STUDY OF THE NONRADIAL DIRECTIONAL PROPERTY OF THE RAYS OF THE STREAMER BELT AND CHAINS IN THE SOLAR CORONA

V. G. ESELEVICH and M. V. ESELEVICH
Institute of Solar-Terrestrial Physics, Irkutsk, Russia (e-mail: esel@iszf.irk.ru)

(Received 12 February 2002; accepted 9 April 2002)

Abstract. Based on analyzing corona images taken by the LASCO C1, C2, and C3 instruments, a study is made of the behavior of the streamer belt spanning one half of the 1996–2001 cycle of solar activity, from minimum to maximum activity, in the absence of coronal mass ejections. It is shown that: (1) The position of the streamer belt relative to the solar equator is generally characterized by two angles: θ_o and θ_E, where θ_o is the latitudinal position (near the solar surface) of the middle of the base of the helmet, the top of which gradually transforms to a ray of the streamer belt with a further distance from the Sun, and θ_E is the latitude of this ray for $R > 5–6\ R_\odot$ from the Sun's center where the ray becomes radial. (2) Only rays lying at some of the selected latitudes θ_o retain their radial orientation ($\theta_o \approx \theta_E$) throughout their extent. Namely: $\theta_o \approx 0°$ (equator), $\theta_o \approx \pm 90°$ (north and south poles), and the angle θ_o lying in the range $\approx \pm(65° - 75°)$ in the N- and S-hemispheres. (3) A deviation $\Delta\theta$ of rays from their radial orientation in the direction normal to the surface of the streamer belt occurs: for latitudes $\theta_o < |65° - 75°|$ toward the equator ($\Delta\theta > 0°$) reaching a maximum in the N and S hemispheres, respectively, when $\theta_{OM} \approx 40°$, and $\theta_{OM} \approx -42°$; for latitudes $\theta_o > |65° - 75°|$ toward the pole ($\Delta\theta < 0°$). The regularities obtained here are a numerical test which can be used to assess of the validity of the theory for describing the behavior of the Sun's quasi-stationary corona over a cycle of solar activity.

1. Introduction

It was shown by Eselevich and Eselevich (1999) that for $R > 3–4\ R_\odot$ from the Sun's center the streamer belt (and chains of streamers, Eselevich, Fainshtein, and Rudenko, 1999) represent a sequence of radial brightness rays with a typical minimum angular size $\approx 2–3$ deg. Furthermore, the radial direction of the rays within $4\ R_\odot < R < 30\ R_\odot$ is conserved with an accuracy of no worse than ± 1.5 deg. At the same time, within $R < 4\ R_\odot$ the radial directional property of the rays is markedly disturbed (see, for example, a schematic image of the eclipsed corona in Bohlin, 1970, or the data from the LASCO C2 instrument on the SOHO spacecraft).

The fundamental importance for investigating the origin of plasma flow in ray structures of the streamer belt is the problem of studying the structure of a particular ray from distances $R \geq 2.5\ R_\odot$, for which it is quite well distinguished in the C2 instrument's field of view, to the solar surface (the field of view of C1) (Eselevich and Eselevich, 2000b). Within distances $R < 2.5\ R_\odot$ near the solar

Solar Physics **208:** 5–16, 2002.

surface, rays are difficult to observe because of the increased brightness of other features (loops, arches, etc.). The deviation $\Delta\theta$ of the ray from a radial direction makes this problem still more complicated, because both the value, the direction and the patterns of variation of $\Delta\theta$ are not known with certainty. On the other hand, the behavior of $\Delta\theta$ for rays lying in different latitudes, with a cycle of solar activity carries information about the physical processes which produce the observed quasi-stationary structures of the solar corona.

