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PHASE HOLOGRAMS OF TRACKS IN BUBBLE AND EMULSION CHAMBERS AND THE POSSIBILITIES OF THEIR PROCESSING

The recording of nuclear reactions or events of creation and decay of elementary particles by means of bubble chambers and other track instruments has the advantage of simplicity, visual clarity, and great information capacity. The volumetric nature of track recording creates, however, additional difficulties in fixation and processing. If the loading of the instrument is large (>10 primary tracks per picture) ([1]), then in photographs obtained using optical systems with a large depth of the imaged space, it is difficult to isolate the events of interest to the experimenter. If objectives with a small depth of the imaged space are used, the background of uninteresting tracks is reduced, but the photographed volume is also reduced, which is disadvantageous.

To increase the loading of the working volume of chambers with tracks, we earlier ([2]) proposed using the achievements of holography. The present article gives the results of an experimental investigation that is a realization of the ideas set forth in papers ([2,3]). These results demonstrate the possibilities of phase holograms of tracks in bubble chambers. Artificial tracks were obtained in a gelatin bubble chamber. These tracks are easily preserved for a relatively long time (5–10 min.) and are practically indistinguishable from tracks in a bubble chamber. For this reason the gelatin chamber proves to be a convenient model of a bubble chamber. In Fig. 1 *I* a photograph of the gelatin chamber is given. Three working sections, A, B, and C, were made in the chamber, the dimensions and arrangement of which were determined by the power of the laser we used. According to papers ([4,5]), the distance of any point of the object and of its holographic real image from the plane of the hologram are linearly related. Thus, the hologram of the working volume of the chamber records without distortion all events in this volume. The reconstruction of individual events with the aid of the hologram can be carried out successively for different plane sections of the volume.

Fig. 1

Figure 1: Fig. 1

In Fig. 1 *III*, *IV*, *V* are shown tracks reconstructed in helium-neon laser light by means of the hologram in sections A, B, and C. It is possible to reconstruct the hologram also in the light of a mercury lamp (Fig. 1 *VI*). In the reconstructed images only the tracks of individual sections are visible; the remaining tracks are imperceptible and do not create a background. The depth of field is very small, and since the phase hologram is completely transparent and is not sensitive to random defects (scratches, etc.) of the film, background effects, diffraction or amplitude ones, are practically absent.

The absence of background, the large depth of the imaged space, and the small depth of field of the reconstructed images make it possible to increase the loading of bubble chambers by ~ 2 orders of magnitude without substantial difficulties in processing the reconstructed images. The depth of the imaged space in holography is easily achieved without substantial reduction of the aperture, i.e., of the size of the holograms. The depth of field of the image Δ' reconstructed with the aid of the hologram can be calcu-

Fig. 1. *I*—three compartments of the chamber; *II*—photograph of tracks in all three compartments; *III*, *IV*, *V*—reconstruction respectively in each of the compartments A, B, C separately; *VI*—reconstruction in the light of a mercury lamp.

by the formulas for optical systems, since these formulas refer to the observed image irrespective of the method by which it is obtained. The depth of field is calculated from the formula

$$\Delta' = 2p'k \operatorname{tg}\psi/(D^2 - k^2 \operatorname{tg}^2\psi), \quad (1)$$

where p' is the distance from the plane of the hologram to the plane of the image; ψ is the angular resolution of the eye; D is the linear size of the hologram; k is the distance of best vision.

The dimensions of the hologram can be increased without great difficulty to 10 cm and Δ' of the order of 1 mm can be obtained. The resolution of the hologram as a diffraction instrument is determined by the total number of fringes and by the wavelength. The simplest hologram of a point light source turns out to be a plane zone plate. According to ([6]), the resolving power of this plate is calculated from the formula

$$\theta = 1.22\lambda/d, \quad (2)$$

where θ is the angular resolution; λ is the wavelength; d is the diameter of the circular zone plate. If the plate is of another shape, then for λ/d there will be another coefficient of order 1.

The validity of Rayleigh' s principles in determining the resolving power of holograms is also indicated by the authors of work ([7]). For helium-neon laser light and $d = 1$ cm

$$\theta \simeq 8 \cdot 10^{-5} \text{ rad.}$$

The value given shows that the resolution of the reconstructed images will be determined by the resolving power of the photographic materials, and not by the hologram itself. Usually, to obtain reconstructed images, photographic materials resolving 2000 lines/mm and more are used.

Analogously to the hologram of a bubble chamber, it is possible to obtain a hologram of tracks in a developed emulsion chamber. This is very important, since it opens up the possibility of using, for the processing of nuclear emulsions, the technique employed for processing photographs from bubble chambers.

The selection of events lying in the planes of sections of the working volume of chambers undoubtedly facilitates the processing of the information supplied by the chambers. The process of selecting and processing tracks can be radically improved if optical filters are used. In the literature ([8–10]) there are indications that, with the aid of filters, one can completely eliminate from the field of view strokes or figures oriented in a definite way. The form of recording information as a hologram appears very convenient for filtration.

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Note: Figure translations are in progress. See original paper for figures.