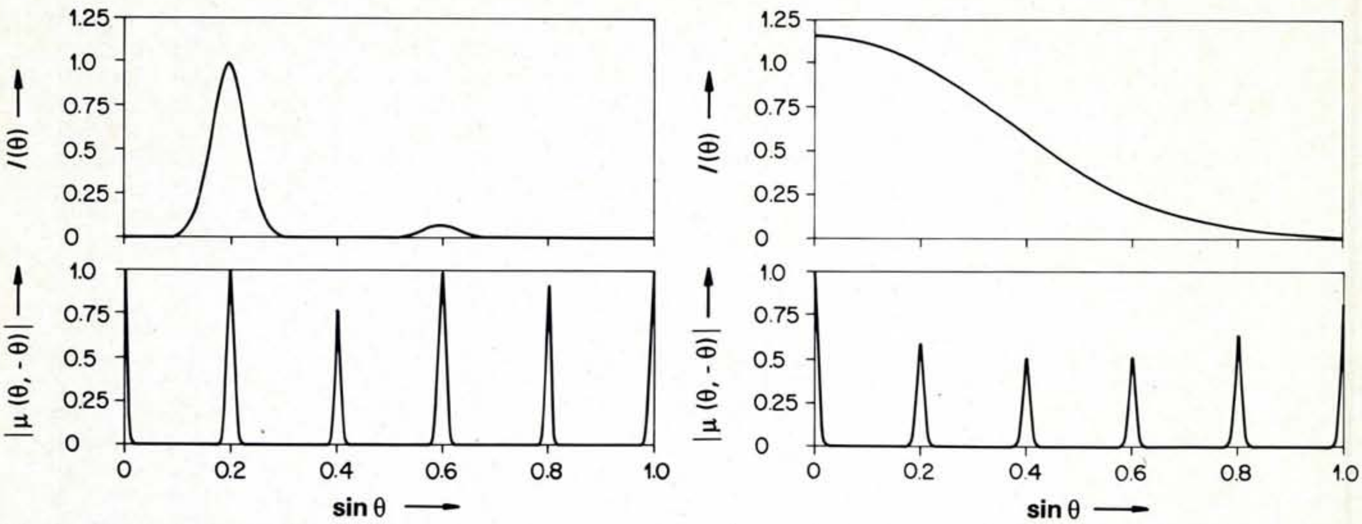


Fig. 4 — Angular distribution of far-zone intensity $I(\theta)$ and degree of coherence $|\mu(\theta, -\theta)|$ of radiation emanating from a lamellar phase grating hidden behind a diffuser. See text for explanation. [After Optica Acta 29 (1981) 169].

cannot be resolved by direct telescope observation.

Phase Gratings Hidden Behind a Diffusor

The situation of a phase grating embedded in a diffuse fluctuating medium or hidden behind a rotating ground glass is somewhat similar to that considered above, the illuminated diffuser acting as the incoherent source of the VCZ theorem. There are, however, two important differences. First, the object to be detected is a phase object. Thus the classical VCZ theorem would yield only a trivial far-zone degree of coherence, furnishing information about the width of the illuminating laser beam, but not the presence of the grating. Second, the diffuser may be characterized by a small, but non-zero correlation length l leading to partially coherent, and not fully incoherent radiation, as required for the VCZ theorem.