A knowledge of $\Delta\theta$ is important in formulating theoretical problems of investigating the structure of the corona and in verifying results derived from solving them. Specifically it is known that the top of the helmet on which the base of any ray has its origin, generally lies within distances $R \approx 2$–$3\ R_\odot$ from the Sun's center. For that reason, at least a part of a total deviation $\Delta\theta$ can be realized above the helmet top. Such a conclusion may well imply the inadequate correctness of the boundary condition on the source surface which is used in calculating the corona's magnetic field within the potential-field approximation (Hoeksema, 1984). When calculating the magnetic field configuration in the corona, taking into account currents localized within narrow current layers helps to improve the situation and provides a good correspondence of the configuration and the latitudinal distribution of the calculated neutral line averaged over ~ 27 days, with the observed streamer belt (Wang, 1996; Wang, Sheeley, and Rich, 2000). The magnetohydrodynamic approach (Pneuman and Kopp, 1971) gives a reasonably good agreement both with the potential-field method and with observations, but in the simplest case, i.e., at minimum solar activity. The approach has not yet been used to describe the changes in the configuration of the streamer belt over a cycle of solar activity. To verify the degree of adequacy of any one of the above-mentioned theoretical models in describing the physical processes in the solar corona requires knowing not only the configuration and the latitudinal location of the streamer belt at a fixed distance R from the Sun but also their changes with the distance. The parameter $\Delta\theta$, the deviation of rays from a radial direction, is an integral characteristic of such changes. It reflects a combined action of different factors or forces resulting in the formation of the observed topology of the streamer belt.

The objective of this paper is to carry out an experimental investigation of $\Delta\theta$, the deviation of brightness rays of the streamer belt (and chains of streamers, Eselevich, Fainshtein, and Rudenko, 1999) from a radial direction over the 1996–2001 semi-cycle of solar activity, and to elucidate its possible origin.

2. Data

We used in the analysis the data on the corona brightness from the LASCO C1, C2, and C3 instruments on the SOHO spacecraft available through the Internet. The C1, C2, and C3 coronagraphs provide corona images for 1.1–3.0 $R_\odot$, 1.5–6 $R_\odot$, and 3.7–30 $R_\odot$, respectively. Daily images in the mpeg format were employed.

The analysis used selected data for the period from 1996 to 2001 (C1 data were missing for dates after June 1998).

3. Identification of Rays in the Streamer Belt – Method of Analysis

It is easy to visually identify a separate narrow ray (angular size $d \approx 2$–3 deg) of the streamer belt in the case where it is at the top of the bend of the streamer belt at a maximum distance to the north or south from the solar equator (Eselevich and Eselevich, 2000a). Because of the projection effect, the apparent latitude Λ of the radial ray can differ significantly from the true latitude of the ray θ on the solar surface. As the ray departs from the plane of the sky due to solar rotation, the difference of Λ and θ will increase.

Because the variations of the true latitude θ of rays were investigated in this paper, we selected the times when the deviation of the ray under consideration from the plane of the sky did not exceed 1–2 days (or $\approx$ 13–26 deg in longitude). In this case the difference of Λ and θ does not exceed 2° for latitudes in the range $\pm$ 60°, and for higher latitudes it was less than 2° (Eselevich and Eselevich, 1999), which is within the measurement error.

Note that our interest was with the deviations of rays from a radial direction in a direction normal to the surface of the streamer belt lying relatively near the Sun (at least nearer than 5 $R_\odot$ from the Sun's center because for $R \geq 5\ R_\odot$ the rays are oriented radially). To do this, we used the areas of the streamer belt which were perpendicular to the plane of the sky, with an extent of several days (or several tens of degrees). When observed on the limb, the cross-section of such areas is distinguished as a clearly pronounced ray of increased brightness. Events were selected in the absence of coronal mass ejections (CMEs).

The technique for deriving experimental information from corona images in the white light involved the following sequence of steps. For a separate image from daily mpeg files for the C1, C2, and C3 instruments, we constructed the brightness distributions $P(\theta)$ cutting the selected brightness ray at different distances from the Sun's center. The value of the ray's deviation $\Delta\theta$ from a radial direction was determined from the dependence of the position of the ray brightness maximum on θ and R.

