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Longitudinal structure of the polar field reversal and decadal trend of the sunspot's gyroresonance emissions in 17 GHz

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Abstract

We investigate the longitudinal structure in transportation of polar magnetic fields by time series of pole-on view maps of magnetic field. As a result, we found an hint of 'active longitudes' in transportation of polar magnetic fields in solar cycle 23. Furthermore, we investigated the long term variation of the sunspot's magnetic flux by using the gyroresonance emissions in 17GHz recorded at the Nobeyama Radioheliograph for the past 20 years. We found that the occurrence of strong gyroresonance emission is significantly enhanced in the later phase of cycle 23. These results may provide a new insight for the recent peculiar behavior of the solar activity.

1. Longitudinal structure of the polar field reversal

I. Introduction : Polar magnetic field reversal is recognized as a fundamental part of the solar activity cycle, and its strength at the minimum phase of the solar activity is found to be correlated with the strength of the following solar cycle. Therefore the details of process of the polar field reversal is of particular interest for understanding the mechanism of the solar magnetic cycle and its prediction.

II. Motivation : According to Ichimoto et al. 1985 and Berdyugina et al. 2006 (Fig 1), it is known that there are characteristics structures of solar activity in longitudinal direction (active longitude). But it haven't been known if there are any structures in longitudinal directions on the pole-ward migration of magnetic flux. To investigate longitudinal distributions, we made time-series of pole-on view maps (Fig 2) of magnetic field using synoptic maps observed by Mount Wilson Observatory (MWO).

III. Results : From fig 2, we observed the spiral magnetic flux whose polarity is opposite to polar magnetic field and migrate from active regions near the equator to the polar region. This opposite magnetic flux cancels polar magnetic fields at the minimum phase of solar activity. This spiral magnetic flux is considered to contribute to the reversal of polar magnetic field and infers a relation to active longitudes in transportation of polar magnetic fields in solar cycle.

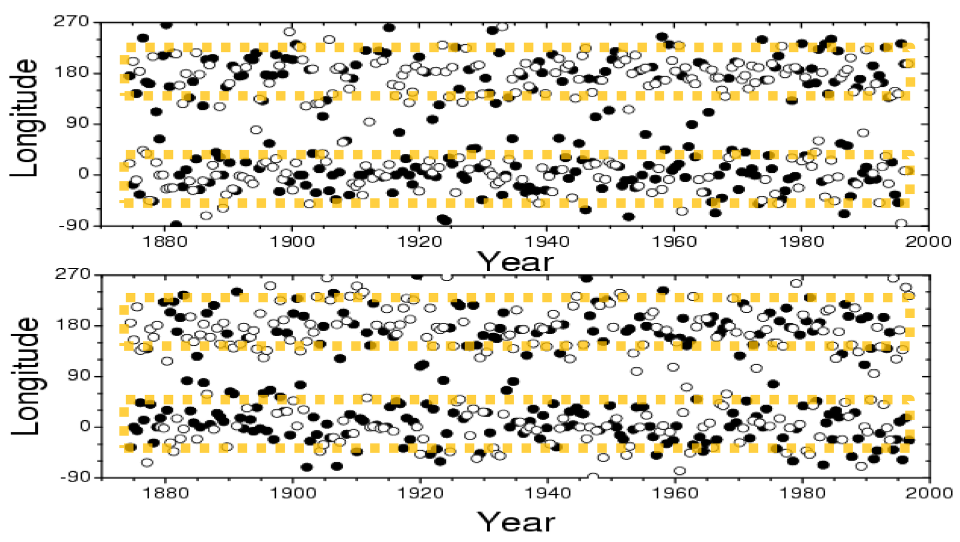

Fig 1. Active longitude (yellow range) in appearance of sunspots for Northern (upper) and Southern (lower) hemisphere. Circles represent active longitudes (Berdygina et al. 2006)

