Observations of the Solar Corona in Polarized White Light During the Total Solar Eclipse of February 16, 1980: Preliminary Results

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Abstract. Photographic observations of the corona were made by a Belgian expedition to Kenya during the eclipse of 1980, February 16, using a polaroid filter oriented in three directions 60° apart. The preliminary results of the reduced data are presented here; these results consist in the analysis of the three following parameters: total intensity, degree of polarization, direction of the electric vector. The local variation of these parameters reveals, among other features, a deep coronal hole at the south pole and peculiar streamer (P.A. 280°) associated to a transient, (the so-called 'tennis racket') also observed by other teams, and a density enhancement at P.A. 200°, possibly associated with a transient observed with the K-coronameter of the High Altitude Observatory 12 hr before the eclipse.

1. Introduction

Since the first scientific observations of the solar eclipses during the XIXth century, most of these events have lead to scientific records intended to the study of the corona and, particularly, its K component (associated with electronic scattering). A large amount of information has been collected; – an extended compilation was published by Hata and Saito (1966). However, the variable quality of the observations, owing to the technology of each epoch, are, for the most, only partially usable to establish reliable coronal models.

Meanwhile, a succession of theoretical models of the global corona have been proposed, with an increasing degree of complexity, going from Baumbach (1937) (pure spherical symmetry) to Van de Hulst (1950) (mixing of the spherical and cylindrical symmetry), and Saito (1970a) (minimal constraint of axial symmetry). This discrepancy between the advances in the theory and the observations prevented any major breakthrough in the domain of the physical study of the mean corona associated with the eclipse observations. For instance, a basic prediction of Thomson scattering by free coronal electrons has not been verified with certitude, i.e. the orientation of the polarization vector parallel to the solar limb, seldom analyzed owing to the higher complexity of the observing apparatus (see for instance Saito, 1970b; Koutchmy and Schatten, 1971, Sazanov, 1972; Kishonkov and Molodensky, 1975).

Moreover, the high quality and large amount of data that must be collected and analyzed to establish a model corona, using the method of Saito, prevented until a few years ago (mostly by the lack of the handling capacity of the computers) the use of such a complex representation.

Technical improvement of the quality and standardisation of eclipse observations, a
wider use of computer data processing, and theoretical progress allow an extension of our knowledge of the coronal medium.

In that respect, the eclipse observations will remain, in the next future, complementary to the developing satellite observations owing to their high image spatial resolution, high resolution in intensity measurements and chiefly to their wider coverage of the corona (especially the internal corona around and below $1.1 R_\odot$).

Among the contributions brought by eclipse records, besides the extraction of zonal deviations in the physical state of the corona (see among others Dollfus et al., 1974; Bohlin and Garrison, 1974; Kurokawa, 1975), the determination of the global electron density distribution (the "background corona") would bring a valuable basic working reference to the radioastronomy and the initial conditions for the study of the solar wind. The purpose of the observations and analysis described in the following sections is to determine the complete set of the linear polarization parameters as a basis for a future computation of a global density distribution. We also report hereafter structural peculiarities already revealed in the corona at this state of the reduction.

2. The Observations

The total solar eclipse of February 16, 1980 occurred when the Sun was very near the last maximum of its sunspot activity cycle. A Belgian expedition to Kenya (EAGB80: Expédition Astrophysique et Géophysique Belge) was organized in order to observe, among other features, the polarized white light of the $K$ corona. For this purpose, photographic images of the corona were taken on a Kodak Plus X emulsion, using a reflex camera mounted at the focal plane of a 1 m focal length and 70 mm aperture compact equatorial refractor. The analyzer was a polaroid filter placed a little in front of the focus, which could be oriented in three directions $60^\circ$ apart ($0^\circ$ corresponding to the north pole of the Sun).

Two sets of observations were performed, consisting respectively of 2 s and 4 s exposures, but because of the rapid saturation of the Kodak Plus X emulsion at the limb vicinity, only the 2 s set was used for the reductions. From this set, five sequential groups of exposures corresponding to the three basic orientations of the analyzer ($0^\circ$, $60^\circ$, $120^\circ$) were constituted (Figure 1).

For every group, the three directions of polarization observed allow calculation without ambiguity of the three parameters characterizing the linear polarization, i.e. the degree of polarization, the orientation of the maximum electric vector (defining the plane of polarization) and the total intensity.

3. Reduction of the Observations

The reduction of the films was carried out using a Joyce and Loebl scanning isodensitograph. The isodensitograms, presenting 45 density levels, were then centered on the solar disc and oriented accurately to allow for point to point comparison. In the next step, we performed some calibration in order to establish the characteristic curve of the