and below 9°K (Fig. 2). According to extrapolation estimates, the saturation in the remaining part of the temperature range can occur in magnetic fields above 100 kOe.

The absolute minimum of the specific thermal conductivity in fields above 30 kOe, in the temperature region 10 - 12°K, can be regarded as the lattice component λ_{latt} of the thermal conductivity of aluminum at these temperatures.

The temperature dependence of the lattice part of the thermal conductivity in the region of its maximum can be approximately described by the expression $\lambda_{latt} = AT^3 exp(-BT)$, which can be reduced for our data to the expression $\lambda_{latt} = 0.38299T^3 \, exp(-0.26087T)$.

The dashed curve in Fig. 1 shows the variation of the lattice part of the thermal conductivity of aluminum in the region of its maximum, as calculated with the foregoing expression. The features that can be noted on the curves (Fig. 1) correlate with the position of the Fermi surface in the first Brillouin zone, and will be discussed elsewhere. The relative change of the thermal conductivity in the temperature interval where the phonon component has a maximum and in a magnetic field H = 30 kOe is of the order of $(\Delta\lambda/\lambda_{latt}) \times 100 = 75°$.

Our results indicate that a transverse magnetic field exerts a strong influence on the thermal conductivity of high-purity aluminum.

[1] A.A. Abrikosov, Vvedenie v teoriyu normal'nykh metallov (Introduction to the Theory of Normal Metals), Nauka, 1972.
[2] J.M. Ziman, Electrons and Phonons, Oxford, 1960.

LUMINESCENCE OF SOLID NEON

I.Ya. Fugol', E.V. Savchenko, and A.G. Belov
Physico-technical Institute of Low Temperatures, Ukrainian Academy of Sciences

Experimental studies of the emission spectra of the simplest condensed systems, solidified inert gases, were initiated only recently, even though these crystals have been cited in the theory of free electrons as early as in the Thirties [1]. The experimental difficulties were aggravated by the need for using low temperatures and the technique of vacuum ultraviolet spectroscopy. The lowest excited state of solidified gases is separated from the ground level by a gap of 8 - 17 eV which is larger the lighter the gas. More studies were therefore made of the heavy gases xenon [2, 3], krypton [3], and argon [3]. The spectra of the neon and helium crystals fall in the wavelength region below 800 Å, where there are no optically transparent materials. It is presently impossible to carry out spectral measurements of the luminescence of solid helium, since it crystallizes at pressures above 25 atm. The radiation of crystalline neon was observed only once and quite recently [4]. We have obtained the spectrum of solid neon and observed a new phenomenon, the fine structure (splitting) of the atomic-luminescence band. We have also studied the luminescence of xenon, krypton, and argon crystals.

A special sensitive procedure was developed for the excitation and registration of the spectra of solidified gases. The luminescence was excited with slow electrons of average energy ∿500 eV, which produced no radiation damage in the crystal lattice. The sensitivity of the system used to register the radiation was 10^{-17} W. The investigations were carried out with the aid of the VMR-2 instrument in the range from 500 to 3000 Å. The spectral resolution was
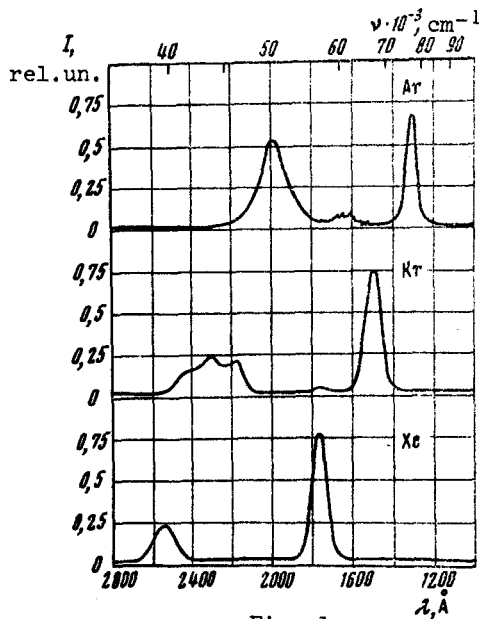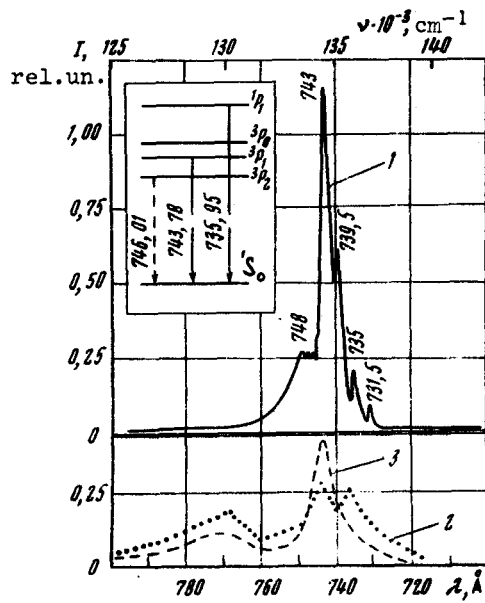
Fig. 1

Fig. 2

Fig. 1. Luminescence spectrum of argon, krypton, and xenon crystals at 6°K.

