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OPTICAL FILTRATION OF LASER TRACK SHADOWGRAMS IN STREAMER CHAMBER

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In streamer chambers with holographic registration the readout of information from the chamber volume is mostly performed applying the Gabor scheme. It expedience is due to its simplicity, low sensitivity to mechanical disturbances, and this procedure is characterized by minimal requirements to the spatial and temporal coherence of the laser being used and to the photoemulsion resolution. At the same time it does possess certain defects that, to a larger extent, enhance the noise present in the reconstructed image, thus complicating further processing of the information. The following features can be included in these defects:

- distortion of the reference beam owing to amplitude and phase influence of the streamers and of other spark discharges within the chamber volume;
- low diffraction efficiency of the holograms.

When the above scheme is utilized, the quality of the reconstructed track image depends strongly on the presence of the wire electrodes of the chamber. The diffraction pattern of the wires decreases the contrast of the track images and suppresses diffraction from the streamer channels with weak optical inhomogeneity.

This can be avoided by using as electrodes glass plates covered with conducting coating. On the other hand track information can be extracted effectively in the presence of wire electrodes by means of optical filtration of the images obtained from holograms. The quality of filtered track images is improved significantly if one utilizes as the input signal to the filtration system track images from shadowgrams /1,2/, instead of images from holograms. The point is that, registering shadowgrams, it is possible to reduce to a minimum the influence of the diffraction pattern of the electrode wires. This is achieved by focusing the lens of the photocamera at the median plane of the chamber or in a plane situated at a certain distance from the streamer chamber from the side of the photocamera. Here it is necessary to note that, although the influence of diffraction on the wires is reduced to a minumum when shadowgrams are registered, in this case the main advantage of holographic registration is lost, namely, the information on the "Z" coordinate of the optical inhomogeneity in the streamer channel is lost. Therefore for obtaining the total information it is necessary to employ stereoregistration of shadowgrams /3,4/.

In this paper we present the results of an investigation of the possibilities of the optical filtration of images obtained from shadowgrams, namely, we discuss how to get rid of the images of the wire electrodes present on the track images /5/.

EXPERIMENTAL APPARATUS

In Fig.1 the registration scheme is presented for obtaining shadowgrams of electron tracks in a helium-methane streamer chamber at a pressure of 10 atm /5/. Shadowgrams were registered using a photocamera (fig.2). In order to register the diffraction patterns from all the streamers the objective was focused at a plane situated at 2 cm from the back wall of the streamer chamber.

Optical filtration was performed according to the scheme presented in Fig.3. To this end the shadowgram was placed in the plane H_1. The Fourier image of the track and the wires is formed by the lens O_1 in the Fourier plane F_1. The lens O_2 performs converse Fourier transformation in the plane F_2, of the images input in H_1.

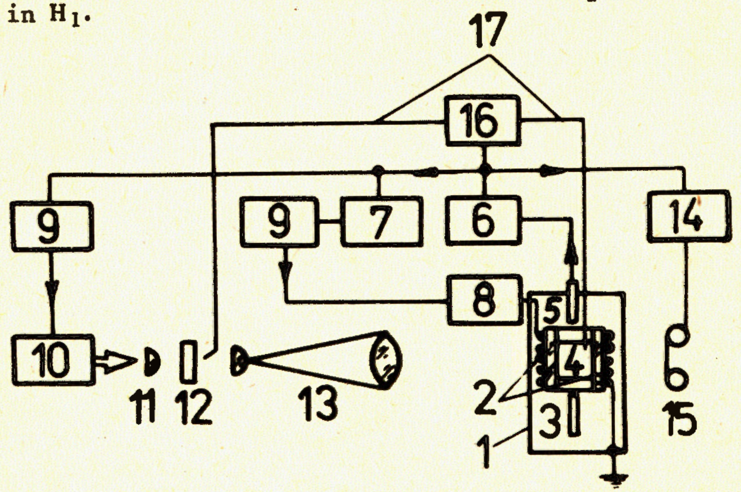
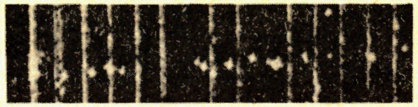


Fig.1. Registration scheme of the holograms: 1 - nitrogen tank, 2 - high-voltage and earth electrodes, 3 - radioactive source ^{90}Sr, *4 - streamer chamber, 5 - photomultiplier, 6 - univibrator, 7 - triggering block for voltage pulse generator (HVG), 8 - HVG, 9 - delay line, 10 - nitrogen laser, 11 - quartz lens, 12 - rhodamine 6G laser cavity, 13 - beam expander, 14 - camera triggering block, 15 - photocamera with the "Helios-40" objective, 16 - oscillograph C9-14, 17 - fiber optics.*

Fig.2. Photograph of a shadowgram of an electron track in the helium-methane chamber at 10 atm.



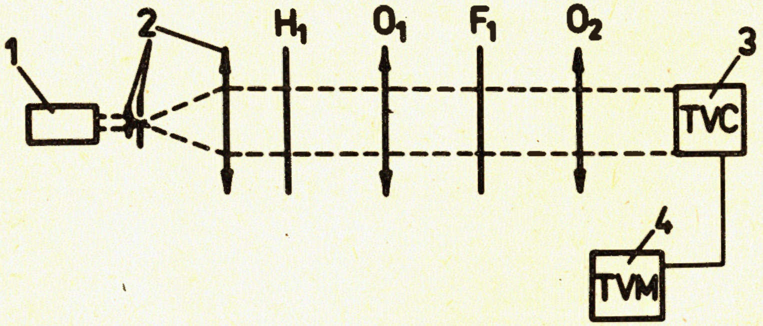


Fig.3. Scheme of optical filtration: 1 - He-Ne laser in the TEM_{00} self-oscillation mode, 2 - beam expander with pinhole O_1 and O_2 objectives for the direct and inverse Fourier transformations, 3 - TV camera, 4 - TV monitor.

