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Solar activity cycle and its anomaly observed by radio

Kiyoto Shibasaki[1*]

[1]Nobeyama Solar Radio Observatory

The 24th solar activity cycle has started and number of active regions and relative sunspot numbers are increasing. However, their rate of increase is rather slow compared to previous cycles. Active region sizes are small, lifetimes are short, and no big (X-class) flares occurred so far. We study this anomalous situation using data from Nobeyama Solar Radio Observatory.

Total radio fluxes from the Sun have been observed by radio polarimeters since November 1951. Data covering almost 60 years in microwave regions are available. Due to well established calibration method, these data can be used as indices of long term solar activity similar to or better than relative sunspot numbers. Minimum values of radio fluxes were recorded in 2009 and now flux values are increasing. However, increasing rate is rather small compared to previous cycles.

Radio imaging observations have been done by Radioheliograph (NoRH) since 1992. We can compare radio images during the latest minimum period with that of the previous one. Solar activity cycle is not only increase and decrease of sunspot numbers, but also latitudinal variations of sunspots and dark filaments, and polar activities. We need to study global activities of the Sun. For this purpose, we synthesized radio a butterfly diagram using 6,500 daily radio images taken by NoRH at 17 GHz.

Beside lower latitude bright active regions, polar regions are bright in radio. This polar activity is anti-phase with the lower regions. The current polar brightness is weaker than the previous minimum. Also we can clearly see north-south asymmetry in polar brightness. Dark features correspond to dark filaments which divide magnetic polarity. Large structure of dark features represents global magnetic structure on the Sun. This structure seems to repeat in 11 years, but low latitude active regions started to activate after 13 years. Synchronization between global cycle and active region cycle seems to be lost or weakened.

When large sunspots appear on the Sun, radio images show very bright, compact and highly circularly polarized emission sources. These are due to gyro-resonance emission. Gyro-resonance emission observed by NoRH at 17 GHz is emitted at 2,000 Gauss iso-gauss layer above sunspot umbrae. In the current solar cycle, number of such sources is very small. These sources always show 3-minutes oscillation. From detailed measurement of oscillation period, we can get temperature of sunspots. Study of such sources during the last solar cycle show that oscillation period, hence sunspot temperature, depends on solar cycle phase. It is quite interesting to study sunspots in the current anomalous solar cycle.

Keywords: solar activity cycle, radio observation, Nobeyama Radioheliograph, radio butterfly diagram