Fig. 2. Emission spectra of crystalline neon at 8°K (curve 1). The lower curves show for comparison the luminescence spectra of gaseous neon (curve 2) [7] and of solid neon (curve 3) [4]. The insert shows the levels of the lower x P-states of the neon atom.

0.3 Å and the working slit width 20 μ. The samples were grown by condensation on a cooled substrate in a cryostat. The experimental procedure and technique are described in greater detail in [5].

The luminescence of solid xenon, krypton, and argon is shown in Fig. 1. A characteristic feature of the spectra is the presence of broad maxima with half-width on the order of 100 Å, strongly shifted towards lower energies in comparison with the exciton-absorption spectra. A fine line structure is observed only for the 1600 Å band in the spectrum of solid argon. The origin of this band is not clear at present. The remaining emission maxima coincide in the main with those described in the literature [2, 3]. The broad bands and the red shift in the spectra of the solidified heavy gases are attributed to the occurrence of a deforming exciton, namely, capture of a free exciton or hole by the lattice with formation of luminescence centers of type R_2^* or R_2^+. Such a localized center in the crystal is analogous to an excited molecule or a diatomic molecular ion. Its presence leads to a strong deformation of the crystal. No atomic luminescence (free excitons) is observed in pure crystals of argon, krypton, or xenon. A theoretical estimate of the process of capture of a free exciton shows that the time of its localization in heavy inert gases is short, $\tau \approx 6 \times 10^{-12}$ sec [6].

The luminescence spectrum of crystalline neon is shown in Fig. 2. The entire radiation lies in the region of 740 Å. We have observed here a group of intense narrow lines at 743, 739.5, 735, and 731.5 Å, with half-width less than 0.5 Å and a maximum at 748 Å, the half-width of which is 8 Å. We observed no other bands in the spectrum. For comparison, Fig. 2 shows also the already-published data: the emission spectrum of gaseous neon [7] (curve 2) and the luminescence spectrum of solid neon as given in [4] (curve 3).

It is seen from our experimental data that the emission band of crystalline neon has a line structure, and the spectrum itself lies in the region of the resonance luminescence of the free neon atom. Special experiments were performed to show that the observed radiation belongs indeed to neon in the crystalline state. The spectra were measured at different condensation rates, at different points of the same crystal and in crystals of different thickness, and at different powers of the exciting electron beam. The spectra were registered immediately after condensation and after storing the samples in vacuum. In all cases, the line structure, the positions of the components in the spectra, and their relative intensities remained unchanged. This means that we have observed the proper luminescence of solid neon.

The structure of the luminescence spectrum is governed by several different factors. The two line pairs 743, 735, and 739.5, 731.5 Å are similar and have a spin-orbit splitting characteristic of the free atom ($\Delta\nu_{so} = 1430$ cm^{-1}). The first pair practically coincides with the spin-orbit doublet in the gas. The occurrence of two pairs of a spin-orbit doublet is connected, in our opinion, with the splitting of the $^3P_1$ and $^1P_1$ levels in the crystal. This splitting ($\Delta\nu_c = 640$ cm^{-1}) is the result of a lowering of the luminescence-center symmetry. When the neon atom is excited to a P state with elongated electron orbit, the degeneracy should be lifted as a result of the asymmetrical distortion of the crystal lattice. In order for each of the P terms to split into two, it suffices to lower the point symmetry of the luminescence center locally from octahedral to axial.

The broader maximum near 748 Å is apparently due to the $^3P_2 - {}^1S_0$ transition, which is forbidden in the free atom and has never been observed before in the spectrum of neon. This transition may become allowed in the crystal because of violation of the spherical symmetry. The width of this maximum may be connected with the presence of several unresolved components.

The proximity of the lines in the solid and gaseous phases is the consequence of the low polarizability of the neon atoms.

[1] Y. Frenkel, Phys. Rev. 37, 17, 1276 (1931).
[2] N.G. Basov, O.V. Bogdankevich, V.A. Danilychev, G.N. Kashnikov, et al., ZhETF Pis. Red. 7, 404 (1968) [JETP Lett. 7, 317 (1968)]; J. Luminescence 1, 834 (1970).
[3] J. Jortner, L. Meyer, S.A. Rice, and E.G. Wilson, J. Chem. Phys. 42, 4250 (1965).
[4] R.E. Packard, F. Reif, and C.H. Surko, Phys. Rev. Lett. 25, 1435 (1970).
[5] A.G. Belov, E.V. Savchenko, and I.Ya. Fugol', Fizika kondensirovannogo sostoyaniya (Physics of the Condensed State), Physico-tech. Inst. of Low Temperature, Ukr. Acad. Sci. (Khar'kov), No. 10, 229 (1970).
[6] M. Martin, J. Chem. Phys. 54, 3289 (1971).
[7] T.E. Stewart, G.S. Hurst, T.E. Bortner, J.E. Parks, F.W. Martin, and H. Weidner, JOSA 60, 1290 (1970).

SPECTRA OF PARTICLES AND ANTIPARTICLES IN THE CENTRAL REGION

L.E. Gendenshtein and A.B. Kaidalov
Physico-technical Institute, Ukrainian Academy of Sciences

Interest in the inclusive [1] reactions a + b → c + x has greatly increased of late. Various dynamic models, such as the multiperipheral model (MPM) [2] and the multireggeon model [3], and also an approach based on the use of the