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Rodney C. Greenhow and Robert J. Hull

December 22, 1965

ADJUSTMENT OF NARROW-BAND ULTRAVIOLET FABRY-PEROT INTERFEROMETERS*

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University of California, Berkeley, California

December 22, 1965

The use of narrow-band dielectric reflection coatings on Fabry-Perot interferometer plates gives rise to difficulties in adjustment of the interferometer, when the reflectance of the coating is peaked in the uv (or ir) region of the spectrum. The usual method of adjustment is to set the interferometer coaxial with a positive lens, in the focal plane of which is a monochromatic light source. Then, with the eye focussed on infinity, the circular fringes in the transmitted light are viewed, and the plates of the interferometer adjusted until movement of the eye in a plane parallel to the plates causes no apparent change in size of the rings.

The method breaks down with narrow-band plates for the uv, because the reflectance in the visible part of the spectrum is frequently little more than that of uncoated quartz. The contrast of the fringes may then be so low as to render them invisible. The situation is further aggravated when long spacers are used, so that the rings have small angular separations.

Matters are greatly improved, however, if the fringes produced in the reflected light are viewed. This can easily be achieved by placing a beam splitter at 45° to the optic axis, between the lens and the interferometer. As is well known,[1] these reflection fringes are the complement of those in the transmitted light. The expression for the intensity of the transmitted light as a function of the phase difference $\delta = (4\pi/\lambda)\, nt \cos\theta$ is

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$$I = \frac{I_0}{1 + [4R/(1-R)^2]\sin^2 \delta/2} .$$

Thus we have $I_{max} = I_0$ and $I_{min} = I_0 / \left\{1 + [4R/(1-R)^2]\right\}$, so that the contrast I_{min}/I_{max} is equal to $[(1-R)/(1+R)]^2$, R being the reflectivity of the coatings. Any absorption in the coatings affects the intensity of transmitted and reflected light, but not the contrast. For R = 0.1 the contrast is 0.82, and the visibility of the fringes $(I_{max} - I_{min})/(I_{max} + I_{min}) = 0.1$. Since the fringes in the reflected light are the complement of those in the transmitted light, we have $I_{min} = 0$, and the visibility is 1. (See Fig. 1)

We have used this method in practice, and the above photographs give a good representation of the improvement gained. They were made using the Hg green line 5461 Å, and interferometer plates[2] coated so that their peak reflectance was at 2537 Å. The spacer was 28 mm, and the fringes were projected with a 200-mm lens. A 12X enlargement was made.

There is a further advantage to be gained by using the beam splitter for alignment of a Fabry-Perot interferometer, when it is to be used in conjunction with a spectrograph, or a pinhole for scanning (or both). In these cases the fringes must be projected so that they are centered on the slit or pinhole. Use of the beam splitter enables one to see an image of the slit or pinhole superimposed upon the fringes. The projection lens can be focussed approximately by parallax methods so that there is no relative motion between the image of the slit and fringes, and then the orientation of the interferometer can be adjusted so that the fringes are centered on the image of the slit. If, in addition, a light source is placed at the plate-holder of the spectrograph, the appearance of a brightly illuminated slit gives assurance that the interferometer, light source under investigation, and lenses are aligned upon the axis of the spectrograph.

