INVESTIGATION OF TRANSITION RADIATION IN FOAMED PLASTIC

A.I. Alikhanyan, E.S. Belyakov, M.P. Lorikyan, K.Zh. Markaryan, and K.K. Shikhlyarov

Submitted 13 February 1973
ZhETF Pis. Red. 17, No. 9, 453 - 456 (5 May 1973)

Interest in transition radiation has increased greatly in recent years. This is due apparently to the extension of high-energy physics to an energy region in which the use of traditional methods of particle identification entails great difficulties. In addition, investigations of the transition radiation itself have shown that this is by far not a faint and difficult-to-discern effect, as was previously assumed [1 - 3], but can be used in real physical installations [4 - 7]. The discovery of transition radiation in porous materials [4 - 6] has also stimulated research in this direction, since it solved the problem of developing detectors having large transmission and good efficiency. There are, however, still no published reports of systematic research on the radiation spectra in porous materials, so that difficulties are encountered in the design of the detectors.

We present here the results of an investigation of transition radiation in foamed plastic in the range 13 - 130 keV, performed with the Erevan electron accelerator. The photon spectra were measured with a scintillation counter with an NaI crystal 2 cm thick and 7 cm diam, with a beryllium window 100 μ thick. The energy resolution at 60 keV was 32%. After passing through the transition radiator, the electrons were deflected with a magnet to prevent their entry into the detector. In each measurement we determined the difference between the results obtained for the transition radiator and a radiator made of dense material of equivalent thickness.

Figure 1a shows the differential spectra of transition radiation in foamed plastic of density $\rho \sim 0.04$ g/cm^3 and thickness 2 cm, for electrons of varying energies. The maxima in the distribution are due to a decrease in the efficiency of photon registration by the NaI counter, and also to absorption of the soft photons in the radiator itself. It is seen from the figure that the emission spectrum becomes harder with increasing electron energy. Figure 1b shows the dependence of the total number of photons on the electron energy.

Figure 2 shows the differential spectra of the radiation (a) and the summary number of photons (b) for 3.0-GeV electrons in a foamed-plastic target 1 cm thick at different densities, as functions of the density. It follows from the figure that the radiation intensity increases linearly with increasing density.

Figure 3 shows the differential spectra of radiation (the measured number of photons) (a) and the dependence of the total number of photons per electrons on the thickness (b), at different foamed-plastic thicknesses

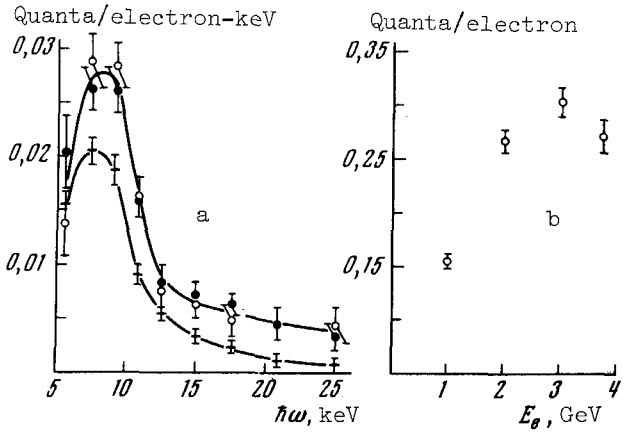

Fig. 1. Spectra of transition radiation in foamed plastic of density $\rho \sim 0.04$ g/cm^3 and thickness 2 cm vs. electron energy E_e: +) E_e = 1.0 GeV, •) 2.0 GeV, o) 3.75 GeV.

