Crosscorrelation Analysis of Small Photospheric Magnetic Features

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We present results of an analysis of high-resolution magnetograms taken daily with the NSO Vacuum Telescope on Kitt Peak from 1975 to 1991. Motions in longitude on the solar surface are determined by a one-dimensional crosscorrelation analysis of consecutive day pairs. The mean sidereal rotation rate of small magnetic features is best fit by

\[ \omega = 2.913(\pm 0.004) - 0.405(\pm 0.027) \sin^2 \phi - 0.422(\pm 0.030) \sin \phi \]

in \( \mu \text{rad} \, \text{s}^{-1} \) where \( \phi \) is the latitude. The small features show a torsional oscillation pattern, alternating bands of faster and slower rotation travel from higher latitudes toward the equator during the solar cycle in such a way that the faster bands reach the equator at cycle minimum. The magnetic torsional oscillation resembles the pattern derived from Doppler measurements, but is different in three respects. Its velocities are larger by a factor of more than 1.5, it lies closer to the equator, and leads the Doppler pattern by about two years. Motions in longitude and also in latitude are determined by a two-dimensional crosscorrelation analysis. The mean sidereal rotation rate of the two-dimensional analysis is in excellent agreement with the one-dimensional rate which assures the robustness of the two-dimensional analysis. In latitude, we find meridional motions of the order of 10 m/s which are poleward in each hemisphere.

Rotation and Magnetic Polarity Separation in Active Regions

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The separations of the leading and following components of plages and, separately, of sunspot groups are used as parameters in the study of the rotation of these features. These quantities are determined by calculating the magnetic flux-weighted positions of fields of leading or following polarity magnetic flux in the case of plages and by calculating the area weighted positions of the spots west or east of the area-weighted centroid of the sunspot groups. (For the sunspot groups there is no magnetic information available as a part of this data set.) After correcting for the effects of magnetically complex regions, it is found that there is a significant correlation between polarity separation and rotation rate; plages with larger polarity separation rotate slower than those with smaller polarity separation. In the case of individual spots, it is known that smaller spots rotate faster than larger spots and for groups the same effect is found, but with a very low amplitude. It is suggested that the group effect is strongly, and perhaps totally, influenced by the spot effect. When the rotation rate of spot groups of varying polarity separations are examined, the opposite effect is seen: Groups with larger polarity separations rotate faster than those with smaller polarity separations. It is suggested that this discrepancy, which is somewhat analogous to other recently-discovered differences in dynamic behavior between plages and sunspot groups, may result from the fact that the magnetic fields of sunspots and plages are anchored in toroidal magnetic flux tubes that are located at different distances beneath the solar surface. The variation with rotation rate in each case might then be a depth effect and represent an indication of the vertical angular velocity gradient.

Radial and Latitudinal Variations in Coronal Polarization Brightness 1985-1990

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Daily measurements of polarization brightness (pB) in the lower corona have been made with the High Altitude Observatory Mark III Coronameter since 1980. Radial scans of pB between 1.1 and 2.2 Rsun (with 0.01 Rsun resolution and obtained every 1 degree of polar angle) are usually well-fit with a power law function. Maps of the fit parameters over latitude and longitude for each solar rotation show the variations in the large-scale structure of the solar corona between 1985 and 1990. Radial profiles of pB from the Solar Maximum Mission data, extending from about 1.5 to 5 Rsun, have recently been combined with the Mark III measurements to obtain pB profiles from 1.1 to 4 Rsun.

The Spartan Ultraviolet Coronagraph


An ultraviolet coronagraph (UVC) is being prepared for a series of orbital flights on NASA's Spartan 201 which is deployed and retrieved by Shuttle. The Spartan 201 payload consists of the UVC and a white light coronagraph developed by the High Altitude Observatory. Spartan is expected to provide 25 orbits of solar observations per flight. The first flight is scheduled for May 1993 and subsequent flights are planned to occur at each polar passage of Ulysses (1994 and 1995). The UVC measures the intensity and spectral line profile of resonantly scattered H I Ly- \( \alpha \) and the intensities of O VI \( \lambda 1032 \) and \( \lambda 1037 \) at heliocentric heights between 1.3 and 3.5 solar radii. A description of the UVC instrument, its characteristics, and the observing program for the first flight will be presented. The initial scientific objective is to determine the random velocity distribution and bulk outflow velocity of coronal protons and the density and outflow velocity of O\(^{2+}\) in polar coronal holes and adjoining high latitude streamers. This work is supported by NASA under Grant No. NAG5-613 to the Smithsonian Astrophysical Observatory.

Plans for Measuring Coronal O\(^{4+}\) Outflow Velocities with Spartan 201

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A goal of the Spartan 201 mission is to derive outflow velocities, \( W \) of coronal O\(^{4+}\) by using a Doppler dimming analysis of the expected resonantly scattered intensities of OVI \( \lambda 1031.9 \) and \( \lambda 1037.6 \). The technique is sensitive to velocities in the range \( 30 < W < 250 \, \text{km} \, \text{s}^{-1} \) and will be used for probing regions of the inner solar corona, between 1.3 and 3.5 Rsun, where significant coronal heating and solar wind acceleration may be occurring. These velocity measurements, when combined with measurements of other plasma parameters (i.e., temperatures and densities of ions and electrons), can be used to estimate the energy and mass fluxes of coronal ions. In particular, it may be possible to locate where the flow changes from subsonic to supersonic and to identify source regions for the high- and low-speed solar wind. The velocity diagnostic technique is discussed with emphasis placed on the requirements needed for accurate outflow velocity determinations. Model calculations of outflow velocities based on expected detector count rates are also presented. This work is supported by NASA under Grant No. NAG5-613 to the Smithsonian Astrophysical Observatory.