References

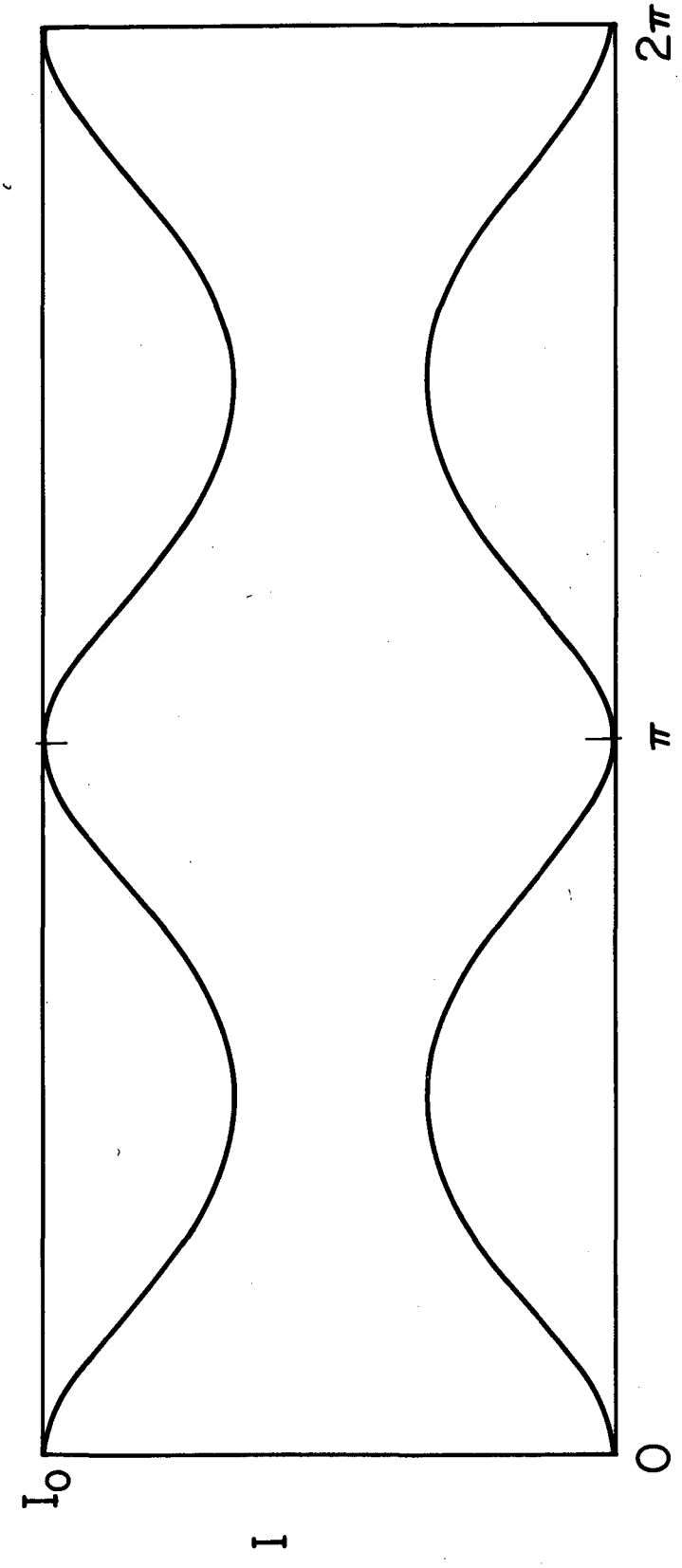
1. F. A. Jenkins and H. E. White, Fundamentals of Optics (McGraw-Hill, New York, 1957), 3rd edition, p. 273.

2. S. P. Davis, Applied Optics 2, 727 (1963). The plates labeled $(UV)_1$ in this article are those under consideration.

Figure Legends

Fig. 1. Intensity of light transmitted (upper curve) and reflected (lower curve) by Fabry-Perot interferometer. These curves are plotted for a reflectance R = 0.1.

Fig. 2. Photographs of fringes in (left) transmitted and (right) reflected light.



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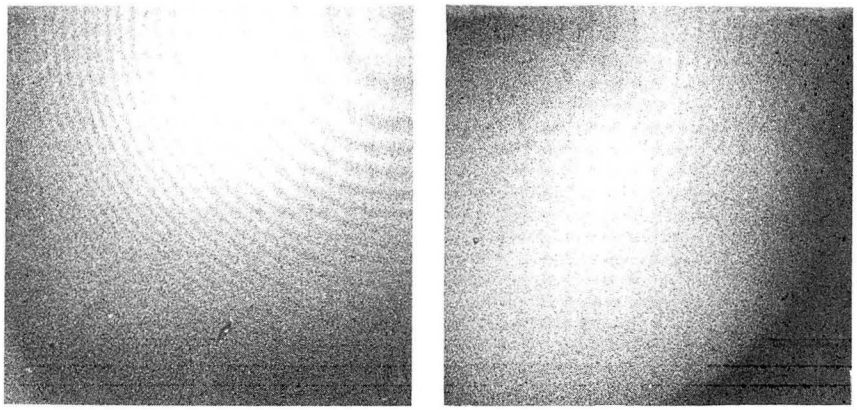

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