MICROINTERFEROMETRIC EXAMINATION OF NUCLEAR EMULSION PLATES*

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The photographic emulsion is one of several means of detecting charged particles emitted in nuclear reactions or from radioactive materials, and emulsion technique has developed enormously over the past few years; it is now an invaluable laboratory tool. Whilst the principles of nuclear emulsion microscopy are well established, the application of interference microscopy to the study of nuclear emulsions is new. Although it seems that the interferometric technique would have no real advantage at the present time over the conventional microscopic methods of track examination, it is felt desirable to report some observations on the examination of tracks by interferometry and to suggest some lines of possible investigation.

Nuclear tracks are delineated by grains of developed silver oriented in the dry gelatin layer after photographic processing, and the resulting heights and depths in the emulsion are clearly revealed by the interference microscope. One disadvantage of the method when used in reflection is that it is only applicable to tracks very near the surface of the emulsion where the developed silver grains are slightly exposed. This limits the method to those experiments where tracks enter the emulsion at near grazing incidence. However, if a

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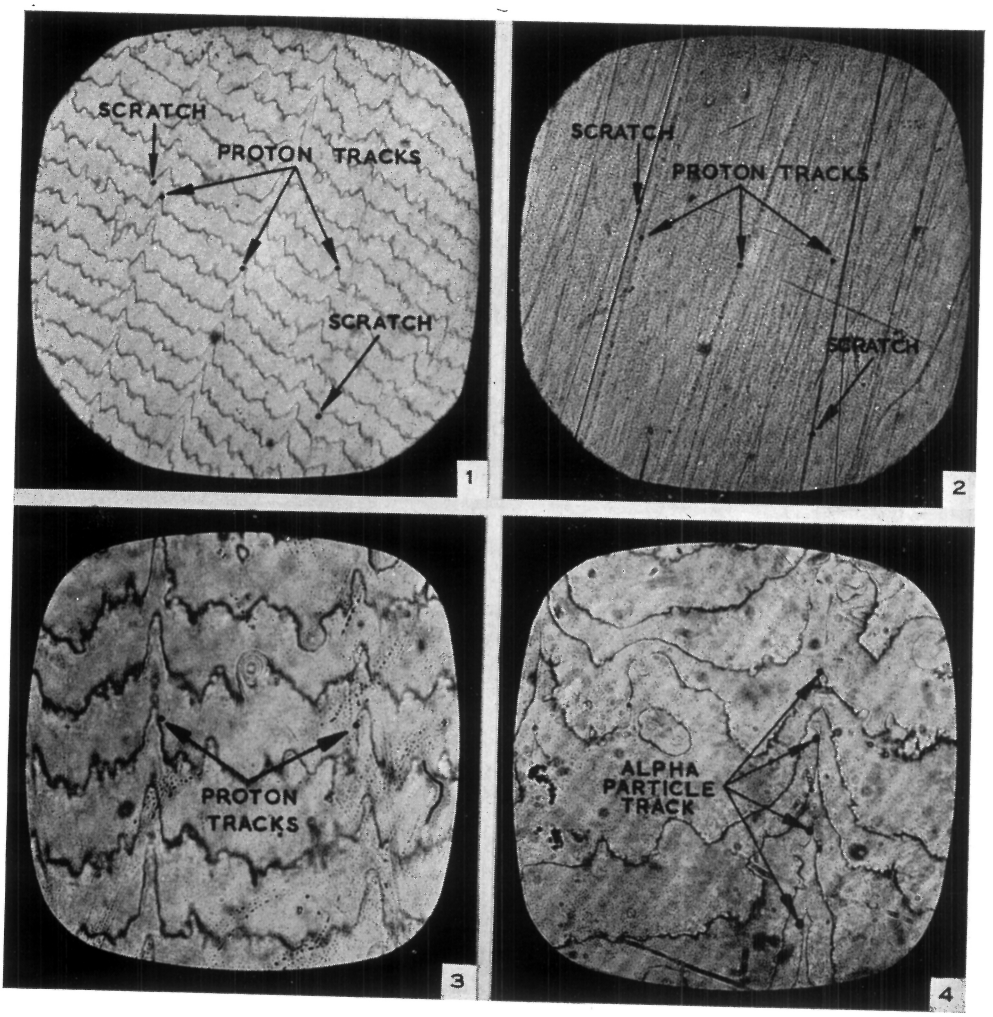