4. Data Analysis

The stage of data analysis involved overlapping brightness ray images at different distances from the Sun's center for three instruments: C1, C2, and C3. The superposition of the images from the C2 and C3 instruments was relatively simple because their fields of view overlap, and the images of brightness rays on them are similar. The inaccuracy of overlapping of the C2 and C3 images in the angle

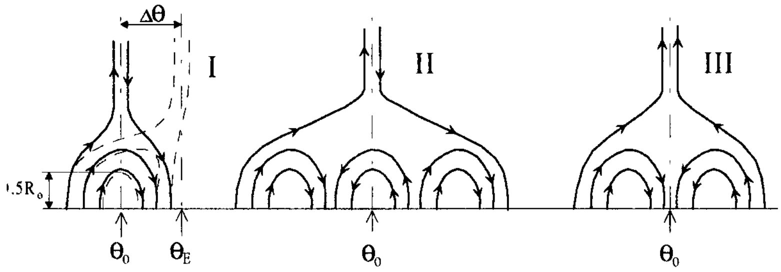

Figure 1. Ideal schematic representation of magnetic field lines within the helmet and in the brightness ray based on it: I and II – in the streamer belt, III – in chains of streamers. *Dashes* in I show the schematic representation of the actually observed picture.

did not exceed ± 1.0 deg. The superposition of the C1 and C2 images was made difficult by three factors: (1) relatively low quality of C1 images in the mpeg format as they represent raw data; (2) the portion of the C1 image, suitable for analysis, was limited to distances within $1.1\ R_\odot < R < 1.6–1.7\ R_\odot$ from the Sun's center; and (3) a marked difference of the form of the brightness distributions from C1 and C2 (a relatively broad helmet, and a narrow ray, respectively). The main criterion by which the events were selected for analysis was the C1 image quality, namely: the presence of a helmet-shaped brightness distribution, inside of which one could identify loop-like structures of one of the three types shown in Figure 1 by solid lines: types I and II correspond to the streamer belt separating the region of the radial component of a global magnetic field of opposite polarity (odd number of loops beneath the helmet), and type III corresponds to chains of streamers separating regions with like polarity of the radial component of a global magnetic field (even number of loops, Eselevich, Fainshtein, and Rudenko, 1999). Type II is observed predominantly near a minimum and at the stage of incipient increase of solar activity when $\theta \approx 0°$ (Schwenn *et al.*, 1997).

Figure 2 shows several examples of schematic sketches of the contour of the observed brightness helmet with brightness loops inside of it and with an extension of the helmet in the form of a brightness ray. The rays in the events of 10 December 1996 and 14 June 1996 refer to type I (upper panel in Figure 2); the rays in the event of 1 February 1996 refer to type II (middle panel); and the ray on 10 April 1997 corresponds to type III (lower panel). The symbol θ_o in Figures 1 and 2 shows the latitude of the middle of the helmet base near the solar surface.

As is evident from the sketches in Figure 2, with the distance from the solar surface the latitude of the middle of the helmet and, subsequently, of the ray, into which the helmet top passes, varies on most occasions. Furthermore, for $R > 5–6\ R_\odot$ the ray becomes radial but its latitude (designated by the symbol θ_E) can differ significantly from the initial latitude θ_o at the helmet base. The variation of the latitude constitutes an angle $\Delta\theta$. For the type I structure, dashes in Figure 1 show the actually observed ray, the latitude θ_E of which generally differs from the latitude at the solar surface θ_o by an angle $\Delta\theta$.

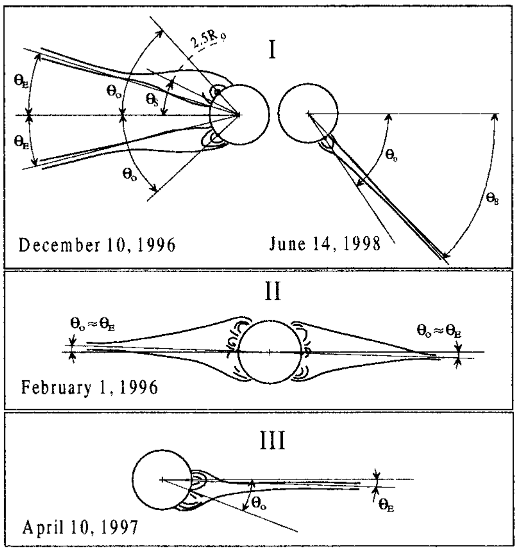

Figure 2. Sketches of the observed contours of the helmet and of the brightness ray based on it within the streamer belt (I and II) and in chains of streamers (III) using the data from the LASCO C1 and C2 instruments.

