LASER ILLUMINATION OF BUBBLE CHAMBERS AND CLOUD CHAMBERS

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In the investigation an attempt was made to use a ruby laser as the illumination source of a bubble chamber and a cloud chamber.

In lasers the light brightness is several orders higher than in ordinary noncoherent sources, and the entire light flux generated by the laser can be utilized. The size of an efficient source can be made fairly small.

The use of Q-switching makes it possible to considerably reduce the duration of the light pulse. The light from a ruby laser is polarized, enabling the extinction of depolarized parasitic scattered light and ghosts. The high degree of monochromaticity of the laser beam facilitates the use of special objectives designed for a single wavelength with a higher resolving power or larger field of view.

The light energy of the ruby laser was 0.1 joule per pulse when illuminating bubbles and 40 joule when working with a cloud chamber. The laser pulse duration without Q-switching was 0.6 msec.

A self-collimated bubble chamber was simulated as follows. A glass plate with air bubbles – the bubble test (Fig. 1) – was illuminated by five light flashes from a laser 1 in successive rotations of the photographic system 2, so that the stationary film 3 saw a track consisting of 5 bubbles (see Fig. 2). The photographing was performed with an objective having a focal distance of 53 mm and an aperture ratio of 1:20 at a distance of 70 cm to a photographic film, sensitive in the red part of the optical spectrum, with a resolving power of 70 lines mm. According to the photographic simulation conditions, the air bubbles in the glass behave with respect to light diffusion at a given angle in the same way as gas bubbles in liquid hydrogen with a diameter approximately 2.5 times smaller. In the bubble test the diameter of the bubbles was 1.4 and 0.7 mm. In order to guard against overexposing

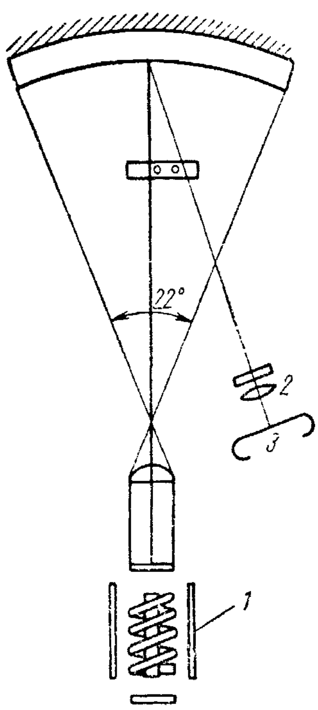

Fig. 1

the photographs, a composite light filter with a transmissivity of 1 30 was used.

Seen on the photograph (Fig. 2) are the tracks of five points strongly overexposed for bubbles of large size and normally exposed for the smaller bubble. Since the smaller bubble in the glass corresponds to a bubble with a diameter of 0.3 mm in liquid hydrogen, bubbles with a diameter of 0.06 mm could therefore be recorded in hydrogen without filters. Recording of smaller bubbles for illumination of a larger chamber can be easily achieved by increasing the laser energy.

The experiment also showed that the illumination of an area with a diameter of 250 mm by a laser beam is fairly uniform (Fig. 3). The smallest cross section of the illuminating beam, or the size of the "luminous body," was photographically measured. This size was found to be 0.4 mm, which corresponded to the calculation. The high-intensity laser beam makes it possible to use a less sensitive film, having a higher resolving power.

When illuminating a cloud chamber a light source of high energy is required, because of the considerably smaller droplet diameter and the small reflection coefficient for light at an angle close to 90°.

The experiment, aimed at finding out the possibility of illuminating a cloud chamber with the aid of a ruby laser and for determining the laser energy necessary for this purpose, was performed with a chamber having internal dimensions of $100 \times 40 \times 20 cm^3$. Not the entire sensitive volume, but only a 100-cm long cylindrical region 10 cm in diameter, was illuminated.

