omit the elastic-loss term and assume that ν_m, D, and τ^* are independent of ε (with $\varepsilon < \varepsilon^*$); when $\varepsilon < \varepsilon^*$ we have $1/\tau^* \equiv 0$. We assume that the electrons that have attained the energy I ionize the atoms instantaneously, i.e., $n(I) = 0$. We subject the flux along the energy axis $j(\varepsilon)$ to the multiplication condition $j(0) = 2j(I)$. In addition, n and j are continuous when $\varepsilon = \varepsilon^*$. Then the equation can be solved in elementary fashion and the stationarity condition $\partial n/\partial t = 0$ leads to a simple transcendental equation for the dimensionless threshold field $Z = Z(\xi, b)$, where $\xi = (\tau_d/\tau^*)^{1/2}$ and $b = (1/\varepsilon^*)^{1/2} \simeq 1.2$. The practically universal function $Z(\xi)$ increases monotonically ($Z(0) = 0.55$, $Z(3) = 0.75$, $Z(5) = 0.95$, $Z(10) = 1.56$) and approaches the asymptotic value $Z = 0.145\xi$ when $\xi > 10$. In our case $\xi = 9p_{atm}$.

The threshold intensity is equal to

$$\mathcal{J} = \frac{3}{2}\epsilon^* \frac{mc}{\pi e^2} \frac{D\nu_m}{\Lambda^2}\left(1 + \frac{\omega^2}{\nu_m^2}\right) Z^2(\xi) .$$

This formula yields $\mathcal{J} \simeq 200 - 250$ MW/cm^2 at $p \simeq 2 - 20$ atm, which is closer to the experimental values, although the minimum of $\mathcal{J}$ turns is displaced, being at $p \simeq 5$ atm in place of the experimental 15 atm. It is remarkable that this simple and compact formula describes well the experimental data [1] on microwave breakdown of xenon in the range of p from 10^{-2} to 10^2 mm Hg.

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EXPERIMENTAL INVESTIGATIONS OF AN ULTRAHIGH ENERGY PARTICLE DETECTOR USING TRANSITION X-RADIATION

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It was shown in [1] that the intensity of the transition radiation of high-energy particles is directed mainly forward and is concentrated in the x-ray band. If the radiation is registered in a definite frequency interval, then the radiation intensity has a strong dependence on the particle energy.

It was shown in [2] that if we register the radiation also in a definite angle interval $0 - \theta$, then the dependence on the particle energy becomes even stronger.

Indeed, it can be shown that if $\sigma/\omega^2 \ll (mc^2/E)^2$ and $\theta^2 \ll (mc^2/E)^2$, then the radiation intensity is

$$\frac{dW}{d\omega} \approx \frac{e^2}{2\pi c} \frac{\sigma_2}{\omega^4} \theta^4 (E/mc^2)^8,$$

where σ is the square of the plasma frequency.

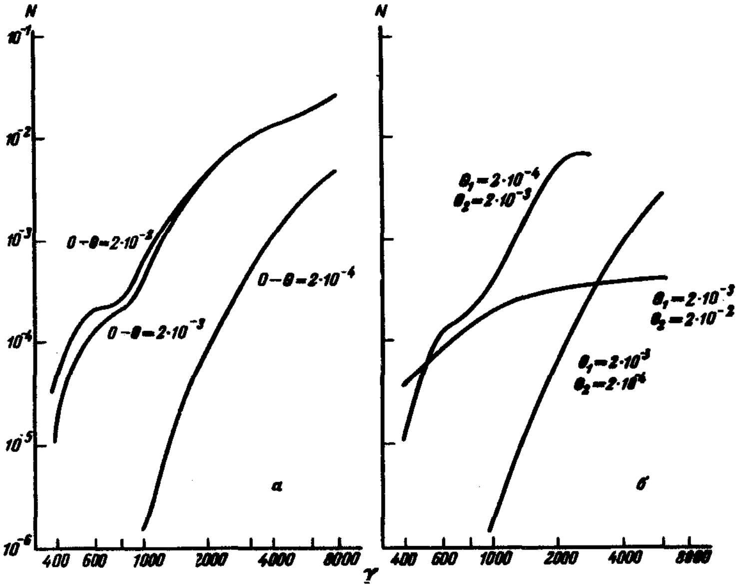

Fig. 1

By way of illustration, Fig. 1a shows plots of the number of photons of the transition radiation in the energy region $\hbar\omega = 10^2 - 100$ keV as a function of $\gamma = E/mc^2$ in different angle intervals between 0 and θ. (The curves were calculated for plates of polyethylene of thickness $a = 4 \times 10^{-3}$ cm, with $\hbar\sqrt{\sigma} = 19$ eV, using the formula for the transition radiation in a plate [3]). It is seen from the figure that in the region $(mc^2/E)^2 \ll \theta^2$ the dependence of the number of photons on γ has the form $\sim\gamma^8$, and that this dependence weakens gradually with increasing γ.

