HE 7.1-12

Application of thermoluminescence for detection of cascade shower II
---- Detection of cosmic ray cascade shower at Mt. Fuji ----

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ABSTRACT

We report here the results of thermoluminescence(TL) chamber exposed at Mt. Fuji during Aug. '83 ∿ Aug. '84. We succeeded to detect the TL signal induced by cosmic ray shower, and compared it with the spot darkness of X-ray film inserted together.

I) Introduction

Characteristics of various types of TL powder, LiF, $CaSO_4$:Tm, $BaSO_4$:Eu and Mg_2SiO_4:Tb, were reported in the last conference by TL-Developments Collaborative Group*[1]*. They concluded that $BaSO_4$:Eu powder is the best for practical purpose from various points of view, that is, it shows negligibly small fading damage, simple glow curve, wide dynamic range and so on.

On the basis of these systematic investigations, we started the use of TL sheet(TLS) composed of $BaSO_4$:Eu, which is coated on Aluminium base with the thickness of 150 μm.

During the time from Aug. '83 to Aug. '84, we exposed a test TL chamber(called TLC II), including both X-ray film and TLS. Therefore, we can calibrate TL intensity with use of spot darkness on X-ray film. The analyses of the latter are summarized in ref. 2, and we report here the preliminary ones of the TLS.

II) Linearity check of CCD and I.I.

Before going to the detail of TL measurements, we should check both linearities of CCD and image intensifier(I.I.), which are cores of our reader system(see Fig. 1 of ref. 3).

We exposed uniform light beam against CCD camera. In Fig. 1, we show the correlation between exposure time of the light and output signal (∝ electric charge storaged in CCD sensor), which is transmitted into frame memory of image processor(I.P.) through high speed ADC. One finds that the linearity is quite well.

Next, we set CCD camera on phosphor screen of I.I. through tandem lenses(NIKON COSMICAR, 50mm, F1.8), and exposed uniform weak

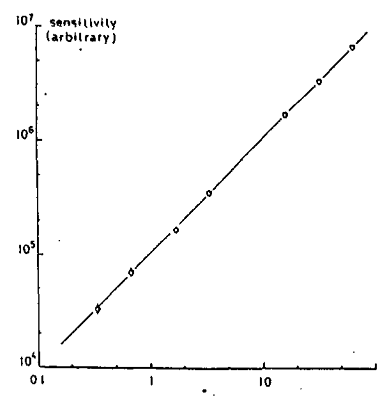

Fig. 1. Relation between exposure time of light and output signal from CCD.

light against photocathode of I.I.. In Fig. 2, we show the correlation between these two in the similar way as Fig. 1. Again we found the linearity is quite satisfactory.

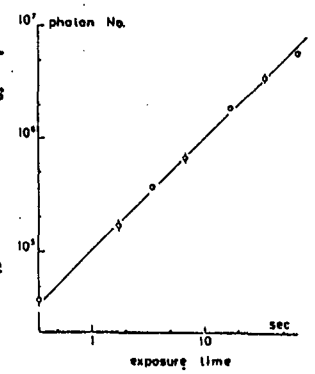

Fig. 2. Linearity check of I.I..

III) Characteristics of TL sheet $BaSO_4$:Eu

i) Glow curve

With use of the utility "READER" in PC9801 (see III-iii in ref. 3), we can draw the glow curve of TL emission on CRT in real time. In Fig. 3, we show an example thus obtained, where Sr^{90} is irradiated for 10 minutes against TLS used practically for TLC II. As the glow peak lies around 210°C, it is enough to integrate TL emission up to 250°C.

ii) Relation between RI intensity and TL emission.

In order to calculate TL transition curves, we need the correlation between electron density ρ ($\propto$ irradiation time of RI) and amount of TL emission I_{TL}. In Fig. 4, we present the relation $\rho - I_{TL}$ for two kinds of TLS; the one composed of Aluminium base coated with TL powder, and the other of the mixture of teflon and that.