DISCUSSION OF THE RESULTS

Optical filtration is based on the fact that a lens can provide the Fourier transformation of an optical signal [6].

In the case of track shadowgrams the function $t(xy)$ describes the registered information on the images of the electrode wires and of the track of the charged particle: $t(xy) = h(xy) + g(hy)$, where $h(xy)$ describes the image of the wires, and $g(xy)$ describes the image of the streamers. If the shadowgram is placed at the plane H_1 (Fig.3), then in the plane F_1 there is formed a Fourier transform of $t(xy)$, i.e., $T(w_x w_y)$. On the other hand, since the Fourier transformation is linear, $F\{t(xy)\} = F\{R(xy) + g(xy)\} = A(w_x w_y) + G(w_x w_y)$, where $H(w_x w_y)$ and $G(w_x w_y)$ represent the Fourier transforms of the functions $h(xy)$ and $g(xy)$ and by the operator F we denote the Fourier transformation.

From the above it is clear that by suppressing the Fourier transform of $h(xy) - H(w_x w_y)$, one can achieve registration at the plane F_2 only of the track image, since the lens O_2, performing the inverse Fourier transformation of the function $G(w_x w_y)$, reconstructs $g(xy)$ at F_2: $F^{-1}\{G(w_x w_y)\} = g(xy)$.

The simplest way of suppressing $H(w_x w_y)$ consists in using a suitable optical filter, which is capable of suppressing further propagation of $H(w_x w_y)$. Experimentally it was established that the use of a simple stop-band filter does not lead

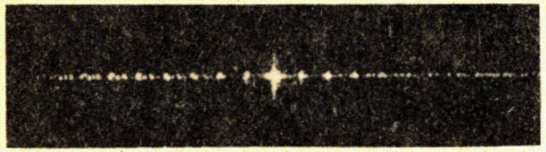


Fig.4. Fourier transform of the images of the electrode wires.

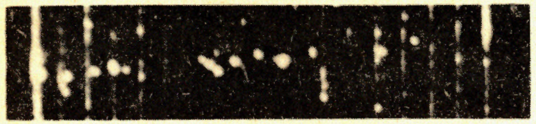


Fig.5. Optical filtered image of the track shown in Fig.2.

Fig.6. Filtered image of track photographed from the screen of the TV monitor.

to a good filtration, since the spatial frequencies of the diffraction images of the elements of the track and of the wires are approximately identical. To suppress $H(w_x w_y)$ we made use of a matching filter which was situated in the plane F_1.

The filter was constructed in the following way. The shadowgram of the electrode wires was placed in the plane H_1 (to obtain only the shadowgrams of the wires the streamer chamber volume was photographed without applying the high voltage pulse, i.e., no track in the chamber was formed). Thus, the film situated in the plane F_1 registered only the Fourier transform of $h(xy) - H(w_x w_y)$ (Fig.4). After being processed photochemically, the film, now representing the filter, is placed exactly at the same place where it was during registration. Only in such a case one can achieve reliable suppression of $H(w_x w_y)$ and provide unimpeded propagation of $HG(w_x w_y)$ for further processing.

In Fig.5 the photograph is presented of a filtered track image registered by a film situated in the plane F_2.

The total suppression of the images of the wires can be achieved by using a telecamera forming the track image on a television monitor (TV). To this end the telecamera was placed in the plane F_2. Adjusting the contrast of the image on the TV monitor it is possible to suppress completely the images of the wires (Fig.6).

Finally, we note that the described filtration system can be used in an on-line scheme of shadowgram registration. To this end the registration of shadowgrams is carried out from the screen of the TV monitor, while at the plane F_1 for contrast elimination of the images of the wires, there is situated the matched filter $H(w_x w_y)$.

CONCLUSIONS

Making use of a simple and compact system of optical filtration one can schieve registration of a clean image of an electron track registered by a shadowgram. A noticeable improvement of the quality of the filtered track image is obtained by utilizing a TV camera with subsequent tranamission of the image to the TV monitor. Thus, from the screen of the TV monitor it is possible to perform photoregistration of a highly contrast track image cleared of all other optical disturbances.

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Оптическая фильтрация изображений треков с лазерных тенеграмм в стримерной камере

Описывается применение метода оптической фильтрации для улучшения изображения трека электрона, зарегистрированного в виде лазерной тенеграммы. Треки регистрировались стримерной камерой, работающей в режиме самошунтирования. Оптическая фильтрация счищает изображение трека от шумовой компоненты - дифракционной картины проволочных электродов камеры.

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Optical Filtration of Laser Track Shadowgrams in Streamer Chamber

The application of optical filtration method for improving the electron track laser shadowgram is described. The shadowgrams are registered by streamer chamber working in self-shunt regime. Because of the diffraction pattern of the wire electrodes, the track shadowgram is suppressed by it, but filtration helps to clean the track image from this noise component.

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