SPECTROSCOPIC INVESTIGATION OF A BIREFRINGENT LYOT-FILTER FOR H$_2^*$

MARINA KRAFFT
Fraunhofer Institut, Freiburg i. Br.

(Received 3 May, 1968)

Abstract. The instrumental profile of a Lyot-filter with 0.5 Å pass-band for H$_2$ has been determined from photographic spectra obtained with a large grating spectrograph and a continuous light source. After line adjustment of the filter, the transmission profile in parallel light agrees closely with the theoretical profile as given by crystal optics. The peak transmission has been found to be 12% of the incident unpolarized radiation.

Convolving the measured instrumental profile with the average solar spectral distribution near H$_2$, it can be shown that the parasitic light (transmission outside the main pass-band) contributes 10% to the total light flux with the filter centered on the line. At wavelength shifts of 0.5 and 0.8 Å, the parasitic light contribution is 25% and 40%, respectively.

The deformation of the line-profile of various solar phenomena (faculae, filaments, flares) by the instrumental profile is discussed quantitatively.

1. Introduction

Until recently Lyot-filters have been used mainly for qualitative investigations; HOUTGAST (1959) was the first to determine quantitatively the instrumental profile of a filter with 0.75 Å pass-band. He used his results to obtain flare intensities. Similar results have been published by HAMANO and SUZUKI (1967).

The total intensity of the light passing through a filter is

$$ E = \int_0^\infty I(\lambda) \cdot A(\lambda) \cdot d\lambda $$

where $I(\lambda)$ is the intensity distribution of the solar spectrum and $A(\lambda)$ the instrumental profile or the transmission curve of the filter. For the application of the filter as a spectroscopic device the instrumental profile and its variation with wavelength shift must be known. It is further necessary to know, for every filter, the deviation of the actual from the theoretical transmission curve. To keep this difference small becomes increasingly difficult for smaller pass-band. Already the homogeneous heating of the different crystal elements poses considerable difficulties: to establish the transmission curve within 0.01 Å, the temperature must be kept constant within 0.03°C. Calculations of GIOVANELLI and JEFFERIES (1954) have shown that the error of alignment between the crystal axis and the polarizer can be ignored if it is less than 0.5°.

Section 2 contains a description of the investigated Lyot-filter (B. Halle, Berlin).

* Mitteilungen aus dem Fraunhofer Institut Nr. 82.

The procedure of measurement and the spectroscopic results are given in Sections 3 and 4.

2. Design of the Filter

A detailed description of the principle and the functioning of a Lyot-filter is given in papers by Lyot (1944) and Evans (1949). The investigated filter is centered on 26562.8 Å and has a pass-band of 0.5 Å. The filter consists of 10 elements. The 6 optically thinner ones are made of quartz, the 4 others of calcite. The contrast-element is of calcite. From the obtained results it must be concluded that the contrast-plate is a second 1 Å-element (in Lyot's original design the 'lame supplementaire' would consist of an 0.75 Å-element). The sheet polarizers are cemented with balsam between strain-free plano-parallel glass plates. The filter elements are put together with silicon oil. All glass-air surfaces are coated for Hz. The free aperture of the filter is 30 mm. As prefilter a dielectric multilayer interference filter is used, which eliminates all the neighbouring pass-bands. By removing the entrance polarizer, the pass-band of the filter is increased to 1 Å. The 5 calcite elements (including the contrast-plate) and the thickest quartz element are constructed as wide-field-elements, thus permitting an inclination of the beam of ±1.6°. The 8 optically thinner elements are split-elements. By virtue of this the number of polarizers is reduced from 12 to 8. The two thickest calcite elements as well as the contrast-element are equipped with line-shifters with a tunable range of ±1 Å.

In order to obtain a homogeneous distribution of temperature, the filter elements are mounted in a brass tube which is heated from outside. The temperature is controlled by a thermostat using a bridge circuit, one branch of which is a NTC-resistor. The temperature can be read on a thermometer within 0.05°C. Fluctuations of the order of ±0.1°C have been observed.

3. Method of Investigation

The instrumental profile has been measured with the large Schauinsland-spectrograph (Littrow-arrangement) of the Fraunhofer Institut. The focal length is 712 cm, the Bausch-and-Lomb grating has a ruled area of 154 mm × 206 mm, with 600 lines/mm and a blaze angle of 49°. The measured resolving power in the 4th order is about 500000 (Göhring, 1967).

The filter was used in parallel light in front of the spectrograph. A zirconium arc lamp was used as light source. Spectra were taken covering a spectral range of 12.6 Å. Using such a small range is justified by the fact that the transmission of the side-bands at greater distances from Hz lies below the useful recording limit of 0.2%. Kodak IV-E film was used and processed in Kodak D 19b (5 min, 20°C). To determine the wavelength of the pass-band, the Hz-line of a hydrogen Geissler-tube was included on each exposure as reference. Photometric calibration was done by means of a step-wedge and a neutral filter of known transmission which covers half of the step-filter. The characteristic curve for each film was thus determined by using a procedure