СООБЩЕНИЯ
ОБЪЕДИНЕННОГО
ИНСТИТУТА
ЯДЕРНЫХ
ИССЛЕДОВАНИЙ

Дубна

E13-95-546

L.M.Soroko

CAUSTICAL MESO-OPTICAL CONFOCAL MICROSCOPE FOR VERTICAL PARTICLE TRACKS. Proposal

1995

1 INTRODUCTION

In the previous paper [1] the principle of the proposed new meso-optical microscope designed for selective observation of the vertical particle tracks in the nuclear photoemulsion has been explained. Some new illuminating systems used in this proposed meso-optical confocal microscope have been presented. The results of the experiments performed on various setups equivalent to the proposed microscope have been given. Due to its high productivity the proposed meso-optical microscope may be recommended for direct application in the experimental investigation of neutrino oscillations.

In this paper a new meso-optical confocal microscope based on the caustic phenomenon is proposed. The principle of this microscope is explained. The results of the experiments performed on a setup equivalent to the proposed microscope with the aim to illustrate the main features of this microscope are given. The proposed caustical meso-optical microscope for vertical particle tracks in the nuclear photoemusion might be effectively used in the experimental investigation of such rare processes as $\nu_\mu - \nu_\tau$ oscillations and of the Pb–Pb interactions.

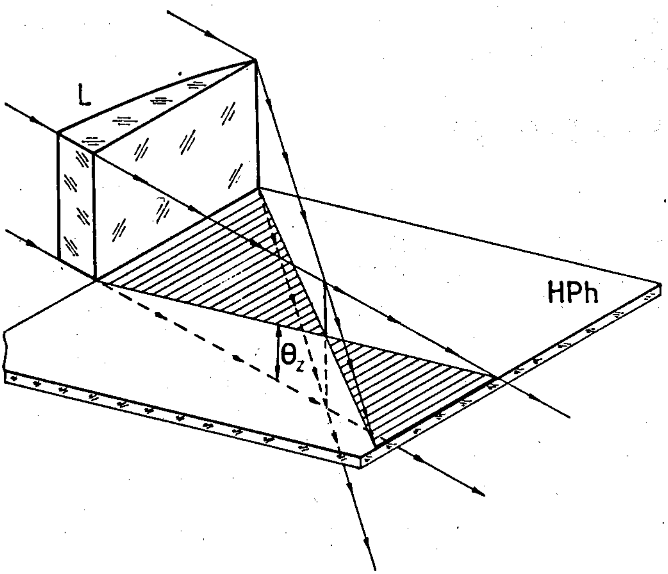


Fig. 1. The geometry of the experiment for observation of the caustic pattern with very high spatial resolution: L — cylindrical half-lens, HPh — holographic photoplate, θ_z — inclination angle of the photoplate.

2 CAUSTIC SYSTEM

The well-known caustic phenomenon [2] can be used to construct another one non-traditional microscope for selective observation of the vertical particle tracks in the nuclear photoemulsion. To demonstrate the caustic phenomenon, an experimental setup, shown in Fig. 1 has been used. A cylindrical half-lens L is illuminated by the collimated light beam. The monochromatic pattern of the cylindrical caustic is detected by means of the photoplate HPh with high spatial resolution of the order of 1000 lines per mm. The plane of this photoplate HPh is inclined at the angle θ_Z with respect to the light beam axis. The monochromatic caustic pattern before and after the focus region is shown in Fig. 2. Its microscopic structure is given in Fig. 3, "1"-"4". The direct photomicrograph of this caustic pattern taken by means of the photo-camera with optical axis parallel to the illuminating light beam is presented in Fig. 4.

The scheme of the proposed confocal caustic meso-optical microscope for selective observation of the vertical particle tracks is shown in Fig. 5. The illuminating cylindrical half-lens L_1 produces the caustic interference pattern, shown in Fig. 3. The nuclear photoemulsion layer is placed in the vicinity of the focus of the half-lens L_1 and is oriented perpendicular to the external light rays of the caustic pattern. The optical stop S absorbs all internal light rays. The imaging cylindrical half-lens L_2 focuses the light rays of the external part of the caustic interference fringes. The region where two systems of the interference fringes, one from the illuminating half-lens L_1 and another from the imaging half-lens L_2 are overlapped can be controlled by transversal moving of these two half-lenses. A typical example of this overlapping is shown in Fig. 5 for the case of the total response width equal to $\Delta/3$.

