Interferometric investigations of the solar corona during solar eclipses and problems for the future

A. Delone, M. Divlekeev, O. Smirnova and G. Yakunina

Sternberg Astronomical Institute, 119899 Moscow, Russia

Received: November 25, 1998

Abstract. Results of interferometric observations in the red corona over eclipses are shortly discussed, and future observations proposed.

Key words: solar corona – interferometer – line profiles

1. Results

For the first time Fabry-Perot interferometer was used by Kalinjak for the observation of the 1941 solar eclipse. After that, Jarrett and von Klüber used this method for the measuring of the line width over eclipses in 1954 and 1958.

The task of motion detecting in the solar corona was set in Sternberg Astronomical Institute before the 1963 eclipse. An instrument with Fabry-Perot interferometer was constructed in our Institute. It gives a possibility to obtain coronal line profiles simultaneously in many points of the corona picture with the arm of measuring of Doppler shift of profiles or their components (Figure 1). In used optical scheme interference picture is localized in the same plane in which the corona image. The first result was obtained during the 1965 solar eclipse. Some profiles in λ 6374 Å (Fe X), having irregular shape, could be well presented as a sum of Gaussians. Sometimes, an additional profile outside the main ring was detected on the radial section through the ring system.

These shifted profiles have been interpreted by authors as displaying of line-of-sight velocities. The interferometric rings are superimposed on the background, caused by the light of the white-light corona, passed through the interference filter-premonochromator, and being comparable by its intensity with the rings. The structure of the light background affects on the intensity dependence along the radial section.

Influence of the contribution of the white-light corona intensity inhomogeneity has been evaluated on the base of the data of 1972 and 1981 eclipses (Delone et al., 1988). Quarter of the shifted details on the radial sections might be the consequence of the white-light corona intensity details.

Velocities data, obtained during several eclipses since 1965 to 1997 are shown in Table 1. Influence of the distribution of the white-light corona intensity has been taken into a consideration. In spite of the fact that great velocities have

Contrib. Astron. Obs. Skalnaté Pleso **28**, (1999), 268 – 271.

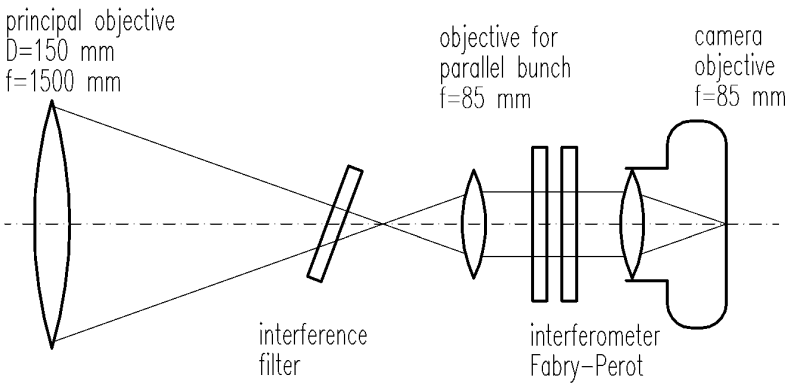

Figure 1. The optical scheme of the device. During the 1997 eclipse, premonochromator was a replaceable interference filter: 1. λ6374 Å, FWHM = 15Å. 2. H_α, FWHM = 10Å. The Fabry-Perot etalon with an air-spacing of 0.3 mm. The instrumental profile FWHM is 0.5Å, free spectral range 6.7Å. The image of the corona and interference rings are localized in the same plane.

been observed during many eclipses, their existence is argued to the present. In last years was made a supposition, that profile components, shifted by velocities, do not belong to the coronal line, but to the weak emission in the H_α line, passed in the wing of the interference filter-premonochromator.

Table 1. The number of case (N) with the line-of-sight velocity, V (km/s)

Data	λ	N				
		V=15-45	46-75	76-105	106-145	145-175
1965	6374	60	4	13	1	0
1968	5303	225	66	80	19	0
1972	6364	230	230	230	130	92
1981	5303	67	34	8	0	0
1990	5303	73	53	19	8	0
1997	6374	72	14	15	0	0

A horizontal solar instrument with a single coelostat mirror and Fabry-Perot interferometer has been used during the 1997 eclipse. The diameter of the solar image was equal to 16 mm. Coronal images were obtained with the exposure of 10 seconds on the film A-700. Its sensitization was made in hydrogen vapor. Interferograms in λ 6374 Å and H_α were obtained consequently by replacing of two interferometric filters used as premonochromator. Film treatment was made automatically on densitometer AMD, connected with a computer.

Line profiles in many cases, measured along the radial section of interferograms, were a sum of Gaussian components with different wavelength shifts, which indicated on the existence of coronal formations with line-of-sight veloci-

ties (see Figure 2). On the west side, the corona emission in the Fe X occupied a region between P = 285° and P = 310°, partly coinciding with the position of the prominence (P = 285°) and partly situated between prominences (P = 285°) and (P = 315°). Interferometric rings were measured to the height of 1.2 $R_\odot$ above both the east and west limbs. In the vicinity and above the image of prominence 2 there are seen H_α rings of cool coronal component, so named 'weak H_α' (Dermendjiev et al., 1994). H_α profiles show also existence of moving details in the cool corona. Values of line-of-sight velocities in H_α are similar to Fe X (λ 6374 Å) ones. Full H_α line profile widths increase with the height too.