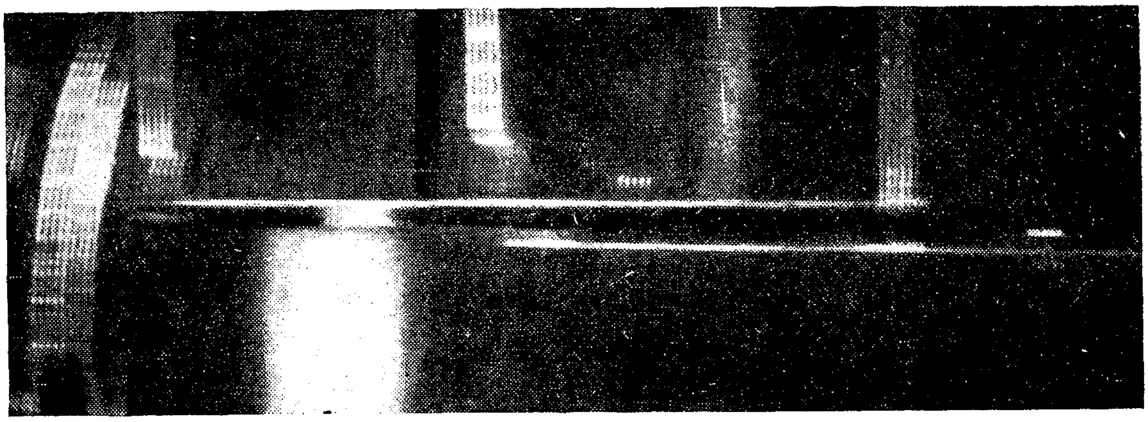

Fig. 2.

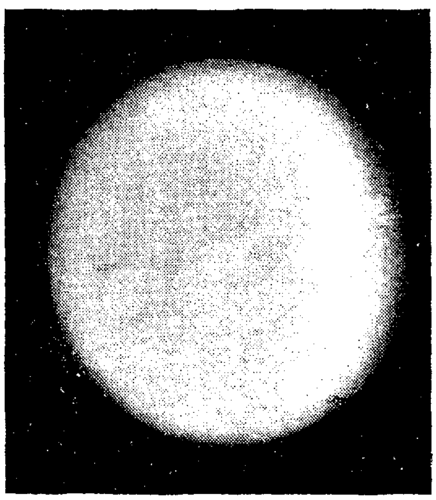

Fig. 3.

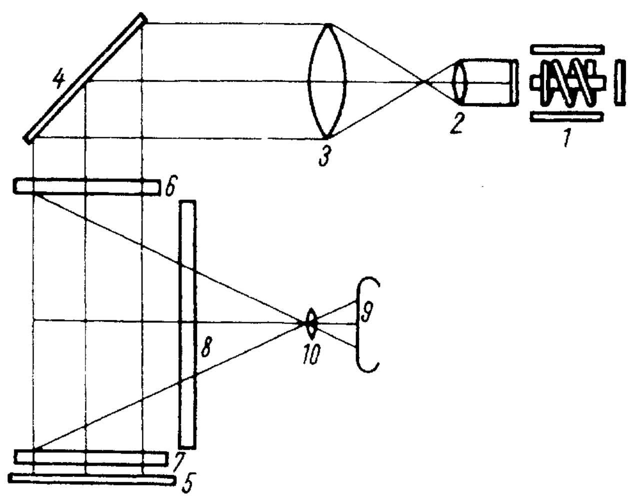

Fig. 4.

In the first series of the experiment the chamber was filled with argon and a mixture of water and ethyl-alcohol in the ratio 1 : 3; in the second series it was filled with helium and the same mixture. From the optical diagram of the installation (Fig. 4) we see that the light from the laser 1 enters a system of lenses 2, 3, where it is formed into a parallel beam 10 cm in diameter. With the aid of the mirrors 4, 5 the light is directed via the lateral windows of the chamber 6, 7 into the sensitive volume, which it crosses twice: in the forward and backward directions along the same path; photographing is per-

The experiment indicated that as a result of the good coherence of the laser beam, the illuminated region inside the cloud chamber has a sharply defined boundary. This can be well seen on the strongly fogged-up photograph (Fig. 5).

