Observation Systems of Cherenkov Radiation from Water Phantom Irradiated with Co-60 Gamma-rays

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ABSTRACT

Blue light of Cherenkov radiation generated by electrons in transparent substances such as water and acrylic resin is well known generally. If students can easily observe the blue light at school, they may be impressed by the fascinating radiation. Four years ago, management of the Co-60 unit for radiotherapy was transferred to Nagoya University School of Health Sciences from a related hospital. We have examined whether or not the Cherenkov radiation in water from secondary electrons generated by Co-60 gamma-rays can be safely observed by eyes and photographs. First, the Cherenkov radiation in the water tank was led to the corridor outside the irradiation room by a mirror, and observed directly without any effect of the radiation exposure. Second, photographs of the Cherenkov radiation were taken under the conditions consisted of several irradiation fields and pass lengths of gamma-rays in water

Keywords: Cherenkov radiation, radiation physics, education

1. INTRODUCTION

When electronic kinetic energy is higher than about 257keV, the electron moves faster than the light in water and radiates blue light. Co-60 radiates the gamma rays of 1.17MeV and 1.33MeV. There occur secondary electrons by these gamma rays, and the secondary electrons with more than 257keV kinetic energy are contained. The Cherenkov light radiated by the secondary electron can be observed[1]. If students actually observe the fantastic blue light, they can realize the Cherenkov light easily. The Co-60 gamma-ray irradiation unit used for the radiotherapy was transferred to Nagoya University School of Health Sciences from an attached hospital several years ago. We examined the observation system of the Cherenkov light radiated from the secondary electron caused by the gamma ray of Co-60. The blue light in the water tank was led to the outside of the irradiation room by a mirror, observed directly with eyes (Fig.1), and then photographed[2]. However, the exposure was measured by an ionization chamber and so on, and then safety against direct observation with eyes was confirmed in advance.

2 . METHODS

The irradiation room must be darkened to observe the Cherenkov light because the intensity of the light is very weak. All luminosities accompanied by indoor irradiation unit were covered with black plastic bags for shielding those lights. The Co-60 gamma-ray irradiation unit with 18.6TBq for radiotherapy was used for the observation. The tank filled with water was put under the gantry head, irradiated with the gamma ray, and then the Cherenkov light was observed. A direct observation by the eyes is done easily if the luminous rate is high. Therefore, the water tank was set up near the gantry head to get higher luminous rate. Furthermore, the mirrors ① and ② slanted at 45° over and under the water tank were set up, and they led the Cherenkov light radiated in the up-down direction of the water tank to the right angle direction(Fig.2).

2.1 Direct observation

The irradiation room is the form for radiation protection as shown in Fig.1. Although the door of the irradiation room is opened and an observer looks into the room from the outside, the observer can't see the water tank directly. We fixed a mirror on a suitable position so that the observer can see the state of the water tank by the mirror from the outside of the irradiation room. First, the observer stood outside the doorway, and memorized the position of a mirror under the bright condition of the irradiation room. After the fluorescent lights were turned off and eyes were fully accustomed to darkness, gamma rays were radiated and the blue light was observed.

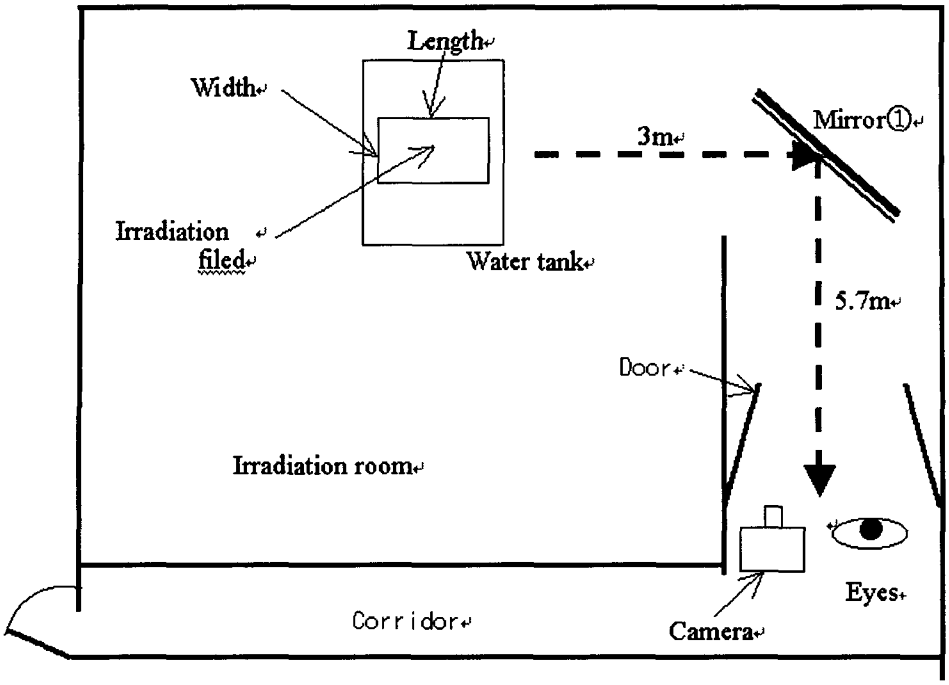


Fig. 1.Observations with eyes and photography at the doorway

2.2 Photography

A camera was fixed on a tripod to take pictures of the blue light moving in the right angle direction against the beam central axis as shown in Fig.2. The observer turned off the fluorescent light of the irradiation room first, opened the shutter of the camera, went to the outside of the irradiation room, closed the door of the doorway and irradiated the water tank with gamma ray of Co-60. After the irradiation was finished, the shutter of the camera was closed at once. Water was filled to the depth 20cm, and the irradiation field was 20cm× 20cm, and many pictures were taken at various irradiation times.

