associated with changes in the physical properties, in the region of second-order phase transitions. The anomalies accompanying the transition from the antiferromagnetic to the paramagnetic state may be explained by a change in the contribution of the exchange interaction energy to the crystal lattice energy when the magnetic structure changes at the Néel point.[1] Thus it becomes possible, by following the displacement of the region of anomalies in the ultrasound velocity, to determine the pressure dependence of the Néel temperature of chromium.

Changes in the travel times of longitudinal 5 Mc ultrasonic waves with pressure at various temperatures were investigated by a pulse method.[2] Measurements were carried out on a cylindrical sample of polycrystalline chromium, 22 mm in diameter and 50 mm long, turned from a casting of pure chromium, reduced by the addition of a small amount of cerium and having the following composition: Cr ≈ 99.9%, Ce ≈ 0.1%, N_2 ≈ 0.02%, O_2 ≈ 0.001%, Mg, Pb, Ni, Al, Ti, Cu ≈ 0.001%.

The results of measurements are shown in Fig. 1. The pressure dependence of the travel time t of the ultrasonic waves has a clear maximum, which is displaced toward high pressures on cooling. This is accompanied by a reduction in the amplitude of the maximum. In all cases, there is a considerable change in the slope with respect to the pressure axis after passing through the maximum.

The pressures at which the dependences t = f(P) had maxima were taken to be the magnetic transition points of chromium and were plotted on a P–T diagram (Fig. 2). To check the correctness of this determination of the Néel point, the travel times of longitudinal ultrasonic waves were measured as a function of temperature at two constant pressures: 1 and 1950 kg/cm^2. The dependences obtained over a narrow range of temperatures next

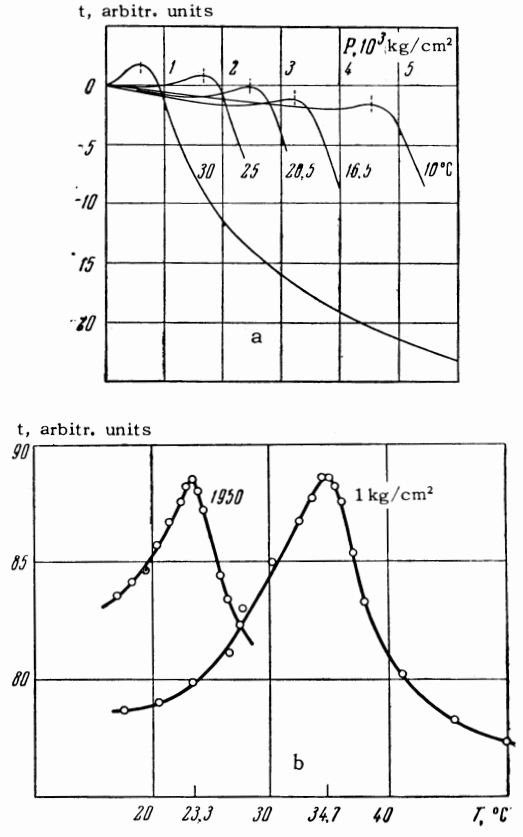


FIG. 1. Pressure dependence of the times of longitudinal ultrasonic waves in chromium at constant temperatures (a), and the temperature dependence of these times at constant pressures (b).

to the magnetic transition points (Fig. 1b) were in good agreement with the temperature dependence of the elastic properties of chromium at atmospheric pressure obtained by other authors near the magnetic transition point.[3] These dependences made it possible to identify clearly the Néel temperature in our sample of chromium: at atmospheric pressure, it was 34.8°C, and at 1950 kg/cm^2, 23.3°C. These points fit well the obtained pressure dependence of the Néel temperature (Fig. 2).

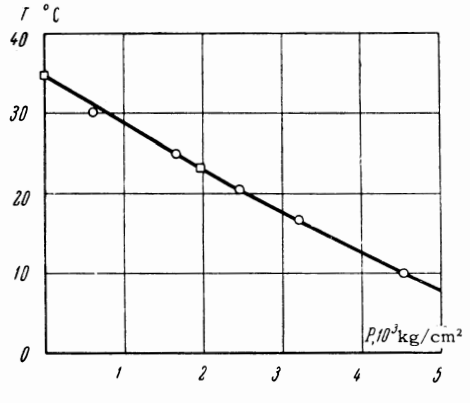


FIG. 2. Pressure dependence of the Néel temperature of chromium.

The results of measurements indicate that the Néel temperature of chromium decreases with increase in pressure at the rate of 5.6°C per 1000 atm. Consequently, the exchange integral, which is proportional to the Néel temperature, also decreases with pressure. Hence, we may conclude that a reduction in the distance between atoms in chromium leads to a reduction in the absolute magnitude of the exchange interaction.