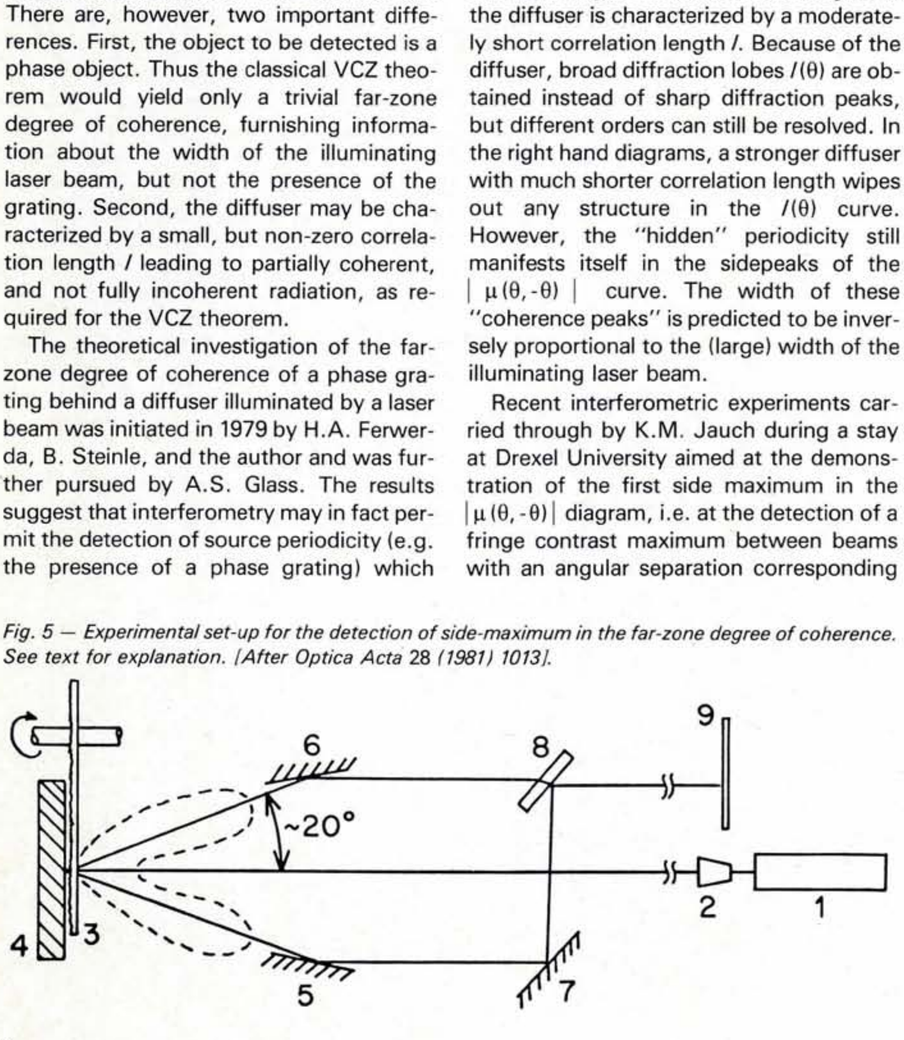
The theoretical investigation of the far-zone degree of coherence of a phase grating behind a diffuser illuminated by a laser beam was initiated in 1979 by H.A. Ferwerda, B. Steinle, and the author and was further pursued by A.S. Glass. The results suggest that interferometry may in fact permit the detection of source periodicity (e.g. the presence of a phase grating) which might be undiscernible otherwise because the radiated intensity is too diffuse.

Typical results are shown in Fig. 4 where the angular distribution $I(\theta)$ of the scattered intensity in comparison with the absolute value, $|\mu(\theta,-\theta)|$, of the far-zone degree of coherence, in a plane perpendicular to the grating grooves. The period of the underlying phase grating (a lamellar reflection grating) is $b = 5\lambda$, λ denoting the wavelength. In the left hand diagrams, the diffuser is characterized by a moderately short correlation length l. Because of the diffuser, broad diffraction lobes $I(\theta)$ are obtained instead of sharp diffraction peaks, but different orders can still be resolved. In the right hand diagrams, a stronger diffuser with much shorter correlation length wipes out any structure in the $I(\theta)$ curve. However, the "hidden" periodicity still manifests itself in the sidepeaks of the $|\mu(\theta,-\theta)|$ curve. The width of these "coherence peaks" is predicted to be inversely proportional to the (large) width of the illuminating laser beam.

Recent interferometric experiments carried through by K.M. Jauch during a stay at Drexel University aimed at the demonstration of the first side maximum in the $|\mu(\theta,-\theta)|$ diagram, i.e. at the detection of a fringe contrast maximum between beams with an angular separation corresponding to that between the first and minus first diffraction orders of the underlying grating. The results are in accordance with the theoretical predictions. A typical experimental setup is shown in Fig. 5. It consists of a laser 1, a beam expander 2, a rough surface 3, a grating 4, mirrors 5, 6, 7, beam splitter 8 and an observation screen 9. In particular, the width of the $|\mu|$ peak was found to be inversely proportional to the beam width as predicted.

An alternative way of detecting the hidden grating would be to measure the degree of far-zone *intensity correlation* by a photo-counting experiment.

Fig. 5 — Experimental set-up for the detection of side-maximum in the far-zone degree of coherence. See text for explanation. [After Optica Acta 28 (1981) 1013].



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5. See e.g.: Klauder, J.R., Sudarshan E.C.G., *Fundamentals of Quantum Optics* (Benjamin 1968), or Chap. 5 in Ref. 1.

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