Photometric setting methods in interferometry

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S U M M A R Y

In this thesis an improvement of the setting accuracy in two-beam interferometry by the application of photometric setting criterions is investigated. Two methods are discussed. The first is a typical half-shadow method due to Kennedy who applied it first about thirty years ago in a repetition of the Michelson Morley experiment. The second photometric method followed from a suggestion by Prof. Zernike. Use is made of three-beam interferences. For this purpose one of the interferometer mirrors is replaced by a so called wedge-mirror. It consists of a transparent wedge-shaped layer sandwiched between an opaque metal layer and a semi-transparent metal layer and returning two beams of equal intensity which form a reference interference pattern consisting of common parallel fringes of equal thickness. Upon this pattern the other beam of the interferometer (measuring beam) is superimposed In general the fringes of the reference pattern are alternately reinforced and weakened. At a certain phase of the measuring beam their intensities are equal and this constitutes the setting criterion.

In chapter 1 the photometric methods are discussed in detail and the setting accuracy attained is compared with the one of a common method of pointing at a fringe with a fiduciary mark. For an adequate investigation of the setting accuracy the conditions of observation must be taken into account. For visual work these conditions can appropriately be described by stating the visual intensity, the visibility and the wavelength used. The dependence of the setting accuracy upon these quantities is investigated experimentally. Under favourable conditions a setting accuracy of 0.002λ can be attained with the half-shadow method and an accuracy of 0.003λ with the three-beam method.

The instrument used in the present investigations is described in chapter 2. Constructional details of the mirror supports are given and different types of beamsplitters are discussed. The most important part of the interferometer is a Jamin compensator where instead of glassplates mica sheets of high optical quality are used as compensator plates. The compensator enables the ad-

justment of path-difference with a precision of a few thousandths of a wavelength, within a range of five or six wavelengths. The accurate measuring methods revealed a systematic error of about one hundredth of a wavelength which has as far as we know not been noticed before and indeed would have been almost undetectable with the common methods. The effect proved to be due to internal reflections in the compensator plates and could be eliminated by a reflection reducing coating.

In chapter 3 the preparation of the wedge-mirrors is treated together with preliminary experiments on very thin metal layers. The interference pattern formed in the wedge-mirror is required to be a true two-beam pattern and this can only be achieved if the internal reflectivity of the front coating is very nearly zero. At the same time the outer reflectivity must be equal to the reflectivity of the back coating times the square of the transmission of the front layer. It is shown that once the thickness of the front layer is chosen so as to make the internal reflectivity very small, the second requirement can be fulfilled by the proper choice of the refractive index of the wedge material. Two types of wedge-mirrors are discussed, one in which a glass plate is used as a wedge and one in which an evaporated layer is used. The first type is to be preferred on account of its simplicity and chemical and mechanical resistivity.

The application of the sensitive photometric methods necessitates the consideration of the effects of finite aperture in the Michelson-Twyman interferometer. These effects are treated in chapter 4. In the case of a circular aperture the calculations are given in a general form including also the effects of localisation of the interferences. A relation to diffraction phenomena analogous to the theorem of van Cittert is indicated.

With the present interferometer a rectangular entrance stop is used. With the photometric setting methods no use is made of localised fringes. The effects of collimation in this case are treated by Bruce and Thornton (1955) and are here extended to an uncompensated interferometer. It is shown that in this case the calculations for the compensated interferometer can be used if only the shape of the entrance stop is properly chosen. An experimental verification of the collimation effects on visibility and fringe-shift is given.

In chapter 5 the photometric setting methods are applied for an investigation of small isotopic fringe shifts caused by impurities in single isotope mercury lamps. The effects could however not be detected with certainty, although the presence of the impurities was evident from the visibility curves of the radiations investigated.