Fig. 1.—Interferogram of proton tracks. Fringes dip opposite ways for tracks and scratches.

Fig. 2.—Proton tracks in emulsion corresponding to Figure 1. (The dark lines are scratches.)

Fig. 3.—Proton tracks in C2 emulsion.

Fig. 4.—α-Particle track and local distortion in D1 emulsion.

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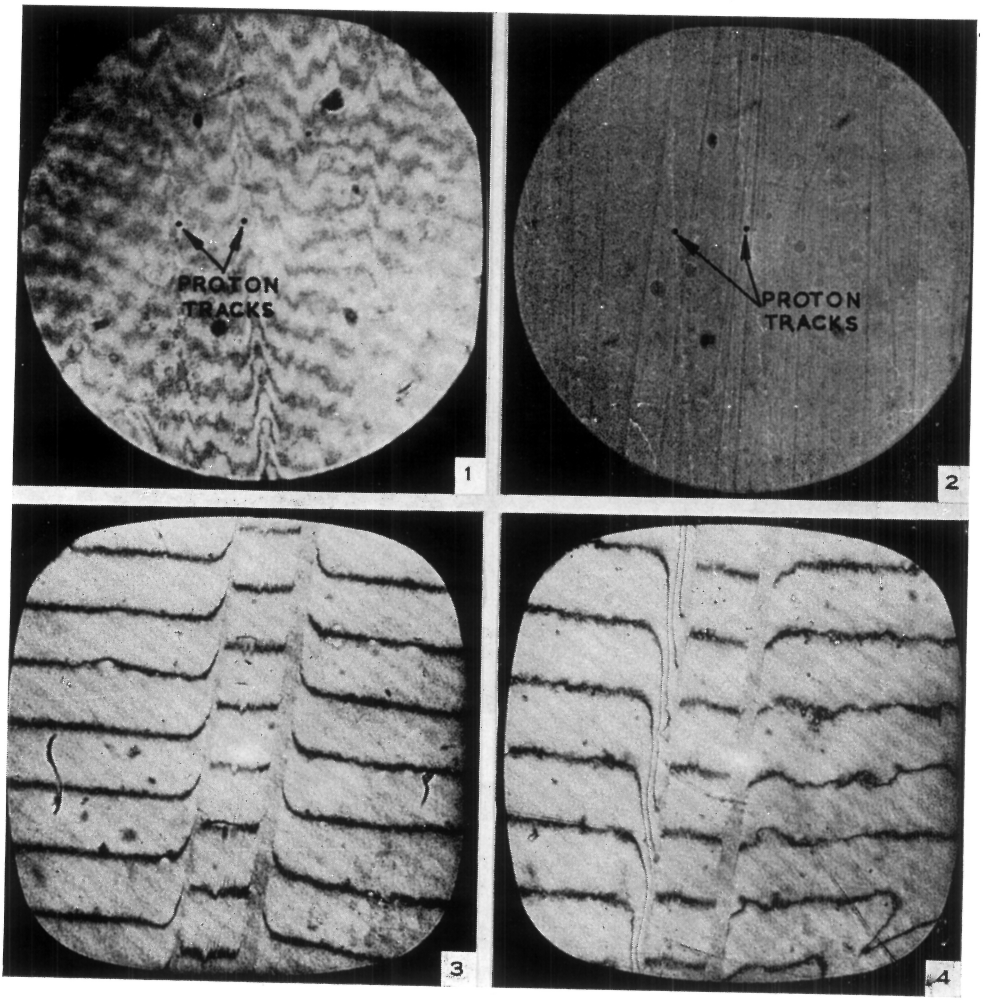

Fig. 1.—Two-beam interferograms of proton tracks.