Since profile widths depend on both the temperature and turbulent velocities, we can evaluate 'cool corona' temperature only if we will do a supposition about velocity values. If turbulent velocity in the corona is the same as in the prominence, situated beneath, then temperature in the 'cool' corona will be 43 000 K. As a limit case, if turbulent velocity will be supposed to be equal zero, then we could obtain that temperature in the H_α corona region is of 100 000 K.

From widths of shifted components of the Fe X line profile it is possible to evaluate dimensions of moving formations in the corona. A half of profiles is narrower than it ought be for the temperature range of the 6374 Å emission (from 0.7×10^6 K to 1.6×10^6 K). Major contributions of these narrow widths are equal to instrumental profile width. Knowing, that interference rings are located in the same plane as the corona image, the instrumental profile width is about 5″. Therefore, the high limit of the dimension of majority of moving formations in the corona is equal or less than 5″.

A part of coronal material, emitting in λ 6374 Å and having observed line-of-sight velocities, is possible to evaluate roughly. Since difference between the widths of the line profiles, corresponding to stable material and to the corona plasma with Doppler velocities, is not so great, the ratio of full line emissions (equivalent widths) might be replaced by the ratio of maximum line intensities. We suppose, for the first approximation, similar conditions of line excitation (i.e. equal n_e and T_e) in all investigated places of the corona. Since in this height the excitement of the line λ 6374 Å to be result of electron shock $I_\lambda \sim n_e^2$. The part of moving matter is evaluated from the ratio

$$\sum[\sqrt{I_{max}(v \neq 0)}] / \sum[\sqrt{I_{max}(v = 0)}] = 1 : 1,$$

As a result, we obtain, that 50 % of the corona material moves.

During forthcoming eclipse in August 1999 we plan to continue in the investigation of motions in corona regions with different temperatures, namely using two Fabry-Perot etalons. We hope to obtain interferograms in lines of Fe X (λ 6374), Fe XIV (λ 5303), H_α and K_{1V} of Ca II K. Since conditions of excitation of H_α and K_{1V} of Ca II K lines are similar, contribution of temperature and turbulent velocity into the line width can be divided, using the molecular

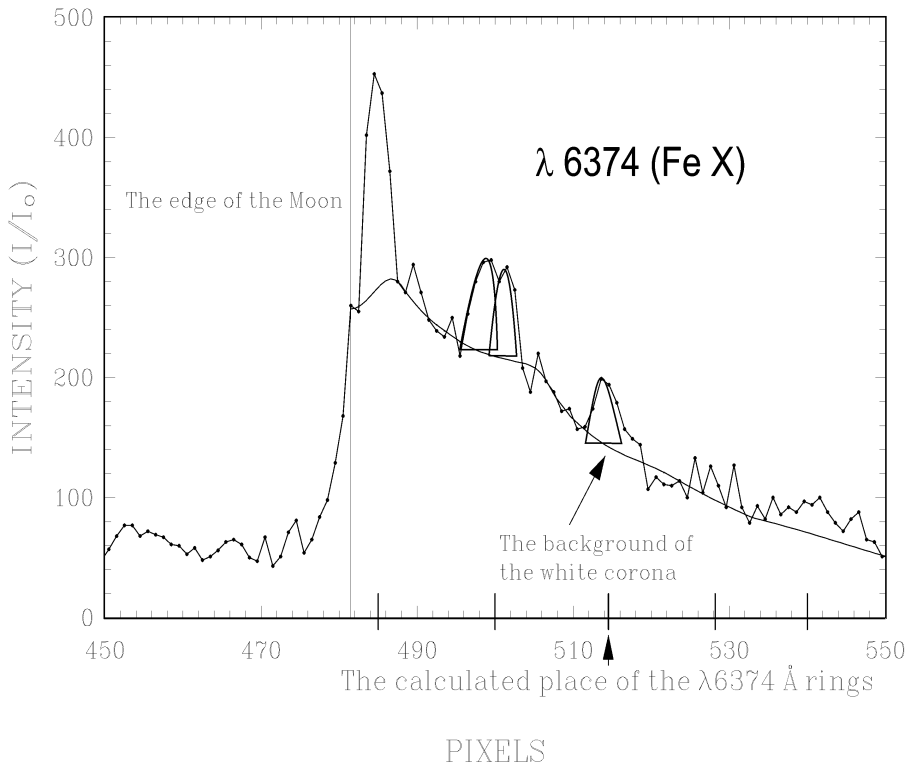

Figure 2. Spectrum measurement on the AMD photometer with an IBM PC, yielding radial photometric cross-cuts through the ring system. The presence of a feature shifted in wavelength implies the presence of coronal structures having a line-of-sight velocity component.

weights difference. This will give us a possibility to make the definition of the 'cool' corona temperature more accurate.

We intend also to superimpose reliably the interferogram with the white-light corona image to remove the influence of the intensity distribution in the last one for concrete points of the interferogram, in order to know in which points we have true velocities.

References

Delone, A.B., Makarova, E.A., Yakunina, G.V.: 1988, *Astron. Astrophys.* **9**, 41

Dermendjiev, V.N., Mouradian, Z., Leroy, J.-L., Duchlev, P. : 1994, *Sol. Phys.* **149**, 267