The optimum delay of the photographing for a

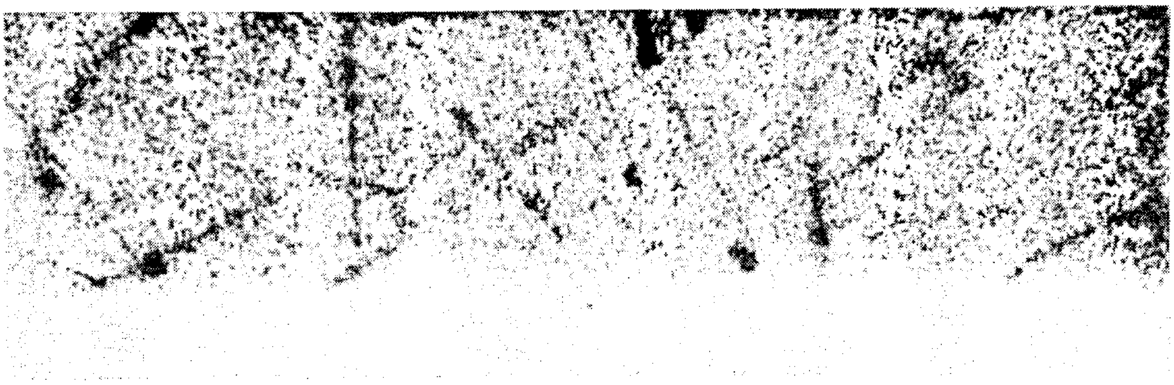

Fig. 5.

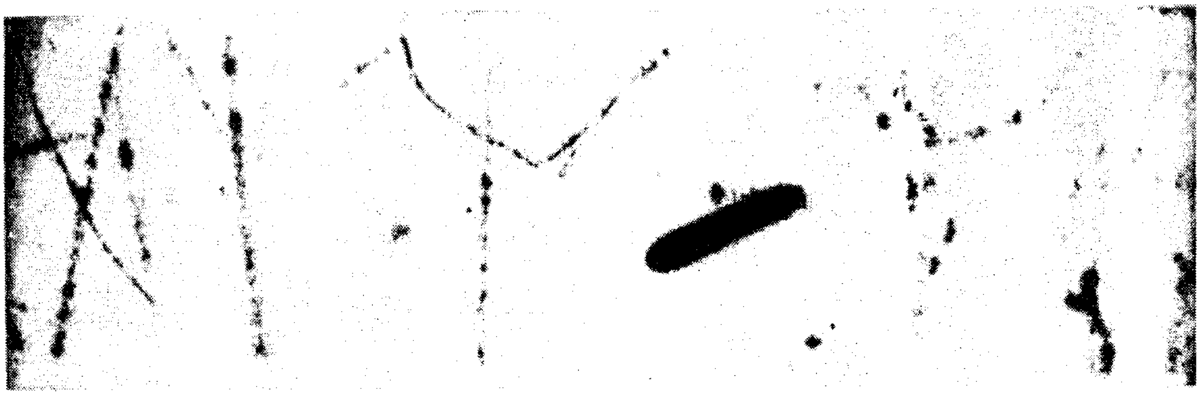

Fig. 6.

formed on a photographic film 9 via the front window of the chamber 8 at an angle of 90 to the direction of the incident beam. The relative aperture of the objective 10 was varied during the experiment from 1:3.5 to 1:16. The photographing scale remained constant and equal to 1:13.

A system of counters was used to select cases of relativistic charged cosmic ray particles passing through the sensitive volume of the cloud chamber. The fairly small purifying electrostatic field and the large time resolution of the chamber made it possible to observe tracks of charged particles which passed at different times with respect to the beginning of the expansion. The expansion time of the chamber was 20 msec. The lag in photographing relative to the end of the expansion varied from 50 to 400 msec.

relative objective aperture of 1:16 and a 40 joule laser energy for both chamber fillings (argon and helium) was 100 msec.

In the photograph of Fig. 6 tracks of relativistic charged particles can be seen, which passed through the sensitive volume of the chamber at different times (both before and after the moment of expansion), as well as the track of a slow alpha particle.

The performed experiments thus show that lasers can be used for illuminating bubble chambers and cloud chambers. The contrast of the photographic image of the tracks of charged particles relative to the background can hereby be considerably improved. Increasing the laser energy, or using an optical system for multiple reflection of the light beam in the sensitive volume of the chamber, will no doubt enable the photographing of smaller bubbles and drops, thus reducing the distortions of the particle track.

It should be noted that when the chamber is illuminated by a laser, the light source can be placed at a fairly large distance from the chamber. The possibility of using chambers of great length arises, and in the case of a cloud chamber with a large number of plates, the distance between the latter can be considerably reduced.