3 EXPERIMENT

By means of the experimental setup shown in Fig. 6 wehave observed the point-spread function of the system which involves two crossed cylindrical half-lenses. The first cylindrical half-lens L_1 focuses the light rays onto the photoplate Ph. The second cylindrical half-lens L_2, placed after the first cylindrical half-lens L_1 and oriented perpendicular to the half-lens L_1, focuses the light rays onto the same photoplate Ph. In such a configuration we can detect the point-spread function shown in Fig. 7 for two different exposure times. We see that the side-lobes of this point-spread function are present only in one quadrant with respect to the central maximum and due to this can induce only minor effect on the signal-to-noise ratio of the whole confocal system.

The configuration shown in Fig. 7 must be used to realize the second stage of the scanning operations described in [1] for meso-optical confocal microscope in which an interference pattern from two half-lenses is used to form the needed point-spread function of the confocal system in the convergent-divergent geometry.

The proposed caustic confocal meso-optical microscope sees selectively only vertical particle tracks and has high productivity, explaind in [1]. No depth scanning is needed in such a microscope. As was explained in [1] the factor of merits of all confocal meso-optical microscopes for region with sides of 5 mm length is equal to $\kappa = 5.8 \cdot 10^3 : 1$ for $N = 25$ and for spatial resolution of the order of 1 μm.