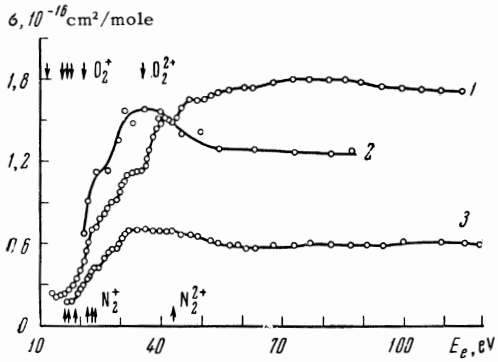
The author is very grateful to E. N. Yakovlev for discussing the results of the work and to A. A. Zmeev for his help in carrying out experiments.

[1] G. E. Bacon, Acta Cryst. **14**, 8, 823 (1961).

[2] Voronov, Vereshchagin, and Goncharova, DAN SSSR **135**, 1104 (1960), Soviet Phys. Doklady **5**, 1280 (1961).

[3] R. Street, Phys. Rev. Letters **10**, 210 (1963).

Translated by A. Tybulewicz
287



Dissociation cross sections for O_2^+ and N_2^+ ions in collision with molecules of air, as a function of electron energy: curve 1 – reaction (1); curve 2 – reaction (2); curve 3 – reaction (3). The cross section for reaction (2) has been multiplied by a factor of 100. The statistical error in the values of the cross sections for reactions (1) and (3) is in the vicinity of 5–10% over the whole electron energy region except near threshold; in the threshold region the error is of the order of 30%. The corresponding values for reaction (2) are roughly 15% and 30%. The arrows denote the positions of the known electronic states of O_2^+ ions ($^2\Pi_g$, $^4\Pi_u$, $^2\Pi_u$, $^4\Sigma_g^-$, Σ)[6] and N_2^+ ions ($X^2\Sigma_g^+$, $A^2\Pi_u$, $B^2\Sigma_u^+$, $^4\Sigma_u^+$, $^4\Delta_u$, $C^2\Sigma_u^+$)[7] and the potentials for production of doubly charged O_2^{2+} and N_2^{2+} ions.[8]

FORMATION OF EXCITED O_2^+ AND N_2^+ IONS IN IONIZATION OF AIR BY ELECTRONS

S. E. KUPRIYANOV

L. Ya. Karpov Physico-technical Institute

Submitted to JETP editor July 31, 1964

J. Exptl. Theoret. Phys. (U.S.S.R.) **47**, 2001-2003 (November, 1964)

IN connection with the physics of the upper atmosphere it is of interest to study the energy state of O_2^+ and N_2^+ ions formed in collisions of electrons with O_2 and N_2 molecules.

To obtain information on the energy state of the ions we utilized the dissociation, as the result of single collisions with molecules, of O_2^+ and N_2^+ ions accelerated to 2.8 keV, since the probabilities of these dissociation processes depend on the energy of the electrons.[1,2] The experiments of Tikhomirov et al with nitrogen[1] and those of McGowan and Kerwin with oxygen[2] were done with equipment not designed for obtaining values of the dissociation cross section of the ions. The dissociation cross section of N_2^+ ions has been determined by Fedorenko[3] in a double mass spectrometer in the ion energy region 5–25 keV. However, the effect of the energy state of the ions on the dissociation cross section was not studied in this case. The maximum electron energy used by McGowan and Kerwin[2] was below the potential for production of doubly charged O_2^{2+} ions, but highly excited O_2^+ ions could be formed in the energy region used. Highly excited atomic ions have been studied by Kupriyanov,[4] but there are no data for molecular ions.

In the present communication we report the main results of a study, made with a double mass spectrometer,[5] of the effect of electron energy on the dissociation cross section for the following processes [1]:

$$O_2^+ + M \rightarrow O^+ + [O + M]^*, \quad (1)$$

$$O_2^+ + M \rightarrow O^- + [O + M], \quad (2)$$

$$N_2^+ + M \rightarrow N^+ + [N + M]. \quad (3)$$

From the curves given in the figure it can be seen that an increase in electron energy results in a sharp rise of the cross sections for reactions (1)–(3). This rise occurs in the electron energy region where the thresholds occur for the excited electronic states of O_2^+ and N_2^+ ions. Some of these states are known to be metastable. There is structure also at higher electron energies, which may be due to the appearance of ions in unknown electronic states with thresholds of about 23–25, 28–29, and 31–32 eV for O_2^+ ions and ~ 25 and 29 eV for N_2^+ ions, as well as to a change in the content of ions of known states in the beams. We were unable to obtain more distinct breaks in the curves,