Visual inspection of Figure 2 shows that the deviation $\Delta\theta = |\theta_o| - |\theta_E|$ of the rays from a radial direction has a maximum in the latitude range $0° < |\theta_o| < 90°$ and $\Delta\theta \to 0°$ when $\theta_o \to 0°$ or 90°. Notice that the deviation of the rays from a radial direction is equatorward ($\Delta\theta > 0°$).

For a qualitative description of these regularities, θ_o and θ_E were measured for the rays selected in accordance with what has been described in Section 3, for the period from November 1996 to June 1998. An example of the determination of the values of θ_o and θ_E for the events of 10 December 1996 is shown in Figure 3. The figure presents the profiles of the brightness distribution $P(\theta)$ for different heliocentric distances R using the images from C1 (upper panel), C2 (middle panel), and C3 (lower panel). For the C1 image, the $P(\theta)$-profile represents the section of a relatively broad helmet. Therefore, the latitude of the middle of the helmet was determined, as shown in the upper panel of Figure 3. Crosses correspond to the position of the middle of the helmet. The profiles, obtained from C2 and C3 images, show a well-pronounced maximum and, hence, it is a rather easy matter to determine the latitude of the ray. In the middle panel of Figure 3 the amplitude-saturated signal at $R = 2.5\ R_\odot$ is reconstructed by a linear extrapolation of the ray brightness profile (shown by dashed lines).

It is evident from the upper panel of Figure 3 that with the distance from the Sun, the latitude of the middle of the helmet is gradually shifted in the angle toward the solar equator, namely: it decreases from $\theta = \theta_o \approx 37°$ at $R = 1.2\ R_\odot$ to $\theta \approx 32°$ at $R = 1.7\ R_\odot$. In the C2 field of view (middle panel in Figure 3) within distances from $R = 2.5\ R_\odot$ to $R = 6.5\ R_\odot$ the ray brightness maximum shifts toward the

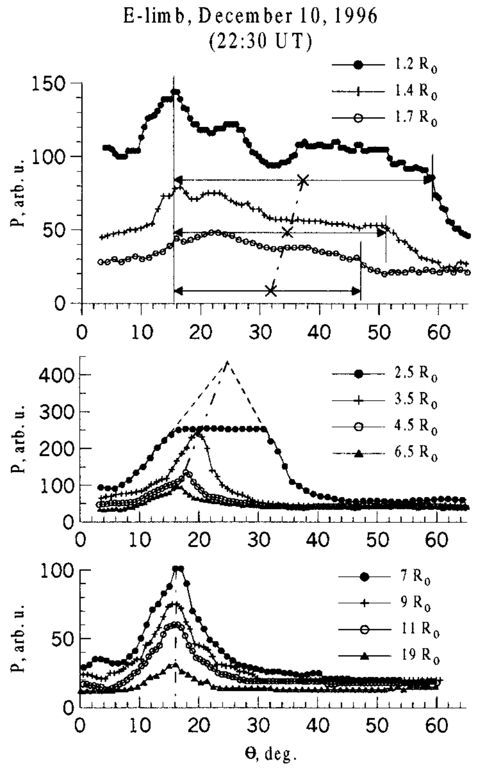

Figure 3. Profiles of the brightness distributions $P(\theta)$ at different distances R from the Sun's center using the data from LASCO C1 (*upper panel*), C2 (*middle panel*), and C3 (*lower panel*). 10 December 1996 (22:30 UT), E-limb.

solar equator nearly by 10 deg and reaches the value $\approx 16°$. With a further distance from the Sun, the latitude of the ray's maximum remains almost unchanged (see the lower panel of Figure 3, C3 instrument) and is $\theta = \theta_E \approx 16°$. Thus for $R > 5$–$6\ R_\odot$ the ray is directed virtually radially with respect to the Sun's center. A total deviation from a radial direction $\Delta\theta$ of the ray under consideration within $R = 1.2$–$5.0\ R_\odot$ is $\Delta\theta = \theta_o - \theta_E \approx 21°$.

