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Long Term Study of Differential Rotation of Solar Atmosphere by Image Analysis

Abstract

In last few decades, precious measurements of solar rotation with respect to latitude as well as height or (temperature) have taken an increased importance in solar astronomy. These types of investigations are helpful to reveal the solar dynamo as well as solar activity.

Regarding the variability of the rotation periods of solar coronal layers with respect to temperature (or height), we have used observations from the Atmospheric Imaging Assembly (AIA) telescope on board the *Solar Dynamics Observatory* (*SDO*) space mission of National Aeronautics and Space Administration (NASA). The images used are at wavelengths of 94, 131, 171, 193, 211 and 335 Å during the period from 2012–2018.

In this study, we found that the sidereal rotation periods of different coronal layers decrease with increasing temperature (or height). The average sidereal rotation period at the lowest temperature (~ 600000 K) corresponding to AIA 171-Å, which originates from the upper transition region/quiet corona, is 27.03 days. The sidereal rotation period decreases with temperature (or height) to 25.47 days at a higher temperature (~ 10 million K), corresponding to the flaring regions of the solar corona as seen in AIA 131-Å observations.

In order to estimate rotational profile of solar transition region, we incorporated a new approach by making latitudinal bands on SFD. We investigated the variability of the latitudinal rotational profile of solar transition region for the period from 2008 to 2018 covering the Solar Cycle 24. We used solar full disk (SFD) observations at 30.4 nm wavelength recorded by the *Solar Terrestrial Relations Observatory (STEREO)* space mission. Our investigations show that rotation rate in the equatorial region is quite high and drops towards the poles (both in the northern and southern hemispheres). The equatorial band from -20 to +20 degree rotates almost with the same rate during 2008 to 2018. Differentiality as a function of latitude is low during the high solar activity period whereas it increases in the ascending and the descending phase of 24th solar activity cycle. Interestingly, the overall rotation rate has maximum value during solar maxima in 2014 and decreases gradually in accordance with the annual sunspot numbers.

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Finally, we reported an evidence of a very strong and statistically significant relationship between hemispheric asymmetry in the solar coronal rotation rate and solar activity. To obtain the hemispheric asymmetry in the solar rotation rate, we use solar full disc (SFD) images at 30.4, 19.5 and 28.4 nm wavelengths for the 24th solar cycle, that is, for the period from 2008 to 2018, as recorded by the *Solar Terrestrial Relations Observatory* (*STEREO*) space mission. Our analysis shows that the hemispheric asymmetry in rotation rate is high during the solar maxima from 2011 to 2014. However, hemispheric asymmetry decreases gradually on both sides (i.e. from 2008 to 2011 and from 2014 to 2018). The results show that the AI leads sunspot numbers by ~1.56 yr. This is a clear indication that hemispheric asymmetry triggers the formation of sunspots in conjunction with the differential rotation of the Sun.

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