Both are expressed by a simple relation,

$$I_{TL} \propto \rho^{1.22}$$

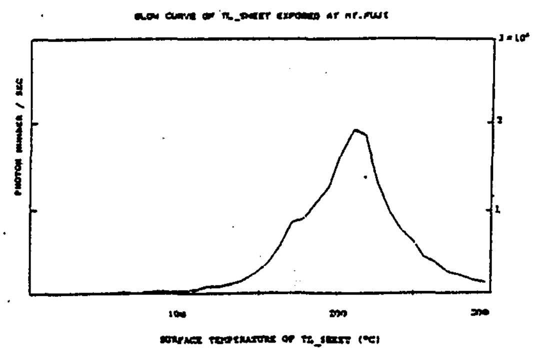

Fig. 3. Glow curve of TLS used for TLC II exposed at Mt. Fuji.

though the sensitivity of the latter gives one order higher than that of the former. The detail of the above supralinearity will be discussed elsewhere.

IV) Structure of TLC II

We constructed a TL chamber(TLC II) at Mt. Fuji in the August of 1983, and exposed for one year. The structure of TLC II is illustrated in Fig. 5, where CR39 is inserted at 10 c.u. by another Fuji Emulsion Collaborative Group in order to search monopole. We inserted there two sheets of TLS at every layers except 6 c.u., which enables us to confirm definitely whether light signal comes realy from TL emission, or due to background noise. That is, if we catch a TL signal in the upper sheet , the corresponding signal will be also detected near the same position in the lower one. In Fig. 6, we show an example of TL map, where two signals inside dotted circle correspond to those due to cosmic ray cascade shower. The transition curves of these TL signals will be discussed in the next section.

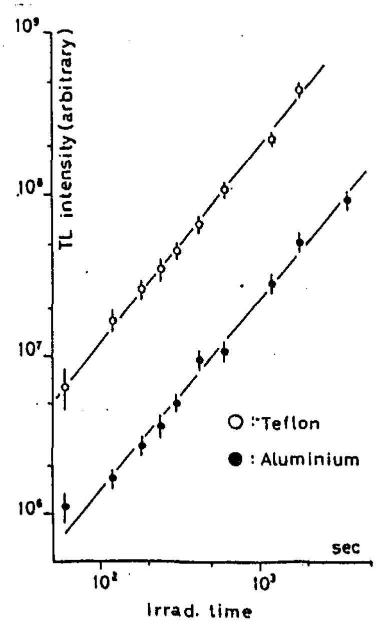

Fig. 4. Relation between RI intensity and TL yield.

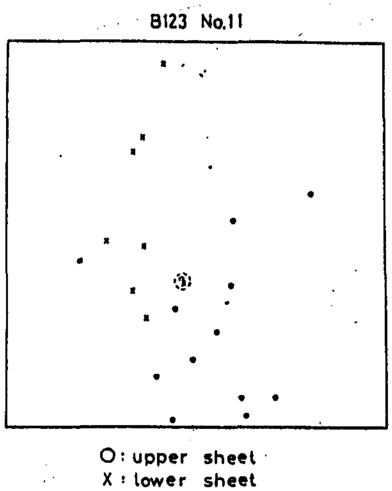

Fig. 6. Example of TL map.

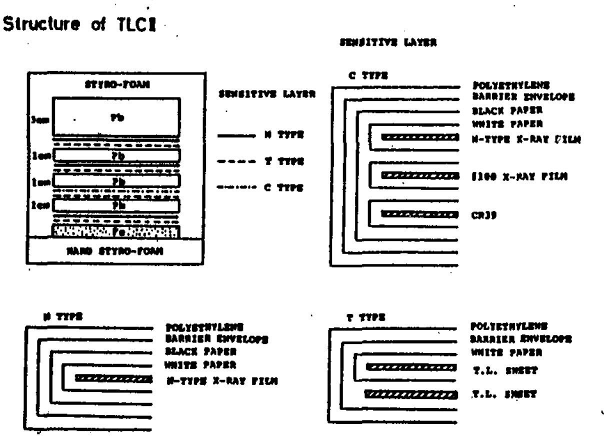

Fig. 5. Illustration of chamber structure TLC II, where three kinds of materials are inserted, X-ray film(Sakura N-type and Fuji #100-type), TL sheet and CR39. CR39 is inserted only at 10 c.u..