From the experimental point of view, the registration of the radiation in the angle interval 0 - θ is connected with the need for separating the particle from the radiation it produces by the methods employed in [4 - 7]. In the present investigation, the problem of separating the particle from the radiation was solved by using a γ-quantum detector of toriodal form, with the charged particles passing through its central aperture. It is obvious that in this case the part of the radiation passing together with the particle through the aperture is not registered. Figure 1b shows plots of the number of photons vs. γ in the angle interval $\theta \le \theta \le \theta_2$, where θ_1 and θ_2 are respectively the maximal and minimal angles subtended by the γ-quantum detector. It is seen from the figure that the optimal angle interval is $\theta_1 \ll 1/\gamma \lesssim \theta_2$.

The high-energy detector based on this principle was investigated with the aid of elecdrons of 0.4 - 4.0 GeV energy in the Erevan synchrotron. The electrons producing the radiation in a layered medium, pass through an aperture in a toriodal CsI(Tl) crystal scintillator of the γ spectrometer and are registered by a scintillation-counter telescope. The inside and outside diameters of the CsI(Tl) crystal were 0.8 and 7.6 cm, respectively. The frequency interval of the registered γ quanta was set by means of a differential amplitude discriminator. To decrease the background and the γ-quantum loss due to absorption, helium bags were used. The apparatus was adjusted with the aid of a laser. The angles θ_1 and θ_2 were set by the distance between the layered medium and the CsI(Tl) crystal. Since the electrons in the layered medium produce, besides the transition radiation, also bremsstrahlung, the latter was taken into account by performing the measurements also in equivalent continuous media.

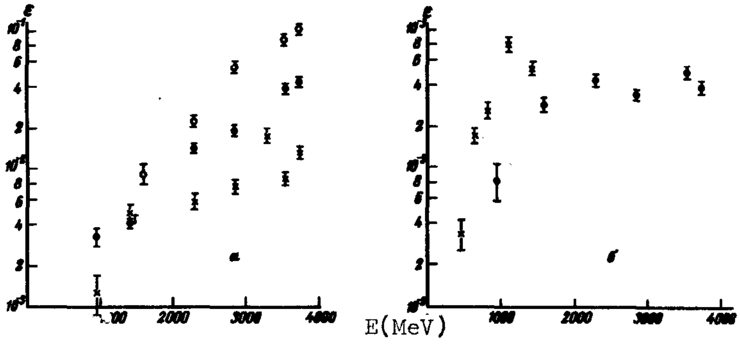

Fig. 2

Figure 2a shows the experimentally determined electron registration efficiencies ε as functions of their energy at different angle intervals $\theta_1 \le \theta \le \theta_2$. In these measurements, the layered medium consisted of $n = 380$ plates of polyethylene with thickness $a = 4 \times 10^{-3}$ cm, located at a distance $b = 0.5$ cm from one another. Similar dependences, shown in Fig. 2b, were obtained by using layered media with $a = 10^{-3}$ cm, $b = 0.5$ cm, $n = 380$, and $a = 10^{-3}$ cm, $b = 0.12$ cm, $n = 930$. (The symbols in Fig. 2a are: × - $\theta_1 = 7.3 \times 10^{-4}$, $\theta_2 = 6.7 \times 10^{-3}$; ● - $\theta_1 = 3.5 \times 10^{-4}$, $\theta_2 = 3.3 \times 10^{-3}$; o - $\theta_1 = 2.6 \times 10^{-4}$, $\theta_2 = 2.5 \times 10^{-3}$; in Fig. 2b: ● - $\theta_1 = 2.6 \times 10^{-4}$, $\theta_2 = 2.5 \times 10^{-3}$; $a = 4 \times 10^{-3}$ cm, $b = 5 \times 10^{-1}$ cm, $n = 380$; × - $\theta_1 = 2.6 \times 10^{-4}$, $\theta_2 = 2.5 \times 10^{-3}$, $a = 10^{-3}$ cm, $b = 1.25 \times 10^{-1}$ cm, $n = 930$).

In all cases, the radiation was registered in the energy region $\hbar\omega \gtrsim 15$ keV. We note that the electron registration efficiency is larger by 2 - 3 times in the case of a layered medium with $n = 930$ layers than in the case of a medium with 380 layers, owing to the increased number of layers and the decreasing plate thickness (i.e., the decreased absorption).

It follows from these preliminary results, as expected, that the electron registration efficiency has a sharp dependence on the energy. In the investigated angle and energy intervals, the efficiency reaches $\varepsilon \simeq 0.1$.

Recognizing that the transition-radiation spectrum decreases rapidly with increasing $h\omega$, it is obvious that the use of γ-quantum detectors capable of recording γ quanta with energies lower than used in our case will make it possible to register high-energy particles with $\varepsilon \simeq 1.0$, provided the values of θ_1 and θ_2 and the number of layers are suitably chosen. Since the intensity of the transition radiation depends on γ, it is also obvious that such a detector can be used to identify particles with different masses at high resolution in the momentum region $\gtrsim 100$ GeV/c, a rather complicated task if Cerenkov counters are used.

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S-SHAPED CURRENT-VOLTAGE CHARACTERISTIC AND PINCHING OF CURRENT IN GUNN DIODES

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In highly doped Gunn diodes, the field in the domain becomes strong, so that band-band breakdown takes place, and electron-hole pairs are generated as a result. This leads to current-controlled negative resistance (S-shaped characteristic) [1 - 3], the mechanism of which is not yet clear, and also to the appearance of stimulated emission and to the formation of glowing filaments [4]. These phenomena were observed in GaAs [4], InP [5], CdTe [6], and in other compounds.