Such a picture of the behavior with the distance R is typical of all brightness rays that have been investigated in this paper. The method described above was used to measure the values of θ_o, θ_E, and $\Delta\theta$ for 51 brightness rays covering the time interval under consideration.

The dependence $\Delta\theta(\theta_o)$ is plotted in Figure 4. In the figure, the values of $\Delta\theta$ for the rays of the streamer belt, observed on E and W limbs, are shown, respectively, by open and dark circles, and for the rays of chains of streamers (irrespective of the limb of observations), they are shown by crosses. The solid curve is drawn through the points which are average points for each 10° interval along the abscissa axis

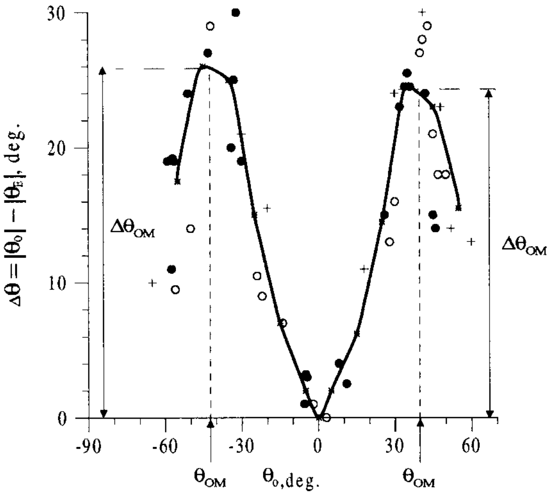

Figure 4. Dependence of a total angular deviation $\Delta\theta = |\theta_o| - |\theta_E|$ on the latitude θ_o for 51 brightness rays of the streamer belt (*dark circles* – W-limb, *open circles* – E-limb) and of chains of streamers (*plus symbols*) for the period from November 1996 to June 1998, based on data from the LASCO C1 and C2 instruments

θ_o. Maximum deviations of the values of experimental points with respect to this curve did not exceed $\approx \pm 5°$.

An analysis of our measurements and of the plot in Figure 4 suggests that within $R < 5\ R_\odot$ from the Sun's center:

(1) The deviation of brightness rays from a radial direction toward the solar equator for the latitude range $\approx \pm 60°$ is about identical in the northern and southern hemispheres (the curve in Figure 4 shows a slight asymmetry about the axis $\theta_o = 0°$) when observed on the west and east limbs, in the streamer belt, and in chains of streamers.

(2) The value of the deviation $\Delta\theta$ depends uniquely on the ray's latitude θ_o near the solar surface.

(3) A contribution to a total deviation from the ray's radial direction is also made by the upper half of the helmet, on the top of which the ray is based. Furthermore, the lower half of the helmet within distances $R < 1.5\ R_\odot$ within the measurement errors of $\pm$ 5° remains radially oriented (see the dashes in Figure 1, I).

(4) There is virtually no deviation from a radial direction for the rays lying in the equatorial plane ($\theta_o = 0°$).

The lack of data from the C1 instrument after July 1998 does not permit us to extend the plot in Figure 4 to a larger time span of the solar activity cycle. However, data from the C2 instrument that are available for the time interval till the present can be used to plot the dependence $\Delta\theta_S(\theta_S)$ for the period 1996–2001. Here $\Delta\theta_S = |\theta_S| - |\theta_E|$ is a part of the value of the angular deviation $\Delta\theta$ from a radial direction for rays for distances from $R = 2.5\ R_\odot$ and further, and θ_S is the latitude of the helmet top at $R = 2.5\ R_\odot$ (or the latitude of the mid-point of