V) Transition of TL emission

As mentioned before, X-ray films are also inserted together with TLS. Since cascade shower is detected as dark spot on X-ray film by naked eyes, we can set the position of TL emission beforehand near the center of photocathode of I.I.. Setting error between these two is ∿ 2 cm, so that we can not find TL signal sometimes at the expected place.

In Fig. 7-a and 7-b, we give two transition curves; the former corresponding to those of spot darkness obtained by X-ray film, and the latter to those of TL emission. Here, the slit size is fixed $200 \times 200\ \mu m^2$ for the measurement of spot darkness, whereas TL emission is integrated within the radius of 500 µm.

In Fig. 8, we present the correlation between the spot darkness and the amount of TL emission. In this stage, it is difficult to conclude decisively the relation $I_{TL} - D$, because of poor statistics, particularly in the region $D \lesssim 1.0$.

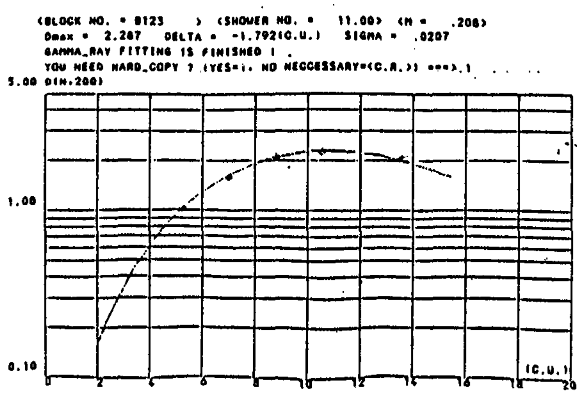

Fig. 7-a. Transition curve of spot darkness obtained by N-type X-ray film, where slit size is set 200 µm.

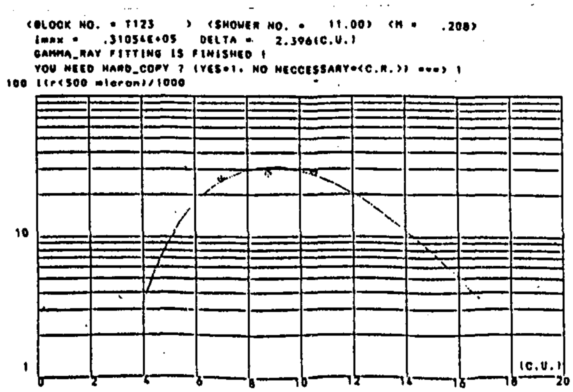

Fig. 7-b. Transition curve of TL emission, where vertical axis is integrated within the radius of 500 µm.

VI) Discussions

We succeeded to observe clearly TL signals induced by cosmic ray cascade showers. On the detection threshold of TL signal, we found, though preliminary, that those with D$\gtrsim$1.0 are at least detectable, corresponding to 20 TeV. Of course, it depends strongly on the exposure time, and it needs more systematic studies to make this problem clear.

As was mentioned in ref. 3, we are now developing the present system so as to collect TL light more efficiently, and starting TL exposure at airplane. These observations will surely bring us to the realization of super TL calorimeter.

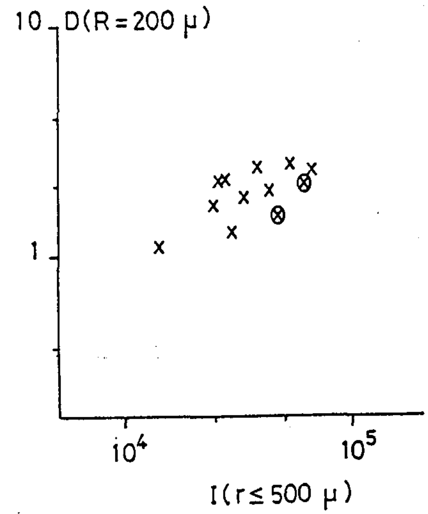

Fig. 8. Correlation between TL yield and spot darkness of X-ray film.

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References

[1] Y.Okamoto et al., 18th Cosmic-ray Conference(Bangalore, '83), Conf. Paper, Vol.8, T6-4, p.161.

[2] M.Niwa et al., To be published to ICR-Report(Japanese).

[3] M.Akashi et al., HE 7.1-6 in this volume.