LOW-SPEED SOLAR WINDS OBSERVED AT DISTANCES OF 20-60 Rs AND CORONAL STRUCTURE OF THEIR SOURCE REGIONS

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Abstract

The interplanetary scintillation (IPS) can probe the solar wind at distance and latitude range where *in situ* measurements have been impossible. Using the IPS method very low-speed ($\leq$ 200 km/s) solar winds were observed at coronal active regions. Low-speed ($\sim$ 300 km/s) winds can be observed even around a polar coronal hole, and this winds is observed with a speed of 600 km/s at R$\geq$60Rs.

1. Introduction

The elucidation of acceleration mechanism of the high-speed solar wind from a coronal hole is one of the most important subjects in the solar wind physics. In order to clarify the acceleration mechanisms, it is important to know how the solar wind is accelerated along a stream line as well as to study relations between the acceleration profiles and physical properties of the source region in corona.

It has been reported that the solar wind has a rather constant flow speed at distances further than 0.3 AU [1,2,3,4]. However *in situ* measurements within 0.3 AU have been impossible though observations there is important to clarify the solar wind acceleration mechanism. The IPS observations at a frequency of 327 MHz, which has been carried out at Nagoya university and Ooty, can probe the distance range of 0.1$\sim$1 AU. We report observational results within 0.3 AU by the IPS method.

2. Speed distribution within 60 Rs

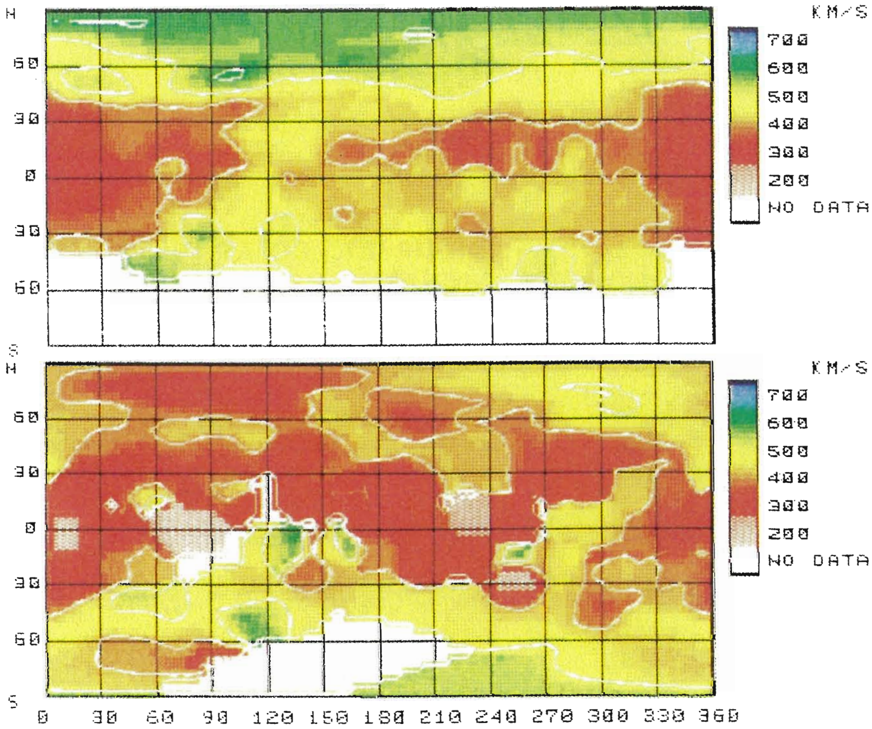

Fig. 1. Solar wind speed distribution on the source. The upper panel was derived with data obtained at distance range of 0.3∼1 AU. The lower one is from data within 0.3 AU

Two panels in Figure 1 are solar wind speed maps on the source surface which were derived by mapping back speeds measured by the IPS method. Coordinates are Carrington longitude and heliographic latitude. These two maps were obtained with data during three Carrington rotations of 1846 to 1848 in the year of 1991. Both maps are for the same period but show quite large difference each other. The reason for the large difference is that the upper one is derived from observations made at distance range of 0.3∼1 AU, while the lower one is made with data obtained at 0.1∼0.3 AU. The lower panel shows some interesting low speed regions. Three very low-speed ($\leq$ 200km/s) regions can be found at low latitudes where coronal active regions locate. Another low-speed region ($\sim$ 300 km/s) is at high latitude where high-speed (∼600 km/s) solar winds were observed in the upper panel. This region corresponds to a HeI polar coronal hole.

