A MODEL FOR THE NORTH CORONAL HOLE OBSERVED AT THE 1973 ECLIPSE, BETWEEN 1.3 AND 3.2 $R_\odot$

Francoise Crifo and Jean-Pierre Picat
D.A.P.H.E. - Observatoire de Meudon
92 190 - Meudon, France

1. THE OBSERVATIONS

At the 1973 eclipse, S. Koutchmy (Institut d'Astrophysique, Paris) obtained several pictures of the white-light corona, using polarizers and a radially-compensated filter. These pictures provide a very good opportunity for studying the large coronal hole at the north polar cap; this hole has been extensively studied during the Skylab period. On the plates of Koutchmy, we could record reliable intensities between 1.3 and 3.2 $R_\odot$. The absolute calibration was made using the stars observed in the field at the same time. This method allows a direct comparison of well-exposed objects on a same plate and must therefore be highly reliable (see Koutchmy et al., 1978). It is well-known that the absolute calibration of eclipse plates is a difficult problem.

The northern hole was very dark and from the synoptic maps and the X-ray pictures, one can conclude that probably no high-latitude streamers were projected over the hole in the plane of the sky. Intensities in the radial and tangential directions of polarization were recorded in the darkest part of the hole between the visible plumes.

2. DENSITY MODEL

The hole is considered as consisting of a weak background over which plumes are superimposed. We estimate that our intensity represents this background, which we assume to be homogeneous and constant with heliographic latitude. Thus a spherical inversion, with the formulae of Van de Hulst (1950) can be performed. As the density calculated at the highest points in the corona by this method is strongly dependent on the gradient adopted for ($I_t - I_r$), we decided to extend our data by those obtained by Munro and Jackson (1977) from the Skylab coronograph in the same hole, between 2 and 5 $R_\odot$. Although these two curves exhibit exactly the same gradient, the data of Munro and Jackson lie 1.51 times higher than ours; so we divided them by this factor. This choice may be of course questionable but the absolute calibration

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of Koutchmy seems to be very good; the intensities measured by Lilliequist (1977) from his eclipse pictures are close to ours and below those of Munro and Jackson in the region where they overlap.

The intensities are best fitted by the following expressions:

$$(I_t - I_r)/10^{10} \cdot \bar{B}_\odot = 500.r^{-7.565} + 120.r^{-4.245}$$

$$(I_t + I_r)/10^{10} \cdot B_\odot = 700.r^{-4.174} + 208.r^{-2.455}$$

where $\bar{B}_\odot$ is the mean solar disk brightness and r the distance from the sun's center.

The density derived is plotted on Fig. 1, together with the one determined by Munro and Jackson along the polar axis in their axy-symmetric geometry, the density calculated by Koutchmy (1976) in the same hole from a different plate he took at the same eclipse, and the Van de Hulst minimum model.

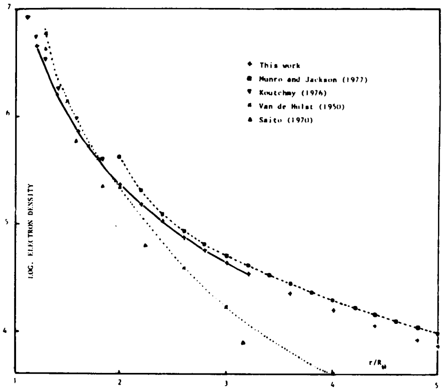

Figure 1. Electron density versus height

3. SOLAR WIND SPEED

Munro and Jackson determined an analytical representation for the shape of the hole's boundary that fits extremely well the eclipse pictures, and even other eclipses (1966 for example). So the surface of the hole is known and the wind speed may be calculated from the equation of mass conservation:

$$Ne(r) \cdot V(r) \cdot S(r) = K.$$

Munro and Jackson calculate the constant K at 1AU:

$$K = \langle Ne \cdot V \rangle_{1AU} \cdot S(1AU)$$

and take a mean value: $\langle Ne \cdot V \rangle_{1AU} = 3.10^{8}\ cm^{-2}\ s^{-1}$, from the work of Feldman et al. (1976), similar to that given by Kopp and Orrall (1977).

The wind speed obtained that way is shown on Figure 2. It is larger than the current values: $V \sim 100$ km/s at 1.3 $R_\odot$ and 400 km/s at 3.2 $R_\odot$ and if the density obtained from our data extended by the reduced intensities of Munro and Jackson is correct above 3.2 $R_\odot$, the speed reaches 750 km/s at 5 $R_\odot$. From Hundhausen (1977) it appears that this speed is observed at 1AU for the fast streams leaving coronal holes; usual wind models show that the speed about doubles between 5 $R_\odot$ and 1AU.

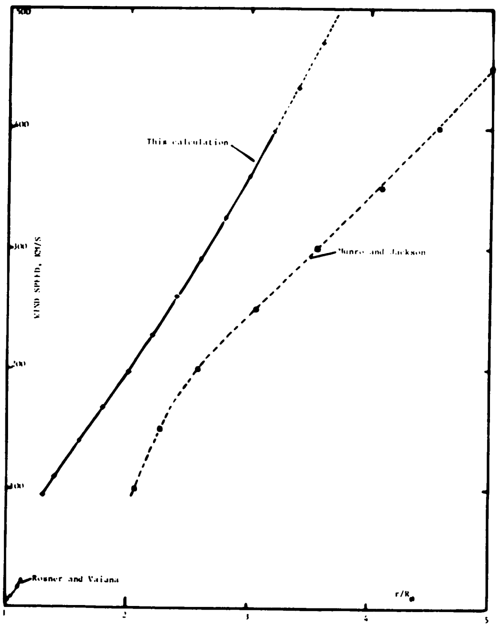

Figure 2. Wind speed versus height

However:

a) It can be reasonably compared with the result of Rosner and Vaiana (1977), who also obtain a very strong acceleration in the transition region.

b) The calculated speed is strongly subordinated to the value adopted for the proton flux at 1AU. Although the work of Feldman et al. (1976) seems rather convincing, the data published in "Solar Geophysical Data" for June and July 1973 from the Pioneer VIII and IX satellites suggest a value about 5 times lower. Using it would reduce the wind speed by this factor of 5, and thus bring it to a more realistic value (if not even too low). Anyway, the real flux over the poles is still unknown.

c) Electron density has been calculated here between the polar plumes. If plumes are inside the coronal hole, they contribute significantly to its mass budget (see Ahmad and Withbroe, 1977), and the mass ejected by the interplume region should be smaller. The mass flux at 1AU of course does not take such inhomogeneities into account.

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DISCUSSION

Steinitz: The flux is variable; how to evaluate it will be shown in the afternoon session.

Crifo: I am very excited to know about this!