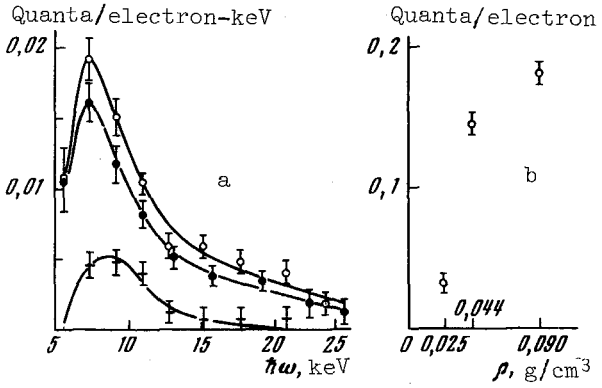

Fig. 2

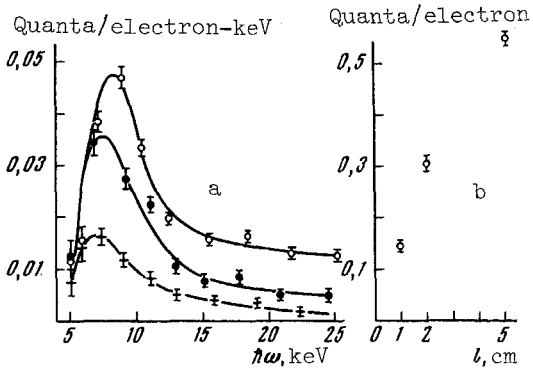

Fig. 3

Fig. 2. Spectra of transition radiation for 3.0-GeV electrons in foamed plastic 1 cm thick and of varying density ρ: +) ρ = 0.025 g/cm³, •) 0.44 g/cm³, o) 0.090 g/cm³.

Fig. 3. Spectra of transition radiation in foamed plastic of density ρ ∿ 0.04 g/cm³ for electrons of energy 3.0 GeV, vs. the plastic thickness ℓ: +) ℓ = 1 cm, •) 2 cm, o) 5 cm.

(average density ρ ∿ 0.04 g/cm³), for electrons of 3.0 GeV energy. It is seen from the figure that the photon yield increases approximately linearly with the thickness, almost up to 10 cm. The growth then slows down, mainly as a result of saturation in the region of soft quanta (to 25 keV), as is particularly noticeable for foamed plastic 25 cm thick. The hardening of the spectra at larger thicknesses can be explained by noting that when the thickness of the plastic is increased the fraction of the hard quanta leaving the target increases because the soft photons produced in the initial part of the radiator are absorbed in the target itself. In addition, when the target thickness is increased the probability of events in which two and more photons are produced increases, but our detectors register them as one photon having the summary energy of the two. This explains also why the values in Fig. 3b are lower than in [6]. In addition, in the cited study the photons in the streamer chamber were registered starting with the softer region ∿2 keV.

It is of interest to compare a foamed-plastic target with a radiator consisting of a laminar medium with optimal parameters. Under the same conditions, for a polyethylene target of 16 films each a = 17 μ thick spaced b = 500 μ apart, the number of photons obtained per electron was η = 0.059 ± 0.004. Foamed plastic of the same thickness, with density ρ = 0.09 g/cm³, yields η = 0.070 ± 0.004, i.e., at an electron energy 3.0 GeV foamed plastic with ρ = 0.09 g/cm has a radiation efficiency not worse than that of a laminar emitter.

[1] F.R. Arutynyan, K.A. Ispiryan, and A.G. Oganesyan, Yad. Fiz. 1, 842 (1965) [Sov. J. Nuc. Phys. 1, 604 (1965)].
[2] A.I. Alikhanyan, K.A. Ispiryan, A.G. Oganesyan, and A.G. Tmanyan, ZhETF Pis. Red. 11, 347 (1970) [JETP Lett. 11, 231 (1970)].
[3] L.C.L. Yuan, C.L. Wang, and S. Prinster, Phys. Rev. Lett. 23, 496 (1969).
[4] A.I. Alikhanyan, K.M. Avakyan, G.M. Garibyan, M.P. Lorikyan, and K.K. Shikhlyarov, Erevan Phys. Inst. Preprint EFI-ME-2, 1970. Paper at Session of USSR Academy of Sciences, Tallin, 7 January 1970 (Izv. AN ArmSSR, Fizika 5, 267 (1970).
[5] A.I. Alikhanyan, G.M. Garibyan, M.P. Lorikyan, and K.K. Shikhlyarov. Paper at International Conference on Apparatus Used in High Energy Physics, Dubna, 2, 542 (1971).