3. Distance dependence of solar wind speed

Let us see more in detail how the solar wind speeds are observed at various distances along a stream line. Lower panels in Figures 2 and 3 show the heliocentric distance dependence of speeds. Each straight line connecting open circles corresponds to one stream. These streams were found from the IPS observations as follows: speeds observed at various distances were mapped back on to the source surface: if they dropped on a small latitude and longitude area, those speeds were supposed to be observed on the same stream line. The foot point of the stream is shown by an open circle or a dot in the upper panel according to speed gradient at 20∼80 Rs. Smooth curves in the lower panel are from the Parker's model with an isothermal assumption for various temperatures. If speed gradient is small as these models, the foot point

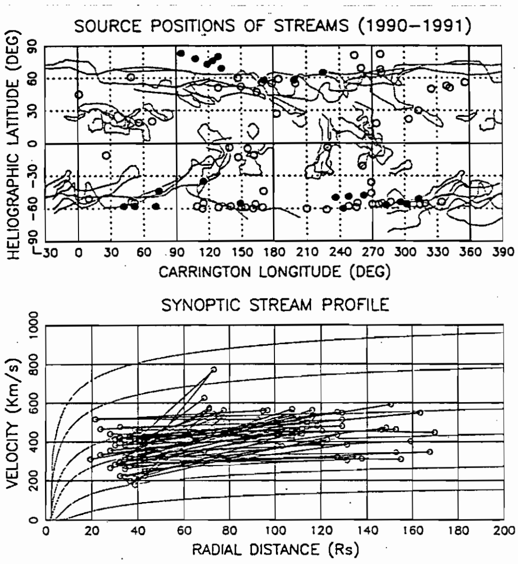

Fig. 2. Heliocentric distance dependence of the solar wind speeds and distribution of stream foot pints on the source surface. These were observed in the solar active phase.

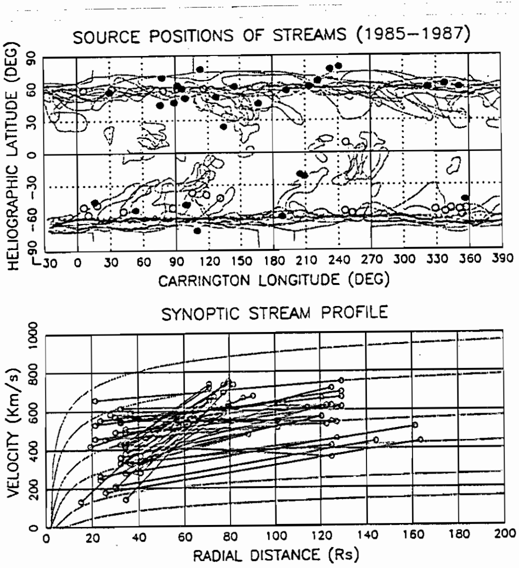

Fig. 3. Same as Figure 2 but for observations in the solar quiet phase.

of its stream is shown by an open circle. Streams with large speed gradient are shown by dots. Thin dotted lines in the upper panel is HeI coronal hole boundaries.

Figure 2 was observed in the solar active phase and Figure 3 is for the quiet phase. Through the whole solar activity cycle, the foot points of streams with large speed gradient distribute in coronal holes or near their boundaries. However all streams from those regions do not necessarily have large speed gradient.

4. Discussion

Since the solar wind observations with the IPS method is indirect measurements and its measurements can be biased [4], explanations for the observational evidences must be made carefully. We have examined whether the low speed observed near the sun could be caused by any biasing effects. If the solar wind is radially expanding at distances further than 0.1 AU, neither integration effects along the line of sight nor observations in strong scattering condition can produce such low speed observations. However if expansion of the high-speed stream is much larger than radial at 0.1~0.3 AU, the high-speed stream near the sun may be too small to be detected by the IPS.

If the large speed gradients observed at 0.1~0.3 AU are real acceleration, the following questions have to answered. Under what conditions cannot the solar wind be accelerated up to 0.1 AU? What is the accelerator which works at 0.1~0.3 AU at the high latitude? If the flux expansion of the high-speed wind is larger than radial, it means within 0.3 AU that pressure between neighboring streams is not yet balanced and that the pressure in higher-speed wind exceeds.

Thus the solar wind changes its properties dynamically even at distances of 0.1 to 0.3 AU and becomes a stable flow at distances further than 0.3 AU. Therefore observations within 0.3 AU is important to clarify the solar wind acceleration mechanism.

References

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