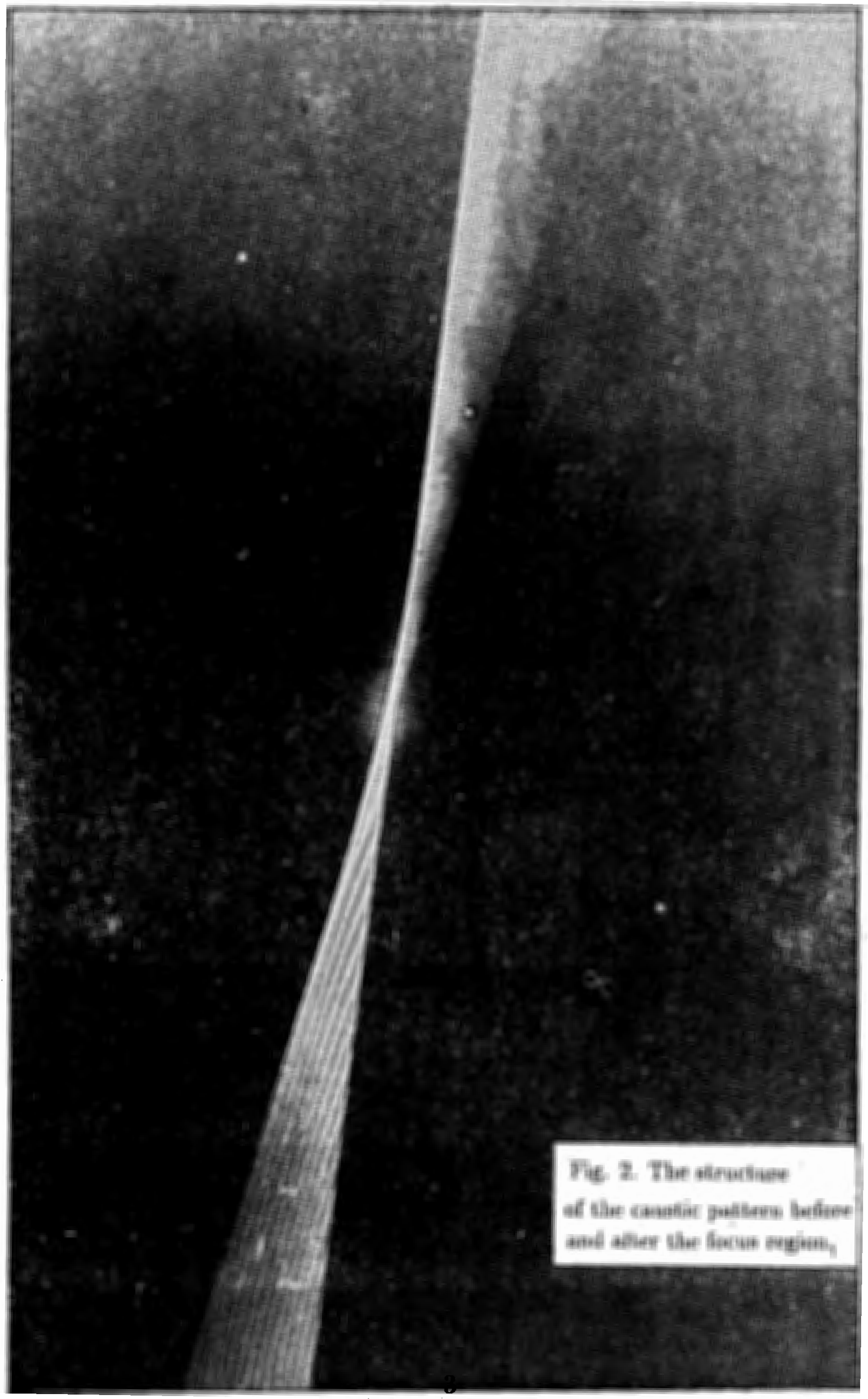


Fig. 2. The structure of the caustic pattern before and after the focus region.

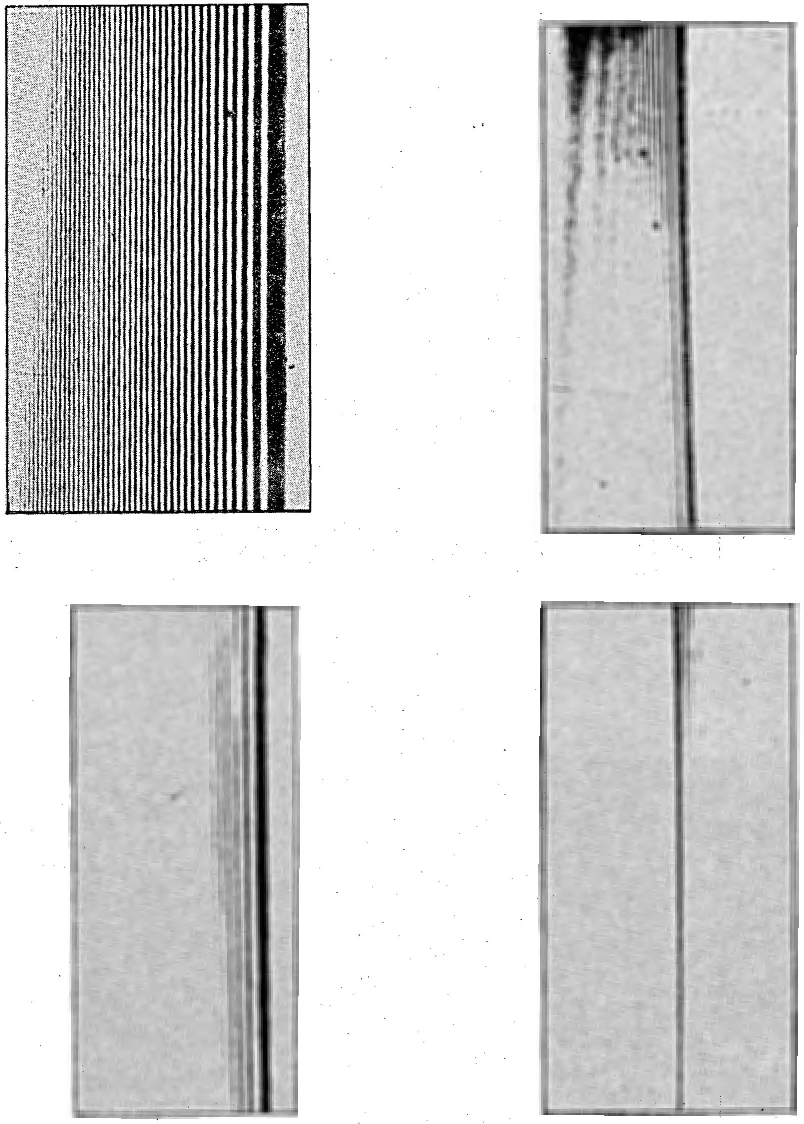


Fig. 3. The microscopic structure of the edge of the caustic pattern, shown in Fig. 2, for several positions of the registration plane relative to the focus region.

Fig. 4. Direct photomicrograph of the caustic pattern in one position of the photofilm.

