and which resemble landscapes in Utah, while J. A. Hudson (Harwell) had laboriously obtained three-dimensional pictures of collision cascades using the field-ion microscope. The theorists in both these fields, but in sputtering in particular, left the conference somewhat chastened. At the end, despite the very considerable progress that had been achieved, delegates felt there was much to be done before the conference reconvenes in Sweden in two years time.

QUANTUM THEORY

## Photons that didn't

from a Correspondent

QUANTUM theorists can breathe again, it seems. The failure of Y. P. Dontsov and A. I. Baz' in 1967 to detect the celebrated self-interference property of photons has been checked by G. T. Reynolds and colleagues at Princeton University and the Brooklyn Polytechnic Institute, who have found that the apparent lack of the expected interference pattern can be explained by signal to noise arguments which they have shown to be consistent with other work on pattern recognition (*Nuovo Cimento*, **61**, 355; 1969). The illustration shows a section of the characteristic circular fringe pattern obtained in the latest work with a very high image intensifier gain. P. A. M. Dirac, in his classic book, showed that a single photon, unrelated in any way to others, should be capable of interfering with itself (*The Principles of Quantum Mechanics*, Oxford; 1947), a remarkable property when considered classically. Optical interference has provided experimentalists with a useful tool for examining the quantum mechanical aspects of the properties of photons—in particular, the interesting phenomenon of photon self-interference.

Since the early part of this century several physicists have performed experiments at ever decreasing photon intensities in the "single photon" situation. Two criteria can be used to determine the limit of low intensity in this context; one is that the coherence lengths of the photons in such a beam must not overlap and the other that only one independent photon must be in the interferometer at any time. In both cases the upper limit of photon flux for a meaningful test of the proposition is about $10^9$ photons $s^{-1}$. These low intensities have to be produced by emission from a low density source of excited atoms because simple filtering of the output of a high density source does not preclude the production of groups of correlated photons by some atomic coupling effect in the source. G. I. Taylor (*Proc. Camb. Phil. Soc.*, **15**, 114; 1909) photographed needle diffraction using a flux of about $10^6$ photons $s^{-1}$, well below the limit mentioned; interference was clearly observed. Subsequent experimenters managed to reduce the photon intensities by several orders of magnitude and, finally, in 1967, Y. P. Dontsov and A. I. Baz' in the USSR announced that, with an intensity of $10^3$ photons $s^{-1}$, they had failed to observe the expected single photon interference effects (*Sov. Phys. JETP*, **25**, 1; 1967). Their interferometer was of the Fabry–Perot type in which fringes are produced by the interference of multiply reflected beams from two parallel thinly silvered glass plates. They examined these fringes by photographing a suitable image intensifier tube, with which the very small signals were amplified.

The Russian results raised the serious possibility of a basic failure of quantum theory and prompted G. T. Reynolds *et al.* to reproduce the experimental procedure of Dontsov and Baz' as closely as possible to re-check the results and look for effects at even lower intensities. They found that the apparent failure to detect an interference pattern could be accounted for satisfactorily by signal-to-noise ratio arguments.

QUARKS

## The Defendant's Exhibit

FOR those who missed the recent tussle over the existence of the quark, here is a chance to spot the track that Professor C. B. A. McCusker believes is that of a quark. Professor McCusker and Dr Cairns took about 6,000 cloud chamber photographs of the ionization tracks from a shower of secondary cosmic ray particles (*Nature*, **223**, 1097; 1969) and found five


A Wilson high-pressure cloud chamber photograph of the track which is claimed to be due to a quark.

tracks that they attributed to fractionally charged particles. The most convincing of these, according to Professor McCusker, is that shown in the figure (*Phys. Rev. Lett.*, **23**, 659; 1969). Tracks 1 to 5 are believed to come from singly charged relativistic particles. Track *R*, which is said to be parallel to this beam, but appreciably less ionizing, is attributed to a quark with a charge two-thirds that of a proton.