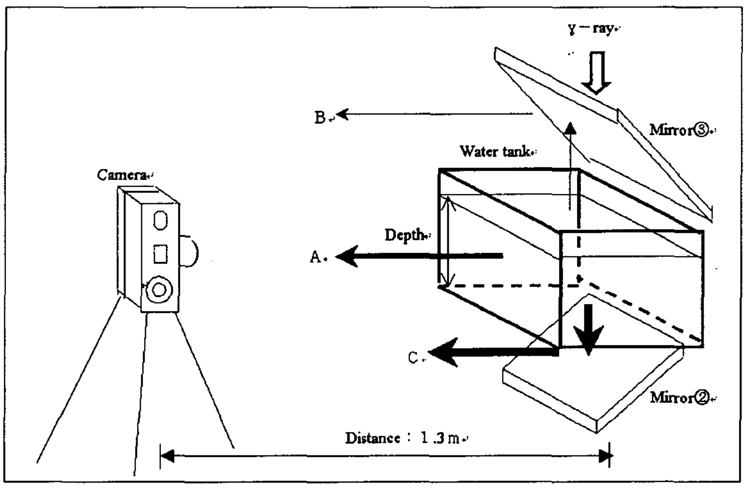


Fig. 2. An arrangement of equipment for photographing in the irradiation room

3. RESULT

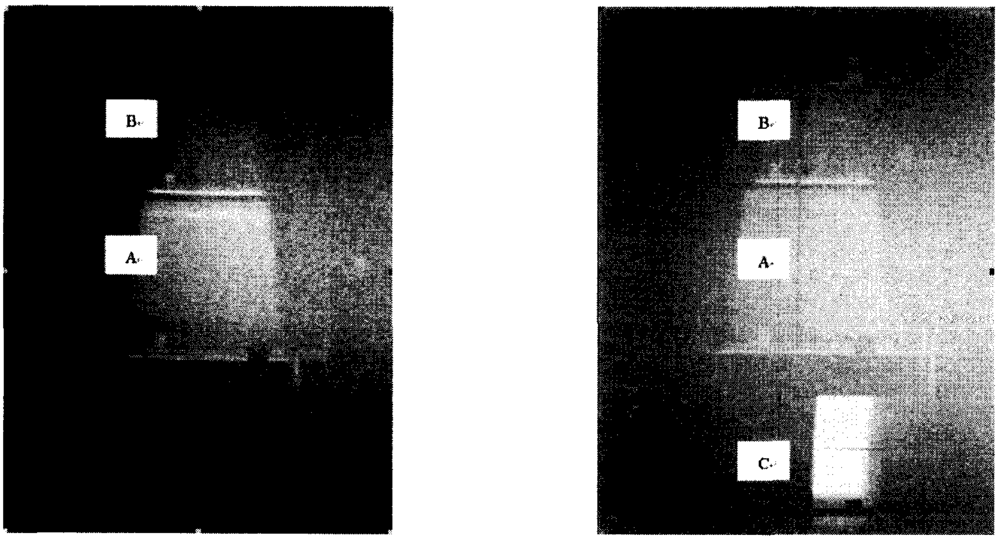
The distance from the source to the water surface was 50-70cm. The exposure rate was 189 μC/kg/s near the water surface.

3.1 Direct observation

At first, it was very difficult to observe the Cherenkov light directly because there were not many amounts of luminosity. After eyes were accustomed to darkness, the blue light could be seen dimly. The dose equivalent rate at the doorway measured by the ionization chamber type survey meter was 6.45μSv/hr. The exposure caused by the direct observation with eyes was fully within the limit of dose equivalent.

3.2 Photography

Fig.3 shows black and white photographs of the blue light of Cherenkov radiation taken in the method as shown in Fig.2. The blue light radiated in the right angle direction against the beam central axis from the water tank was observed at part A. The blue light radiated to the top and the bottom was observed at parts B and C. Part C was the lightest, and the brightness was enough to slightly confirm the blue light even if the irradiation time was shortened to one minute. This part showed the light radiated to the under direction parallel to the beam central axis and the intensity was higher than that of the right angle direction. Part A showed the light radiated at right angles against the irradiation direction. There was the least light intensity in part B, and the image was the gloomiest too.



(I) was the case using mirror ③　　(II) was the case using mirrors ② and ③.

Fig.3 Examples of the Cherenkov radiation taken in the method as shown in Fig 2.

4. DICUSSIONS

If the water tank is closer to the gantry head, the fluence rate of the blue light is higher. The water tank was approached to the gantry head as much as possible to increase the fluence rates of the blue light. With little exposure, observation with the naked eyes of the Cherenkov light became possible by reflecting it with the mirror. Because of the dim bluish light, it was observed after the whole irradiation room was fully darkened. However, there was a person who couldn't confirm the blue light due to the individual difference of dark adaptation. The blue light was taken more clearly by setting photography time at about thirty minutes. Above all, the picture of the mirror C put under the water tank was taken most brightly. The Co-60 gamma-ray irradiation unit for the radiotherapy can be used for the radiation measurement experiment fully though the radioactivity declined very much. Furthermore, it can be used for the observation of the Cherenkov light in radiation physics class too.

REFFERENCES

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