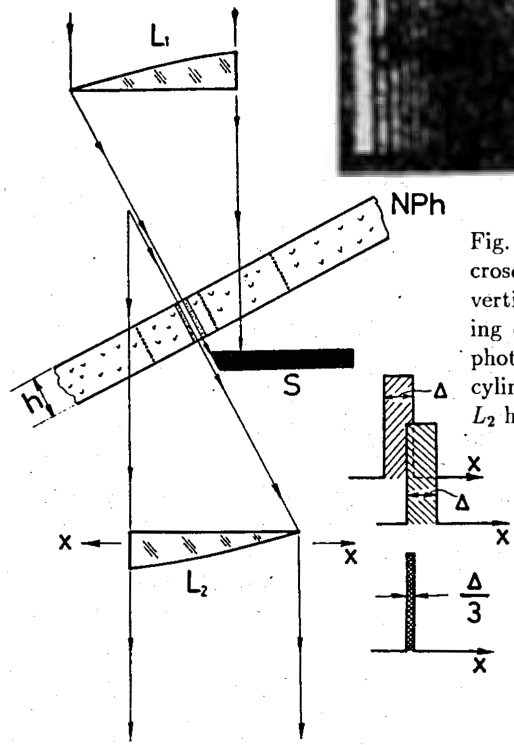


Fig. 5. Confocal caustic meso-optical microscope for selective observation of the vertical particle tracks: L_1 — illuminating cylindrical half-lens, NPh — nuclear photoemulsion, S — stop, L_2 — imaging cylindrical half-lens. The moving of the L_2 half-lens is accomplished along x-axis.

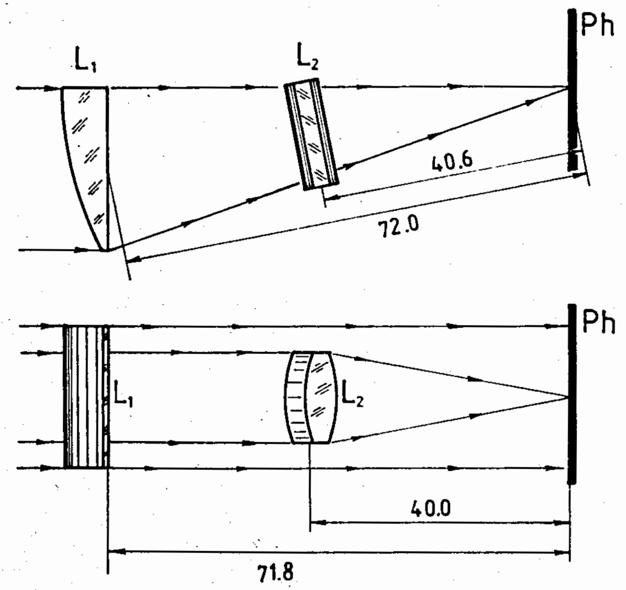
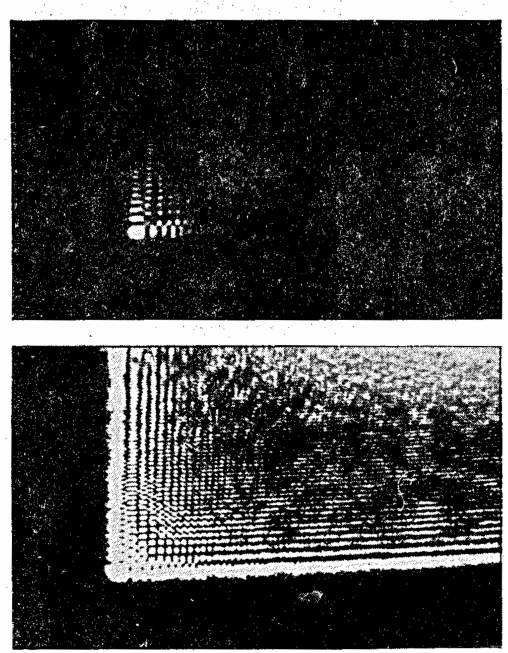


Fig. 6. The experimental setup used for observation of the point-spread function in the system with two crossed cylindrical half-lenses.



a)

b)

Fig. 7. The photos of the point-spread function of the system, shown in Fig. 6, with crossed half-lenses, for two different exposure times.

4 CONCLUSIONS

1. There is proposed a new meso-optical confocal microscope based on the caustic phenomenon and the principle of this microscope is explained.

2. An experiment which illustrates directly the main features of the proposed microscope has been performed.

REFERENCES

1. L.M. Soroko, Commun. JINR E13-95-545, Dubna, 1995

2. Yu.A. Kravtsov, Yu.I. Orlov "Geometrical optics of the non-homonous media". (in Russian) M., Nauka, 1980, c. 33, 88.

Received by Publishing Department
on December 29, 1995.