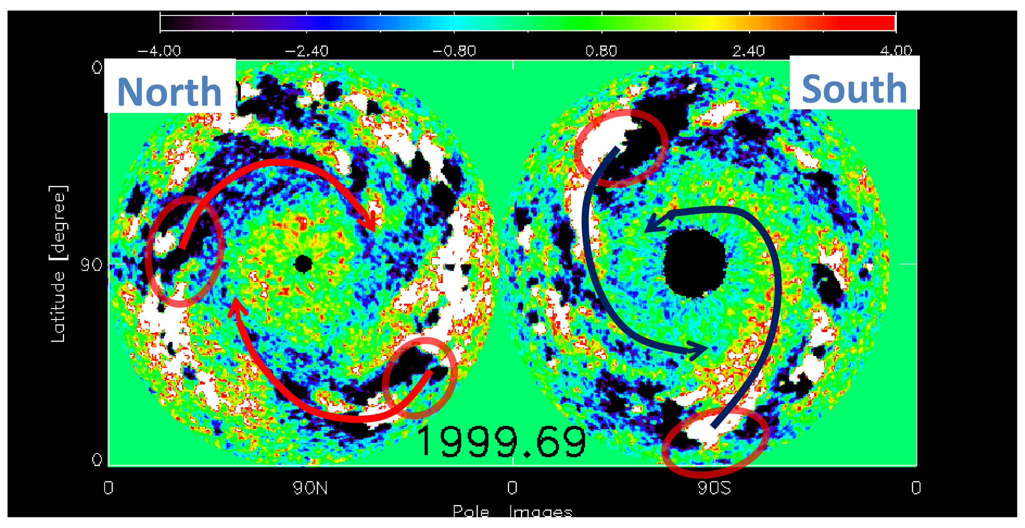

Fig 2. Pole-on view map using the synoptic map observed by MWO. Left and right image is northern and southern hemisphere, red and black color represents positive and negative flux. The spiral magnetic flux are marked.

2. Decadal trend of gyroresonance emission

I. Introduction : Gyroresonance emission (GR) is produced by the gyration of the thermal electron around magnetic field lines due to Lorentz force. In the Sun, it is dominant in strong-field regions above sunspots, and generally at frequencies above a few GHz. This mechanism produces circular polarization, and observed frequencies of emissions are multiples 's' of gyro-frequency, $s\nu_B = 2.80 \times 10^6 sB[G]$ Hz. The Nobeyama Radioheliograph (NoRH) has been obtaining 3rd-harmonics GR emission (s=3) arising from 2000 *G* fields at 17GHz. We made databases of active regions, including their positions, area, peak and average flux of GR emissions since 1992 July (when the NoRH started to observe at 17GHz). We investigated long-term variations of occurrences frequency GR emissions in comparison with the number of active regions.

II. Results : The ratio of all active regions to GR emissions (Fig 4). We found that the ratio of the number of active regions is not constant and the occurrence of GR emissions is enhanced in the later phase of cycle 23.

