Solar wind speed and expansion rate of the coronal magnetic field, IV

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The R-F Model devised by Hakamada and Kojima is applied to compute the coronal magnetic field with photospheric magnetic field during 8 Carrington rotations between the solar maximum and the minimum phases. After the field line tracing the ratio of radial component in the photosphere to the one in the source surface at 2.5 solar radii is computed as the expansion rate (RBR) of magnetic flux tube. The solar wind speed (SWS) on the source surface is also estimated by the CAT method devised by Kojima et al. A good negative correlation (r=-0.63) is found between the SWS and the RBR. The tilt of axis of maximum variance is stable during the 8 rotations, suggesting that we can estimate the solar wind speeds by the photospheric magnetic fields by using the empirical formula of average axis.

The solar wind drags out magnetic fields from the corona into interplanetary space producing the heliosphere. The magnetic energy of the solar wind is put into the Earth's magnetosphere by interactions between the interplanetary magnetic field and the Earth's magnetic field resulting in magnetospheric stoms. Then, it is, important to study the coronal magnetic field. The radial filed model (R-F Model) devised by Hakamada and Kojima (1999) is applied to compute the coronal magnetic field from the photospheric magnetic fields observed at the Kitt Peak during 8 Carrington rotations (CR1830, CR1844, CR1855, CR1870, CR1887, CR1898, CR1901, CR1909) between the maximum phase of the solar activity cycle (CR1830) and the minimum phase (CR1909). Magnetic line-of-force is traced by solving numerically the field line equation to construct the 3-D structure of the coronal magnetic field. After this tracing the ratio of the magnitude of radial component in the photosphere to the one in the source surface at 2.5 solar radii is computed as the expansion rate of magnetic flux tube in the corona. The expansion rate is named as RBR. The distribution of RBR on the source surface is compared to the one of solar wind speed.

The radio waves from radio stars are scattered by fluctuations of electron density and interfered in each other during their propagation in interplanetary space. This phenomenon is called as 'Interplanetary Scintillation (IPS)'. Large-scale distributions of solar wind speeds are inferred by IPS observations. Kojima et al. (1998) devised a method based on the Computer-Assisted-Tomography (CAT) technique to get an unbiased solar wind speed. The solar wind speed (SWS) during the same time interval as the one for the RBR is estimated by the CAT method. The distribution of SWS on the source surface is compared with the one of the RBR.

All data about 500000 points of the SWS and the RBR are plotted into a scatter diagram and good correlation (r = -0.63) is found between them. This suggests that the high-speed winds emanate from the low expansion regions and the low-speed winds emanate from the high expansion regions. The low and high expansion regions correspond to a coronal hole and a vicinity of active regions in the photosphere. This result is in agreement with previous results. The correlation analysis is performed to each rotation. The axis of maximum variance between the SWS and the RBR is computed. It is found that the tilt of axis of maximum variance is stable during these 8 rotations. And, it is also found that the location of average values of (SWS, RBR) changes parallel to the average axis of maximum variance, suggesting that we can estimate the SWS by the RBR by using the empirical formula of the average axis. The project of 'Space Weather Forecast', which tries to forecast magnetospheric storms, is now going on in Japan and other countries. The solar wind speed is the one of the most important parameters for the model of space weather forecast. We can estimate the solar wind speed by the photospheric magnetic field.