[6] A.I. Alikhanyan, E.S. Belyakov, G.M. Garibyan, M.P. Lorikyan, K.Zh. Markaryan, and K.K. Shikhlyarov, ZhETF Pis. Red. 16, 315 (1972) [JETP Lett. 16, 222 (1972)].
[7] A.I. Alikhanyan, S.A. Kankanyan, A.G. Oganesyan, and A.G. Tamanyan, Erevan Phys. Inst. Preprint EFI-ME-18, 1972.

WIDTHS OF PEAKS OF TWO-PHOTON RESONANT RAMAN SCATTERING IN CRYSTALS

A.A. Klochikhin, B.S. Razbirin, and G.V. Mikhailov
A.F. Ioffe Physico-technical Institute, USSR Academy of Sciences
Submitted 14 February 1973
ZhETF Pis. Red. 17, No. 9, 456 - 460 (5 May 1973)

We determined the shift and broadening of the lines of two-photon resonant light scattering in CdS crystals excited with light of different wavelengths. The theory of resonant two-phonon scattering is considered and it is shown that these effects are a reflection of a fundamental distinguishing feature of resonant scattering.

An interesting distinguishing feature of resonant Raman scattering in crystals is the unusual narrowness of the two-phonon lines [1]. Their width is close to that of the one-phonon peak. This phenomenon is difficult to understand at first glance, since in two-phonon scattering, unlike in one-phonon scattering, the momentum conservation law permits participation of phonons with all possible momentum values, and the width of the two-phonon spectrum should seemingly be equal to double the width of the phonon branch. Figure 1a shows the spectrum obtained by us for resonant scattering by longitudinal optical (LO) phonons of a CdS crystal excited with light of $\lambda = 4880$ Å. As seen from the figure the half-width of the 2LO line is ~ 7 cm^{-1}. This width is greatly influenced by the anisotropy of the phonon branch [1]. When anisotropy is taken into account, the "true" value of the half-width of the 2LO line is ~ 4 cm^{-1}, which is close to the half-width of the 1LO peak (3.6 cm^{-1}) and is much less than double the width of the optical branch in CdS (18 cm^{-1}) [2]. It is also remarkable that in two-phonon scattering there appear only phonons with small wave vectors, so that the frequency of the two-phonon maximum is equal to double the frequency of the one-phonon peak. This result is not explained by Born's semi-phenomenological theory [4] and differs considerably from the known experimental data on two-phonon scattering spectra in alkali-halide crystals [5, 6] far from resonance.

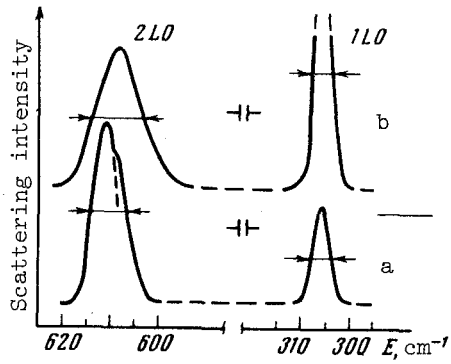

Fig. 1. Spectrum of resonant Raman scattering in CdS crystal excited with light $\lambda = 4880$ Å (a) and 6328 Å (b) at 4.2°K. To exclude effects due to interaction with plasma oscillations [3], we investigated in our experiment only undoped insulating crystals.

In this paper, using longitudinal optical phonons as an example, we explain the observed features of resonant two-phonon scattering. We shall show that these features are a fundamental property of resonant scattering in crystals.

It was established earlier [7, 8] that to explain the experiments on one-phonon scattering by LO phonons in the resonance region it is necessary to take into account the intraband interaction of the LO phonons with the electrons. This interaction enhances the resonance in the dependence of the one-phonon scattering over the value obtained when only the interband interaction is taken into account [9]. In the