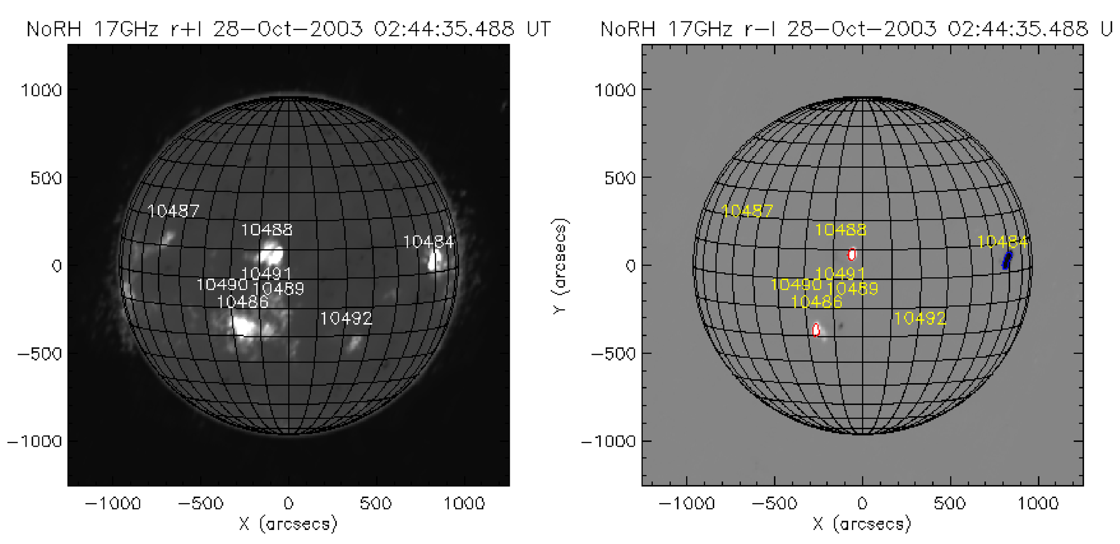

Fig 3. Example of GR emission observed at the NoRH. Left panel is total intensity (R+L), right panel is circular polarized image (R-L). Bright points in right panel are corresponding to GR emissions. Red and blue color represents right and left circular polarity.

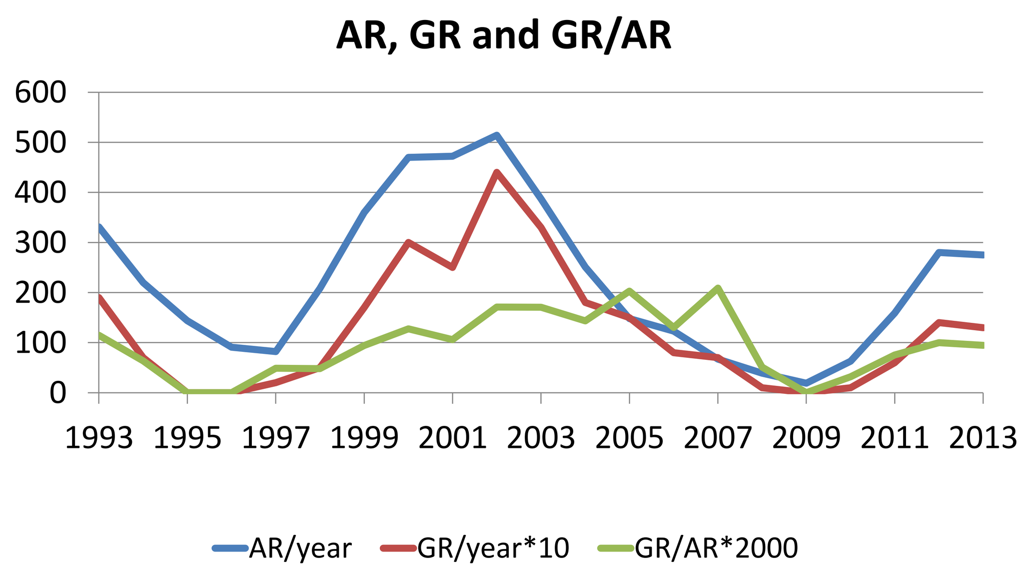

Fig 4. Time-variations of the number of active regions (blue) and that occurred GR emissions (red), the ratio of the number of active regions to GR emissions (green) per year.

3. Discussion and future work

Longitudinal structure of poleward flux transportation is discovered. Further study is necessary to evaluate the amount of transported flux that may determine the strength of polar magnetic field at solar minimum and, eventually, the strength of the next solar cycle. Long-term trend of GR emission discovered in this work infers that the individual sunspot's magnetic flux gets larger in the later phase of cycle 23. This result apparently contradicts with the finding that the sunspot magnetic field gets weaker in the later phase of solar cycle (Livingston et al. 2012).

Future work : More quantitative analysis of flux transportations and relations between GR emissions and sunspot type to investigate the methodology to predict periodic solar activities from the process of the polar magnetic field reversal and long-term variations of sunspot magnetic flux.