Fig. 2.—Proton tracks corresponding to Figure 1.

Fig. 3.—Interferogram of groove ruled in unprocessed emulsion. Increasing fringe order from bottom to top.

Fig. 4.—Interferogram of groove ruled in plate after processing. Increasing fringe order from top to bottom.

section of emulsion stripped from the glass is examined in a transmission interference system using equal chromatic order fringes, the paths of tracks well below the surface of the emulsion could be examined. Preliminary experiments have indicated that care must be taken in mounting the stripped emulsion so that it is quite flat and free from warping over the region to be examined.

Typical reflection microinterferograms ($\times 51$ in each case) of proton tracks in a lithium loaded Ilford C2 emulsion, and α-particle tracks in a boron loaded Ilford D1 emulsion, are shown in Plate 1, Figures 1–4, and Plate 2, Figures 1–2, together with some corresponding microphotographs also taken in reflection. The fact that the proton tracks in the microphotographs of Plate 1, Figure 2, and Plate 2, Figure 2, appear black and white respectively is due only to a slight out of focus effect. Using a Linnik interference microscope much higher surface magnifications can be obtained if required. Apart from distortion, there seems to be a small difference between the types of interferograms from α-tracks and from proton tracks. The α-tracks examined seem to give much sharper and longer peaks in the fringe pattern. The plates were vacuum coated with silver to 80 per cent. reflectivity. Actually silvering is not strictly necessary, since two-beam fringes can be obtained from the unsilvered plate as shown in Figure 1 of Plate 2.

The tracks usually have certain dip angles which can be measured in the conventional manner of change of focus and, if the angle of dip is known, the grain size along the track can be found from the microinterferogram. This could possibly serve to help distinguish between different types of particles, especially those of high ionizing power where " clogging " is observed and the tracks form a continuous line, making it impossible to measure density of ionization by grain counting. If the plates receive grain-gradation development (Van der Grinten 1948) in order to increase the differentiating power, then the interference technique combined with this method should be capable of easily differentiating between particles and simultaneously providing the range-energy curve, since the size of the grain agglomerations is given by the fringes and the mean size of a single developed grain is approximately $0{\cdot}3\ \mu$. The method of grain gradation does not seem to be widely accepted but has on several occasions given very useful information (Yagoda 1949).

A possible improvement in the accuracy of measurement of the angle of dip of nuclear tracks would be introduced by adapting the principle of the optical coincidence gauge (Gardner and Case 1931) to the measurements of change of depth. The most obvious instrument for making these measurements is the ordinary microscope with a fine focusing micrometer attachment as is used in conventional nuclear research microscopes. However, there is a lack of precision arising from depth of focus unless an objective of large numerical aperture is used, in which case the working distance becomes very small. The optical coincidence microscope described by Gardner and Case is similar in principle to a range-finder and the precision is intermediate between that of a screw micrometer and an interferometer.

Multiple beam interferometry or even two-beam interferometry can be used to obtain an accurate measure of the shrinkage factor of an emulsion and its variation with humidity and other factors, if part of the plate is left unprocessed and a groove ruled across the plate through the treated and untreated emulsion. A typical multiple beam microinterferogram of the groove in the unprocessed emulsion is shown in Plate 2, Figure 3, and that for the processed emulsion in Plate 2, Figure 4. The groove was ruled with a ruling tool 0·008 in. wide in this case. The shrinkage factor can be calculated by measuring the groove depths from observations of the fringe fractions in three different wavelengths. Small changes in the shrinkage factor can be determined quite readily in this way. Although the high accuracy thus obtained is not warranted in conventional practice, it may become of importance when more precise measurements are required.

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References

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