eliminates some of the difficulties of Treder's theory pointed out in [8, 9]. At the same time, in fact that the expressions obtained for the heliolorelativistic effects (15) and (21) as well as the predictions of the perihelion advance noted in [8, 9] do not agree with the observational data (see, for example, [11, 12]) indicates that this theory must be developed further by the introduction of a more general form of the single variational principle for the gravitational field and the nongravitating matter.

I thank Professor D. D. Ivanenko for a helpful discussion.

LITERATURE CITED


THE PHOTOCONDUCTIVE EFFECT IN
ZnS—Cu MONOCRYSTALS

M. P. Andronov, B. L. Dvinyaninov,
F. F. Gavrilov, and A. I. Kolodyazhnyi

UDC 539.2

The frequency dependence of the photodielectric effect, transition-process kinetics, and peculiarities of IR light action on Δtan δ are studied. It is shown that a photodielectric effect of the first type occurs not only in ZnS—Ag crystals but also in ZnS—Cu crystals.

The photodielectric effect (PDE) in compounds based on ZnS, CdS may be produced by localized electrons (type I PDE [1]) or by conduction electrons (type II PDE [2]). The contribution of one or the other type of PDE is determined by individual specimen peculiarities and measurement conditions [3, 4].

In the crystallophosphors ZnS—Ag type I and II PDE may be observed simultaneously [5, 6]. In crystallophosphors doped with Cu, the existence of a type I PDE is now under discussion [6-8]. The reason that a type I PDE has not been observed in ZnS—Cu crystals may be the dominant influence of conduction electrons in an inhomogeneous specimen. To verify this theory, the present study undertook a study of PDE in ZnS—Cu monocrystals.

The monocrystals were grown from a melt under pressure. According to chemical analysis data, the copper content comprised (0.7-2) · 10⁻⁴ wt.%. Copper was introduced into the melt in the form of the compounds Cu₂S, CuCl, and CuAl₃. Dislocation concentration was within the limits (30-100) · 10¹⁵/cm². PDE measurements were performed in the following manner: the specimen (diameter, 5-15 mm, thickness, 1.5-3 mm) was mounted between two capacitor plates and installed in a cooling device within a cryostat. The specimen was excited by UV light from a DRSh-250 mercury lamp from the side direction. Capacitance C and conductance G were measured by an E8-2 meter with external generator and indicator. Dielectric loss angle tangent was determined from C and G.

Fig. 1. A tan δ versus frequency for two specimens of ZnS—Cu monocrystals measured in present study, and for ZnS—Ag (5) from [6], at temperatures of 140 K (1), 200 K (3), 296 K (2, 4, 5). 1, 2, 3) Specimen No. 1; 4) specimen No. 2.

Fig. 2. Time dependence of A tan δ for various illumination and measurement conditions at frequencies of 20 kHz (1), 5 kHz (2), 0.2 kHz (3-5). Arrows indicate switchon and switchoff of UV and IR light.

In studying the spectral dependence of IR light action on PDE a DMR-4 monochromator was used with an incandescent filament lamp. In calculating spectral characteristics, monochromator dispersion and spectral characteristic of the incandescent lamp were considered. In studying A tan δ as a function of IR background illumination, semiconductor light-emitting diodes with λ = 910 nm, W = 10-20 mW, with controlled watt-ampere characteristics, were used. To increase efficiency the light-emitting diodes were mounted in the direct vicinity of the specimen. IR background illumination intensity was controlled by variation of injection current.

The frequency dependence of A tan δ for two ZnS monocrystals is shown in Fig. 1. Three maxima can be seen, each of which is dominant in a certain temperature region, 500 Hz, 10 kHz, and 20-50 kHz (curves 1, 2, 3, Fig. 1). Depending on temperature, excitation conditions, IR background illumination, and individual specimen peculiarities, the intensity ratios of these maxima vary, which leads to their displacement and even complete disappearance. In the opinion of Bergunas and Skobel'nitsa [6] these peculiarities indicate the connection of these maxima with type II photodielectric effect.

A more detailed analysis performed by the present authors shows that there may be another explanation of these facts, in particular, responsibility of type I PDE for the 20-50 kHz maximum. In some ZnS—Cu monocrystals the A tan δ maximum at 20-50 kHz appears even at room temperature (curve 4, Fig. 1). In cases where the 20-50 kHz maximum is not observed, the presence of type I PDE can be established by its other attributes. One of the most unique of these is the dependence of the PDE magnitude on excitation intensity [9]. Type I PDE varies monotonically with change in excitation intensity, while type II PDE passes through a maximum. The same process may be observed by switching on and off sufficiently high-intensity UV excitation [2], which was done in the present study (Fig. 2).

If the crystal is excited by a U-shaped UV light pulse, in practically all ZnS—Cu specimens studied at frequencies of 20 kHz and above, A tan δ changes monotonically in the transition-characteristic region (curve 1, Fig. 2). With measurement at lower frequency, A tan δ passes through a maximum at both switchon and switchoff of the UV excitation (curves 2 and 3, Fig. 2). The time needed to attain the maximum τm depends on measurement frequency, decreasing with increase of the latter. At an excitation intensity of 1 mW τm comprises tens of minutes in the 200-Hz region (curve 3, Fig. 2), and fractions of minutes or minutes in the range 2-10 kHz (curve 2, Fig. 2). IR light action in the damping stage accelerates the process. Thus, with IR switchon on the rising branch of the A tan δ curve an IR flare and extinction may be seen (curve 4, Fig. 2), with extinction only on the falling branch (curve 3, Fig. 2). Consequently, in ZnS—Cu crystals at frequencies of 20 kHz and above, there exists a type I PDE (curve 1, Fig. 2), which may not appear as a separate maximum.