Geophysical Research Abstracts
Vol. 15, EGU2013-2891, 2013
EGU General Assembly 2013

Strong magnetic fields of the solar photosphere and their imbalance

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Strong photospheric magnetic fields in the sunspot zone were studied on the basis of Kitt Peak synoptic maps (1976 – 2003). The fluxes of the positive and the negative magnetic fields for the Northern and for the Southern solar hemispheres were considered separately. Each of these four fluxes depending on its polarity can be interpreted as the magnetic flux of the leading or the following sunspots of one of the solar hemispheres. All the four fluxes change according to the 11 year solar cycle; nevertheless, there are certain differences in their time dependence.

The aim of the present work is to study the regular features of these differences. Thus, we consider: 1) correlations between the above fluxes; 2) the imbalance between the positive and the negative fluxes of the same solar hemisphere; 3) imbalance between the positive and the negative fluxes associated only with the leading sunspots; 4) imbalance between the positive and the negative fluxes for the following sunspots only.

The imbalance of the fluxes, associated with the leading sunspots in each of the hemispheres displays the following regular changes in the course of the solar cycle. For the ascending phase of the cycle (from the solar activity minimum to the Sun's global magnetic field inversion) the Northern hemisphere fluxes always play the dominating role, while for the descending phase (from the inversion to the minimum) the Southern hemisphere fluxes dominate. The imbalance of the fluxes of the following sunspots changes analogously. Thus, the North-South asymmetry of the magnetic fluxes results from the domination both of the leading and the following sunspot fluxes in one of the solar hemispheres. The sign of the North-South asymmetry of the magnetic flux remains unchanged (from the solar activity minimum to the global magnetic field inversion and from the inversion to the minimum).

The imbalance between the positive and the negative fluxes for the whole equatorial region (heliolatitudes from -40° to +40°) changes in the same way as the imbalance of the leading sunspots. The sign of the imbalance does not change during 11 years from one inversion of the Sun's global magnetic field to the next one and always coincides with the sign of the global magnetic field in the Northern hemisphere.

The sign of the North-South asymmetry and the sign of the magnetic flux imbalance are determined by the quarter of the 22-year magnetic cycle during which the magnetic configuration of the local and the global magnetic fields doesn't change (from the minimum, where the sunspots reverse their polarities according to Hale's law, to the inversion of the global magnetic field of the Sun, and from the inversion to the minimum).

The sign of the North-South asymmetry depends only on the phase of the solar cycle (before or after the inversion). The sign of the magnetic flux imbalance is determined both by the phase of the solar cycle and by the parity of the solar cycle.