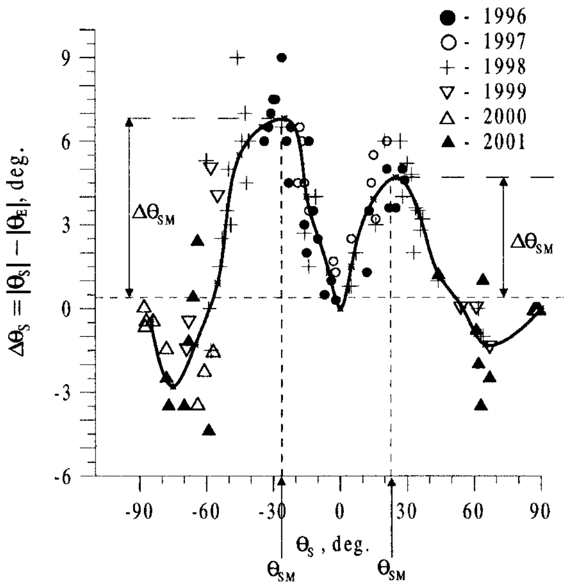

Figure 5. Dependence of a part $\Delta\theta_S = |\theta_S| - |\theta_E|$ of the angular deviation on the latitude θ_S of the helmet top at $R = 2.5\ R_\odot$ (or, what is the same, of the latitude of the ray at $R = 2.5\ R_\odot$) for the period 1996–2001 according to the LASCO C2 data.

the helmet cross-section at $R = 2.5\ R_\odot$). The determination of θ_S is presented schematically in Figure 2 (upper panel), 10 December 1996. The importance of this dependence is as follows: if the behavior of $\Delta\theta_S(\theta_S)$ and $\Delta\theta(\theta_o)$ is found to be similar for the time interval 1996–1998 considered above, then their similarity can also be expected for a longer period, into the year 2001. The experimental dependence $\Delta\theta_S(\theta_S)$ is presented in Figure 5.

The solid curve is drawn through the points which are average points for every 10° interval along the abscissa axis θ_S. It is evident from Figure 5 that at the transition from minimum to maximum activity rays of the streamer belt are observed at increasingly larger maximum latitudes θ_S: for 1996–1997 (dark and open circles) up to ± 30 deg, for 1998 (crosses) to − 60 deg in the S hemisphere and to 40 deg in the N hemisphere, for 1999 (inverted triangles) up to ± 70 deg, and for the year 2000 (unshaded triangles) up to ± 90 deg. In 2001, maximum values of θ_S begin to decrease to 80 deg for the S hemisphere and to 70 deg for the N hemisphere. All this reflects, to a certain extent, the well-known process: a gradual displacement of some areas of the streamer belt to the poles as one approaches the phase of maximum solar activity. As soon as the phase of maximum activity is over, this is followed by a gradual displacement of these areas toward the solar equator. And the value of the deviation of rays from a radial direction $\Delta\theta_S$ satisfies a common dependence $\Delta\theta_S(\theta_S)$ (solid curve in Figure 5) for the entire period 1996–2001, or one half of a solar activity cycle.

To verify the similarity of the $\Delta\theta_S(\theta_S)$ and $\Delta\theta(\theta_o)$ curves in Figures 4 and 5, we make use of an obvious association relating $\Delta\theta$ and θ_o to $\Delta\theta_S$ and θ_S (see Figure 2, upper panel):

$$|\theta_o| = |\theta_S| + \Delta\theta - \Delta\theta_S. \quad (1)$$

We now calculate the latitudes θ_{OM} of the position of maxima of the deviation in the S and N hemispheres for the curve in Figure 4, to which the latitudes θ_{SM} of maximum $\Delta\theta_{SM}$ of the curve in Figure 5 of the respective hemispheres correspond. Upon substituting into formula (1) the values of $\Delta\theta_{SM} \approx 7°$ and $\theta_{SM} \approx -26°$ from the Figure 5, and $\Delta\theta_{OM} \approx 26°$ from the Figure 4 (the value of the left-hand maximum), we obtain $\theta_{OM} \approx -45°$, which is close to the observed value of $\theta_{OM} \approx -42°$. Upon substituting into formula (1) the values of $\Delta\theta_{SM} \approx 4.5°$ and $\theta_{SM} \approx 22°$ taken from the Figure 5 and $\Delta\theta_{OM} \approx 25°$ from the Figure 4 (the value of the right-hand maximum), we obtain $\theta_{OM} \approx 42.5°$, which is close to the observed value of $\theta_{OM} \approx 40°$. The agreement between the calculated (by formula (1)) and observed values of θ_{OM} indicates a similarity of the behavior of the curves in Figures 4 and 5, at least in the portion from $\theta_o \approx -45°$ to $\approx 45°$ (for $\theta_S \approx$ from $-26°$ to $22°$), i.e., between maxima of $\Delta\theta_{OM}$ (or $\Delta\theta_{SM}$) of the S and N hemispheres. This suggests that the behavior of $\Delta\theta(\theta_o)$ is also similar to the $\Delta\theta_S(\theta_S)$ at larger angles of up to $\pm 90°$.

