A RELATION OF VARIABILITIES BETWEEN THE SOLAR DUST RING AND THE SOLAR MAGNETIC FIELD

S. Isobe and A. S. Kumar

National Astronomical Observatory, Mitaka 181, Japan

There have been 23 observational attempts, which were aimed at detecting the circumsolar dust (Isobe and Kumar 1993). A distribution of the successful and non-successful detection of the solar ring depending on time shows a good correlation of the 11-year solar activity cycle.

A formation of the solar ring has been explained by an effect that interplanetary dust could become stabilized against Poynting-Robertson drag over 100–1000 days and concentrated in region(s) near the sublimation zone(s) (Mukai and Yamamoto 1979). To create the variability of the solar ring, some additional perturbing force is needed.

Isobe and Kumar (1993) made a detailed calculation of an effect of the Lorentz force to a dust grain locating at different distances from the sun and showed that, if the solar magnetic field at a distance of the solar ring from the sun is strong, the additional Lorentz force contributes to scatter away dust grains from the ring in a period less than a few hundred days.

To estimate the effect of the Lorentz force on a charged dust grain, we need to know the values of two parameters, i.e., the charge on the dust grain, and the ambient interplanetary magnetic field. In the region(s) considered, the rate of decrease in the number of electron acquired by the grain is obtained from the photoemission rate, the rate of thermionic emission, and the rate of positive ion capture. The first two mechanisms are affected by the solar radiation field and do not depend on the solar magnetic field. The rate of increase is obtained from the rate of electron capture, which is much higher then that of positive ion capture, and which depends on the solar wind velocity.

Satellite observations (Sheeley and Harvey 1981) show that the high velocity solar winds are related to the solar coronal holes, which appear in the lower latitudes around the solar minimum (Waldmeier 1981). A smoothed contour map of the observed solar magnetic field in the period 1960 to 1985 (Stenflo 1988) shows that its strength in the lower latitudes is weak at the solar minimum when the solar coronal holes frequently appear, and is strong at the solar maximum when the solar coronal holes only appear at the high latitudes.

If the solar wind velocity would be continuously high with a value near 1000 km/s, the charge of dust grain would not vary depending on the solar activity cycle and be near zero volt. Therefore, to explain the 11-year cyclic variation of appearance and disappearance of the solar ring, we need a strong variation of the solar magnetic field near the ecliptic plane at a distance around the solar ring. At the solar maximum, the grain charge is positively high because the strong magnetic field reduce the solar-wind velocity and then the dust grain has the positive charge. When the strong magnetic field cooperates with the positive charge, the grains in the solar ring suffer the strong Lorentz force and are scattered away from the ring.

If these mechanisms really work in the region(s) considered, an observational fact in a good correlation between the 11-year variations of the solar ring and the solar activity gives the first evidence, that is, that an strong solar magnetic loop around the solar maximum extends from the solar surface at the low latitude to the region near the ecliptic plane with a distance further than 4 time solar radius but that around the solar minimum shrinks down to the distance nearer than 4 time solar radius.

References

1. Isobe, S. and Kumar, A., 1993, *Astroph. Space Science* **205**, 297.
2. Mukai, T. and Yamamoto, T., 1979, *Publ. Astron. Soc. Japan* **31**, 585.
3. Sheeley, N. R., Jr. and Harvey, J. W., 1981, *Solar Physics* **70**, 237.
4. Stenflo, J. O., 1988, *Astroph. Space Science* **144**, 321.
5. Waldmeier, M., 1981, *Solar Physics* **70**, 251.