The North-South Asymmetry in the Rotation of the Photospheric Magnetic Field During Solar Cycles 21 and 20

P.H. Scherrer, J.T. Hoekema (Stanford Univ.), and E. Antomucci (U. of Torino, Italy)

The photospheric magnetic field rotates more slowly in the southern hemisphere than in the northern hemisphere during Solar Cycle 21. Measurements from the Wilson Solar Observatory at Stanford from 1976 to 1982 show an asymmetry in the rotation rates of the large-scale magnetic field with respect to the equator. Fourier analysis of the synoptic charts in the frequency range near the solar rotation period indicates that the northern fields have a 26.9 day period while the southern fields rotate every 26.1 days. These periodicities appear in relatively wide latitudinal zones centered near 15°N and 30°S. Comparative analysis of higher resolution maps from the National Solar Observatory confirms the difference in rotation during Cycle 21. Mt. Wilson data from Cycle 20 show a quite similar asymmetric rotation structure.

6.10 Solar Meridional Flow
A. Keith Pierce, National Solar Observatory
James C. LoPresto, Edinboro University of Pennsylvania

The Sun's meridional flow has been observed by comparison of the average doppler shifts of the two solar Fe lines at 6301.5A and 6302.5A observed along the Sun's equator and meridian. The equatorial rotation was eliminated by folding the east-west velocities about the center and averaging to obtain the center to limb variation. This curve was then compared to the folded pole to pole variation. From 25° to 45° the motion is equator directed with a velocity of about 30 m/sec. From 45° to 60° there is a rapid increase of the motion reaching 120 m/sec toward the pole at 60°-70°. At 75° the velocity has dropped to about 0 m/sec and by our observations remains so to the pole.

6.11 The Meridional Flow Inferred from the Shape of Large-scale Magnetic Structures in the Photosphere
J.T. Hoekema, M. Herant, P.H. Scherrer (Stanford Univ.), and A.M. Title (Lockheed Palo Alto Res. Ctr.)

Large structures in the photospheric magnetic field often appear to originate at low latitudes and extend poleward and eastward. If the surface field originates in active regions and is subsequently carried away by diffusion, meridional flow, and differential rotation, the relative contributions to the total flow govern the shape of these "plumes". From the known rotational velocity and the estimated diffusion component, we can infer the meridional component. This is analogous to determining the vertical velocity of a plume of smoke from its observed shape if the wind velocity is known. The plumes observed in National Solar Observatory magnetic field synoptic charts imply a net poleward motion of about 100 m/s. The contribution to this flow from diffusion is certainly less than 50 m/s. This leaves a meridional component on the order of 50 m/s. The observed upper limit of surface meridional flow is less than 20 m/s.

Some possible explanations for this discrepancy, including flux emergence outside of active regions at higher latitudes and sub-surface meridional flow, will be discussed.

6.12 Azimuthal Rolls and the Solar Cycle
H. E. Snodgrass (Levis & Clark College), F. R. Wilson (Caltech, U. Sydney)

A model is being developed in which a system of giant convective azimuthal rolls drives the solar cycle.

Evidence for the existence of these rolls is derived from correlations among patterns of motion in the photosphere, temperature variations, coronal emissions, high-latitude ephemeral regions and the sunspot butterfly diagram. The rolls are generated at the poles and propagate to the equator in ~18 years. Their generation and propagation is the result of the interplay of giant cell convection with the \( \nu \) - \( \omega \) dynamo. The development of activity at specific longitudes occurs as the rolls, which originally encircle the poles, begin to break up. An observational search for evidence of this break-up is described.

6.13 Spherical Harmonic Analysis of Steady Photospheric Flows - Effects due to Nonzero latitude; Limited Spatial Resolution and Limited Spatial Coverage
D. H. Hathaway (NASA/MSFC)

The analysis of steady photospheric flows using spherical harmonic basis functions (Hathaway, Solar Physics 1987) is extended to include the tilt (\( \beta \)-angle) of the Sun's rotation axis toward the observer and to investigate the effects of limited spatial resolution and limited spatial coverage (both hemispheres). The tilt of the Sun's rotation axis introduces an apparent mixing between modes of the same spherical harmonic degree but with different longitudinal wavenumbers. This mixing can be partially removed by transforming the spectral coefficients to the tilted coordinate system. Mixing between different spectral modes is also produced when the spatial resolution is degraded and when the spatial coverage includes much less than a hemisphere. This mixing, however, cannot be removed and the effects are different for different spectral components. Synthetic data is analyzed to determine the magnitude of this mixing for varying degrees of spatial resolution and coverage. Degrading the spatial resolution lowers the high wavenumber cutoff and decreases the accuracy in determining the remaining spectral coefficients. Limiting the spatial coverage introduces more cross-talk between various modes and illustrates the need to extend the coverage to include as much of the visible disk as is possible.

6.14 On the Relation Between Large-Scale Granular Flows and Supergranules and Mesogranules
G. Simon (AFGL/NSO/SP), S. Ferguson, T. Tarbell, A. Title, K. Toepke (Lockheed PPARL), L. Novembre (NSO/SP), H. Zirin (Caltech)

Comparisons are made between large-scale photospheric flows deduced from white-light photographs obtained from the SOUP experiment on Spacelab 2 (5 Aug 85) and magnetic, H-alpha, and calcium-K data observed simultaneously at the Big Bear Solar Observatory. These flows have velocities (0.3-1.0 km/s) and spatial scales (10-30 Mm) corresponding to supergranules and mesogranules. We present results showing how these flows coincide spatially with the network pattern defined by the magnetic, calcium, and H-alpha structures.

6.15 Rotation of Coronal Holes during Sunspot Cycle 21
J. Harvey (NSO/NOAO), W. R. Sheeley, Jr., (NRL)

Full-disc spectroheliograms in HeI 10830A have been obtained nearly daily since 1974 with the NSO vacuum telescope on Kitt Peak. These images indicate the presence of coronal holes by a weakening of line strength and the contrast of the chromospheric network. The daily images are converted to Carrington latitude and longitude maps that are smoothly merged into a continuous time series. An algorithm has been developed that converts the 10830 time series maps into coronal hole maps. We investigated a number of methods to determine the rotation rate of coronal holes as functions of latitude and phase of the cycle. The problem is complicated by the aperiodicity and rapid evolution of holes during much of the