It follows from the similarity of the behavior of these curves that the streamer belts retain their radial orientation throughout their extent in the following selected latitudes: $\theta_o \approx 0°, \pm 90°$ and when $\theta_o \approx \pm 65°-75°$. Furthermore, for the latitudes $\theta_o < |65°-75°|$ the deviation of rays from a radial direction toward the equator $(\theta < 0°)$ and reaches a maximum in the N and S hemispheres, respectively, when $\theta_{OM} \approx 40°$, and $\theta_{OM} \approx -42°$. At high latitudes $\theta_o > |65°-75°|$, the deviation of rays from a radial direction is poleward $(\Delta\theta < 0°)$, by analogy with $(\Delta\theta_S < 0°)$ tending to $0°$ at the poles of the Sun.

5. Discussion

Analysis of the physical factors responsible for the nonradial character of rays of the streamer belt is impossible without a well-developed theory which adequately describes the structure of the Sun's quasi-stationary corona. Currently there are several theoretical approaches based on calculating the corona's magnetic field within the potential-field approximation (Hoeksema, 1984; Wang and Sheeley, 1992). One of such approaches in which the magnetic field at the solar photosphere is assumed radial and currents in narrow layers outside the source surface are taken into account, gives a good agreement between the calculated neutral line averaged over $\approx$ 27 days and the observed location of the streamer belt over a portion of the 1996–1999 cycle of solar activity (Wang and Sheeley, 1992; Wang, Sheeley, and Rich, 2000). The magnetohydrodynamic theory of the solar corona is not as

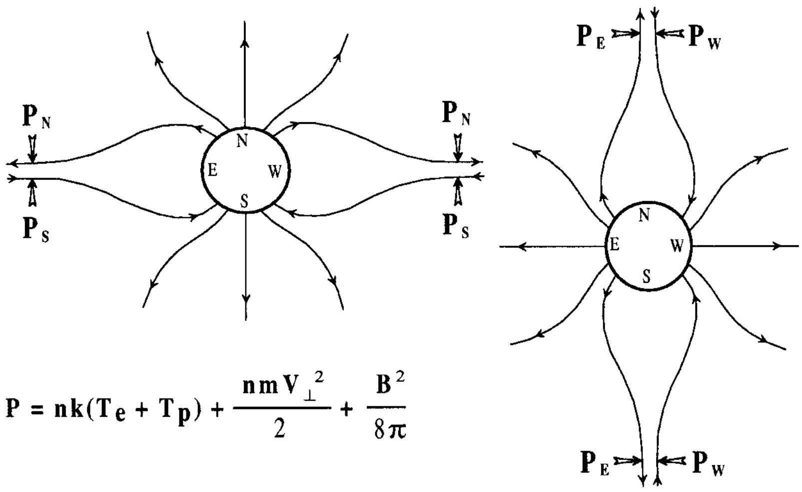

Figure 6. Schematic representations of the position of rays of the streamer belt in the plane of the sky, and of pressures acting on them at minimum (*left*) and maximum (*right*) solar activity.

well developed (especially as regards the description of the coronal structure over a cycle of solar activity). The factors that are responsible for the deviation of the rays of the streamer belt from a radial direction, when treated within the potential-field approximation according to Wang (1996) are the following: the existence in the photospheric magnetic field of a strong quadrupole component of the field, in addition to the dipole component, and the presence of a current within the narrow layer. The magnetohydrodynamic approach provides a means of ascertaining the formation mechanism for this narrow current sheet which involves the operation of pressures of different kinds across the magnetic field direction in a magnetized plasma. They are magnetic $P_B = B^2/8\pi$, gas kinetic $P_g = nk(T_e + T_p)$ and dynamic $P_d = nmV_\perp^2/2$ plasma pressures. Here: n is plasma density, k is the Boltzmann constant, T_e and T_p are the electron and proton temperatures, respectively, m is the mass of protons, and $V_\perp$ is the plasma velocity component directed across the magnetic field B. Total pressure is their sum $P = P_B + P_g + P_d$. The latitudinal location of a ray of the streamer belt at different distances from the Sun will be determined by a local balance of pressures P across the streamer belt.

