

Formation of a polar magnetic field in a cycle 24

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Abstract:

Analysis of synoptic data from the Synoptic Telescope for Operating Prognosis (STOP) at Kislovodsk mountain astronomical station and the Vector Spectromagnetograph SOLIS shows that the reversals of solar polar magnetic fields exhibit the asymmetry in activity between Northern and Southern hemispheres. The evolution of the polar magnetic field was considered, and it was shown that the polarity in cycle 24 was reversed December 2014–January 2015 in the Southern Hemisphere. In the northern hemisphere, there was a three-fold reversal in November 2012, in July 2013 and in October 2014. Three-fold polarity reversals were observed in cycles 12 and 14 in the Southern Hemisphere and in cycles 16, 19, and 20 in the Northern Hemisphere.

The annual variation of the amplitude of the polar magnetic field associated with the projection effect is much higher for the southern hemisphere than for the northern hemisphere. Perhaps this is due to the presence of an essential horizontal component of the magnetic field.

In a classical model of solar activity cycle, the magnetic regions of predominantly following polarity fields are transported polewards due to meridional flows and diffusion. This field gradually cancel out the polar magnetic field of the previous cycle, and rebuild the polar field of opposite polarity setting the stage for the next cycle. The preferential diffusion of the lower-latitude, leading-polarity flux across the equator leads to a net surplus of trailing-polarity flux in each hemisphere. In this model, the difference between the field of the leading and tail polarity is due to the difference in latitude of these spots (Joy's law). However, the polarity reversal begins much earlier than the flux of leading spots is compensated by the opposite hemisphere.

We consider the hypothesis that the difference between the drift of the magnetic fields of bipoles to the poles is due to the difference in the geometry of the base of the flux tube for the spots of the leading and following polarities anchored near the base of the convective zone. The surface meridional circulation promotes the emergence of following polarity fields, but not the leading polarity.