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Non-axisymmetric features in the distributions of sunspots and photospheric magnetic fields

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We study the non-axisymmetric features both of the sunspot distribution (Greenwich- USAF/NOAA, 1874–2016) and of the magnetic field distribution (NSO Kitt Peak, 1976–2016) using the method of vector summing. As a result, the vector of the longitudinal asymmetry (LA) is calculated for each Carrington rotation; its modulus characterizes the magnitude of the asymmetry, while its phase points to the active longitude. These characteristics are to a large extent free from the influence of a stochastic component and emphasize the deviations from the axisymmetry.

For the sunspot area, the modulus |LA| of the vector of the longitudinal asymmetry changes with the 11-year period; however, in contrast to the solar activity, the amplitudes of the asymmetry cycles obey a special scheme. Each pair of cycles from 12 to 23 follows in turn the Gnevyshev–Ohl rule or the Gnevyshev–Ohl anti-rule. Possibly, this effect is a manifestation of a 44-year periodicity in the activity of the Sun.

The localization of the active longitude for the sunspot area changes both when the polarities of global magnetic fields change (polar field inversion) and when the polarities of local magnetic fields change at the minimum of solar activity. The maximum of the longitudinal distribution is 180° for the period from minimum to inversion and 0°/360° for the period from inversion to minimum.

Longitudinal asymmetry of the magnetic fields is studied separately for two sharply differing groups: strong (B> 50 G) and weak (B <5 G) fields. The magnetic fluxes of these two groups of fields change in antiphase. Localization of the two groups in longitude is also opposite. For strong fields, active longitudes change in the same way as for sunspots. Weak fields concentrate on diametrically opposite longitudes. However, the values of asymmetry |LA| for strong and for weak fields change synchronously and follow the 11-year cycle of solar activity. Stability of the localization of the maxima of the longitudinal distribution of sunspots and magnetic fields is an evidence in favor of the hypothesis about rigid rotation of active longitudes.