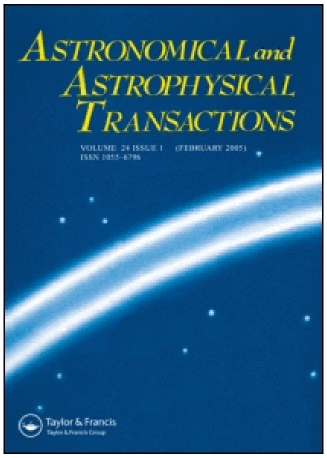

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THE SOLAR CORONAL PLASMA MOTIONS AND THE SOLAR CYCLE

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The solar coronal plasma motions and their connection with the solar cycle are investigated. Results from more than 70 reports of the observational period since 1956–1997 have been analyzed to study the dependence of the velocity values on the solar cycle phase.

KEY WORDS Solar corona, cycle, velocities

At the Sternberg Institute the solar corona motions have been studied since 1965 using red and green line interferograms. We obtained Doppler velocities of small volumes of the corona up to 160 km s^{-1}; this caused some criticism stating (from observations) that the velocities do not exceed 20-30 km s^{-1}. This discrepancy urged us to consider more than 70 publications dealing with velocities in both the corona and transition layers measured from line profiles and image shifts in different spectral regions – from radio to hard X-rays. The velocities found from line profiles were obtained from their broadening but not from their shifts, i.e. from line components shifted often by velocities to the line wings. This corresponds only to the motion of a part of the line-of-sight plasma.

From the studied publications we chose 20 where the velocities were found to be more than 200 km s^{-1}. In Figure 1 the velocity values are plotted versus the solar activity phase for the observation dates. The same was done for velocities not exceeding 200 km s^{-1} (Figure 2). The point labels correspond to the numbers in the reference list. All the data analyzed refer to four solar cycles from 1957 to 1997. Nine publications are not presented in the figures because no moments of the observations are given. The velocities (reported in these papers) are less than 100 km s^{-1} in C IV for active regions and about 50–100 km s^{-1} in loops, observed in lines of Fe XIII, Mg X and Mg IX. Whatever the activity phases for these results are, they cannot change the conclusions obtained from other publications, that 80–100 km s^{-1} velocities are connected with active events on the Sun.

We can see three points with very high velocities in Figure 1. Those are 850 km s^{-1} from radio observations of coronal loops at 50 MHz, 1840 km s^{-1} from SMM observations of hard X-rays above a flare and a 1500 km s^{-1} velocity of the loop

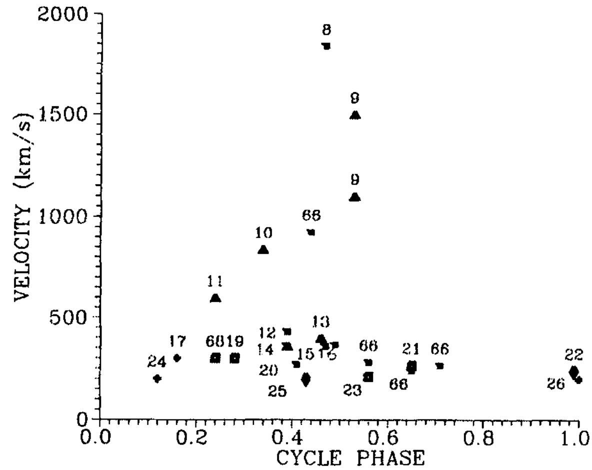

Figure 1 The dependence of the velocities in the corona and the transition layers on the phase of the solar cycle. The points are numbered corresponding to the papers taken from references. The velocities obtained by the line profiles in the corona are marked by squares, and in the transition region – by diamonds. Triangles and crosses show the velocities obtained by the image shifts in the corona and in the transition region correspondingly. Filled and open circles show the velocities of the corona and the transition region taken from papers where the method was not described.

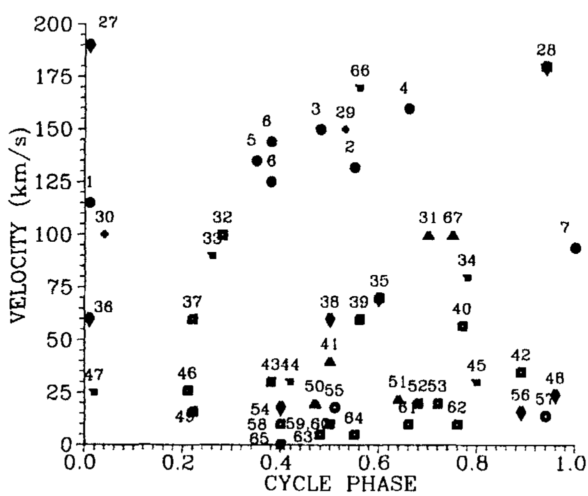

Figure 2 As Figure 1, but for velocities < 200 km s^{-1}.

propagation (projected on the picture plane). These loops are rooted in bright X-ray points and observed in soft X-rays. These three points appear at the maximum activity of the solar cycle and in its descending branch. If they are excluded, the remaining high velocities are concentrated at the *maximum* of the solar activity.

These are connected with flares, surges, eruptive prominences and bright X-ray point loops.

In Figure 2, high velocities are also found at the maximum or at the beginning of the descending branch of the solar cycle. Our interferometric eclipse velocity measurements in λ 5303 Å and λ 6374 Å show the same behaviour (Figure 2, marked by asterisks). Only the maxima of the velocities, observed during these eclipses, are plotted in Figure 2. The majority of the velocities are naturally much lower (Delone *et al.*, 1969, 1975, 1973, 1976, 1983, 1998, 1999). The strong deviation of the 1972 measurements (λ 6374 Å), corresponding to a decrease of the solar activity should be noted.

Analysis of the data of all the works quoted allows us to draw the following conclusions: the velocities derived from the shift of the entire profile are low; the velocities found from the shifted components of the profile are considerably higher; in this case only some of the line-of-sight material has a high velocity. This is natural, because high velocities are connected to active phenomena.

Thus, the existence of high-velocity motions in the corona and transition layer has been confirmed by repeated and methodically differing observations. Their domination at the maximum of the solar activity is distinctly connected with different active phenomena. Therefore, it is obvious that high-velocity events can also be observed during other activity phases, but with lower probability.

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