Figure 6 schematically shows two extreme cases where the rays of the streamer belt are radially oriented: when $\theta_o \approx 0°$, along the equatorial line (Figure 6, left), and when $\theta_o \approx \pm 90°$, along the line of the N–S poles (Figure 6, right).

According to Eselevich *et al.* (1990), the solar wind velocity V (and, hence, its component $V_\perp$) increases proportionally with the area S of the coronal hole from which the solar wind originates, if $S < S_C \approx 5 \times 10^{10}$ km^2. When $S > S_C$ the velocity V is independent of S and is $V \approx 750$–800 km s^{-1} for distances $R > 10\ R_\odot$. These facts are important for understanding the qualitative picture of formation of radially oriented rays shown in Figure 6. At minimum activity

(Figure 6, left) there are two large ($S > S_C$) coronal holes at the N and S poles, from which the SW with about identical characteristics originates. As a result, total plasma pressures on the streamer belt lying in the equatorial plane are balanced from the north P_N and south P_S by $P_N \approx P_S$ thus ensuring the radial orientation of its rays. In the case of maximum activity coronal holes lie outside of the poles in the region of mid- and low latitudes and generally act on the streamer belt with about equal total plasma pressures from the east P_E and west P_W, so that $P_E \approx P_W$ (Figure 6, right). This ensures a radial orientation of the rays of the streamer belt along the N–S line. When the orientation of the belt along the equator changes to the orientation along the poles, a change of sign of the quantity $\Delta\theta$ from $\Delta\theta > 0°$ to $\Delta\theta < 0°$ can be expected. This seems to explain the detected radial orientation of the rays when $\theta_o \approx \pm(65°–75°)$ in the N and S hemispheres.

6. Conclusions

A study of the streamer belt covering one half of a cycle of solar activity (1996 –2001), from the phase of minimum to the phase of maximum activity, in the absence of CMEs has revealed the following features:

(1) The position of the streamer belt relative to the solar equator is generally characterized by two angles: θ_o, and θ_E, where θ_o is the latitudinal position (near the solar surface) of the middle of the base of the helmet, the top of which gradually transforms to a ray of the streamer belt with a further distance from the Sun, and θ_E is the latitude of this ray for $R > 5–6\ R_\odot$ from the Sun's center where the ray becomes radial.

(2) Only rays lying at some of the selected latitudes θ_o retain their radial orientation ($\theta_o \approx \theta_E$) throughout their extent. Namely: $\theta_o \approx 0°$ (equator), $\theta_o \approx \pm 90°$ (north and south poles), and the angle θ_o lying in the range $\approx \pm 65°–75°$ in the N and S hemispheres.

(3) A deviation of rays from their radial orientation in the direction normal to the surface of the streamer belt occurs: for latitudes $\theta_o < |65° - 75°|$ toward the equator ($\theta_o > 0°$) reaching a maximum in the N and S hemispheres, respectively, when $\theta_{OM} \approx 40°$, and $\theta_{OM} \approx -42°$; for latitudes $\theta_o > |65°–75°|$ toward the pole ($\theta_o < 0°$).

(4) The regularities obtained here are a numerical test which can be used to assess of the validity of the theory for describing the behavior of the Sun's quasi-stationary corona over a cycle of solar activity.

Acknowledgements

The SOHO/LASCO data used here are produced by a consortium of the Naval Research Laboratory (USA), Max-Planck-Institute für Aeronomie (Germany), Laboratoire d'Astronomie (France), and the University of Birmingham (UK). SOHO is a project of international cooperation between ESA and NASA. We are grateful to V. M. Mikhalkovsky for his assistance in preparing the English version of the manuscript. Grant governmental support for Russian Federation's leading scientific schools N961596733 and GNTP 'Astronomy'.

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