ANOMALOUS ABSORPTION OF ULTRAVIOLET RADIATION IN QUARTZ UNDERGOING A PHASE TRANSITION

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Among the many peculiarities of crystalline quartz during its phase transition (573°C), the sharp temperature dependence of its refractive index, observed in the visible part of the spectrum [1], is worthy of interest.

It would be natural to assume that this rapid variation of the refractive index with temperature is connected with a singularity in the absorption spectrum of quartz at the same temperature. The long-wave boundary of the absorption spectrum of crystalline quartz lies, according to our data, in the region of the vacuum ultraviolet (near 1550 Å). The temperature dependence of the absorption coefficient of ultraviolet in quartz was investigated in this region of the spectrum only in general outline [4]. A jump in the temperature dependence of the ultraviolet absorption coefficient of quartz was observed in this investigation at the phase transition. However, as shown by Yakovlev et al. [1-3], the width of the temperature interval characteristic of the phase transition of quartz is only 0.1°C. This small temperature interval, which is decisive for the phase transition, was not investigated in the studies of the ultraviolet absorption coefficient of quartz. We deemed it necessary to study just this temperature region, monitoring the phase transition of quartz by an objective method independent of the course of our main experiment.

Our experiment was performed as follows. A quartz disc 0.4 mm thick, cut perpendicular to the optic axis of the crystal, was placed in the channel of a narrow tubular oven in vacuum, between a source of ultraviolet radiation (discharge tube) and a vacuum spectrograph. The gas-discharge spectrum was photographed through the central section of the quartz disc. The coefficient of radiation absorption in the quartz was determined by photometry of the image produced on a photographic plate by several spectral lines of the gas discharge. The density curve of the photographic plate was plotted by using exposures of different lengths. The use of this method of plotting the density curve was valid in view of the high stability of the employed gas-discharge light source.

The temperature of the investigated quartz disc was measured with a thermocouple. However, the occurrence of the phase transition in quartz was monitored by a special and very sensitive method, based on a phenomenon observed and studied by Shustin and Mikheeva [5,6]. Namely, if a quartz plate (cut perpendicular to the optic axis) placed between crossed Nicol prisms is observed in visible light, then this plate has, of course, an evenly darkened appearance far from the phase transition temperature. Near the transition temperature, however, a characteristic system of dark and light regions can be seen on the surface of the plate. This picture offers evidence of the temporary occurrence of local birefringence in the quartz undergoing the phase transition. Such a state can be maintained in the quartz for a long time by adequately stabilizing its temperature. We have used this phenomenon to monitor the phase-transition point, using an auxiliary polarization optical system and a mercury lamp as the source of visible light. Measurements of the temperature dependence of the ultraviolet abption coefficient α_t in the quartz were made for several spectral lines. The results of these measurements are shown in Fig. 1, where the abscissas are the experimental temperatures and

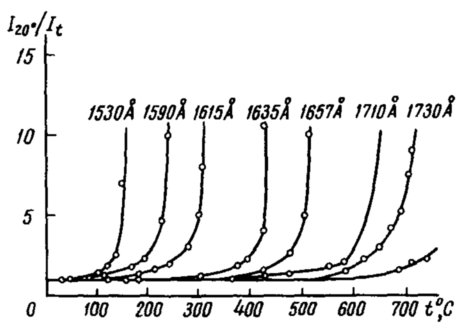

Fig. 1

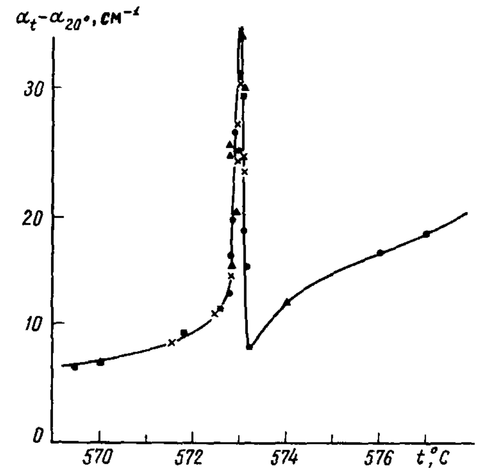

Fig. 2

the ordinates the values of the ratio of the intensity $I_{20°C}$ of the light transmitted by the quartz at room temperature to the intensity I_t transmitted by the quartz at t°C. The most interesting result was obtained near the phase-transition temperature (Fig. 2). In this case, as expected, a λ-like maximum was observed in the ultraviolet absorption of the quartz near the $\alpha \rightleftharpoons \beta$ phase transition. We show in Fig. 2 the observed temperature dependence of $\alpha_t - \alpha_{20°C}$ for the 1685 Å spectral line. Similar results are obtained also for many other spectral lines located near the long-wave boundary of ultraviolet absorption in crystalline quartz at the temperature of the $\alpha \rightleftharpoons \beta$ transition.

In conclusion, I am deeply grateful to I. A. Yakovlev for continuous interest and guidance. I also take the opportunity of sincerely thanking O. A. Shustin for help and valuable advice.

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