RED ASYMMETRIES OF OPTICAL LINES AT THE IMPULSIVE PHASE OF SOLAR FLARES

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Abstract

Impulsive phase spectra of two chromospheric flares were obtained with high temporal resolution. Hα, Ca II K, He I D_3, and other metallic lines were observed simultaneously and their red asymmetries were studied. Velocities derived from K and D_3 line emissions are found to be as large as Hα velocity, contrary to the previous works.

1. Introduction

The red asymmetry of Hα line profile is one of the characteristic features of the impulsive phase of solar flares. This phenomenon is now explained by the high-velocity (40–100 km s^{-1}) downward motion of emitting region (Ichimoto and Kurokawa, 1984), which is a counterpart of the chromospheric evaporation producing the blue-shifted soft X-ray emission.

Although Hα is the most popular line to observe solar flares, other lines also give us important informations about the flaring atmosphere. Švestka (1976) summarized that the highest velocity is found for hydrogen ($\sim$100 km s^{-1}), smaller velocities are deduced from helium and Ca II H and K lines (a few tens of km s^{-1}), while the velocity in metals is close to 10 km s^{-1}. But the time scale of the impulsive phase is order of seconds, and there's been no simultaneous observation of these lines during the impulsive phase with high temporal resolution.

In 1989, we successfully obtained the impulsive phase spectra in five wavelength regions simultaneously, with sufficiently high temporal resolution. We present here the results of velocity measurements of Hα, Ca II K, and some other lines.

2. Observation and Analysis

Observations were made in October 1989, using the Horizontal Spectrograph of Domeless Soalr Telescope at Hida Observatory of Kyoto University.

NOAA 5747 produced several flares everyday during its traverse on the solar disk. On October 21 it was near the disk center. Table 1 gives fundamental data of the two flares analyzed in this paper. Our data analyzed here start at 01:54:06 UT and 23:48:52 UT.

Table 1. Data of the Flares.

	Flare A	Flare B
Date	Oct.21	Oct.21
NOAA	5747	5747
Location	S27W09	S27W22
Start(UT)	0153	2347
Max(UT)	0155	2353
End(UT)	0206	2423
Opt.	1N	SN
Xray	M2.4	M3.1

We selected eight conspicuous emission streaks (three from Flare A, five from Flare B) in the Hα spectra and measured the profiles of Hα, Ca K, He D_3, Na $D_{1,2}$ and three Fe I lines near the K line for these streaks.

The method to analyze each profile is basically the same as that of Ichimoto and Kurokawa (1984). Profiles of optically thin emission are obtained by subtracting a quiet profile, while optically thick emission is found in the original non-subtracted profiles.

We determined the central wavelengths of emission at wings and peaks for Hα and K lines. D_3 shows broad emission, too, but the line is triplet and each profile is too broad to be separated in a flare emission. We measured only the peak position of the main component of D_3. The shifts of $D_{1,2}$ and Fe-line emissions were measured only at the emission peaks because their profiles are narrow.

3. Results and Discussion

(open circles), K wing (filled squares) and peak (open squares), D_3 (triangles), D_1 (asterisks), and Fe I 3922.9Å(crosses).

Figure 1 shows two examples of the velocity behaviors. General results are: (1) K-line wing gives as large velocities as Hα wing. (2) Usually the emission peaks of Hα and D_3 are largely red-shifted as the Hα wings, too. (3) Shift of K-line peak is usually as small as $D_{1,2}$ and metallic lines. (4) Duration of the strong red asymmetry is less than one minute.

Two more facts should be noted: (5) Even a streak above the sunspot umbra (e.g. the streak of Figure 1(a)) shows red asymmetry. (6) In one case that is shown as Figure 1(b), slight enhancement is found in the blue side of Hα profile before the appearance of strong red-shofted emission.

Results (1)–(3) would be important informations for the purpose of modelling a flaring atmosphere. Švestka (1976) suggested two explanation for the difference in velocities of these lines; difference in the height of line formation and conservation of momentum. Result (1) denies the latter explanation because Ca ion is much heavier than hydrogen and still gets as large velocity. He also noted that the asymmetry vanishes above sunspots, but we found it exists above the sunspot umbra. Existence of blue asymmetry at the onset of a flare has not yet been confirmed. We found a positive case, though most of emission streaks show only red asymmetries.

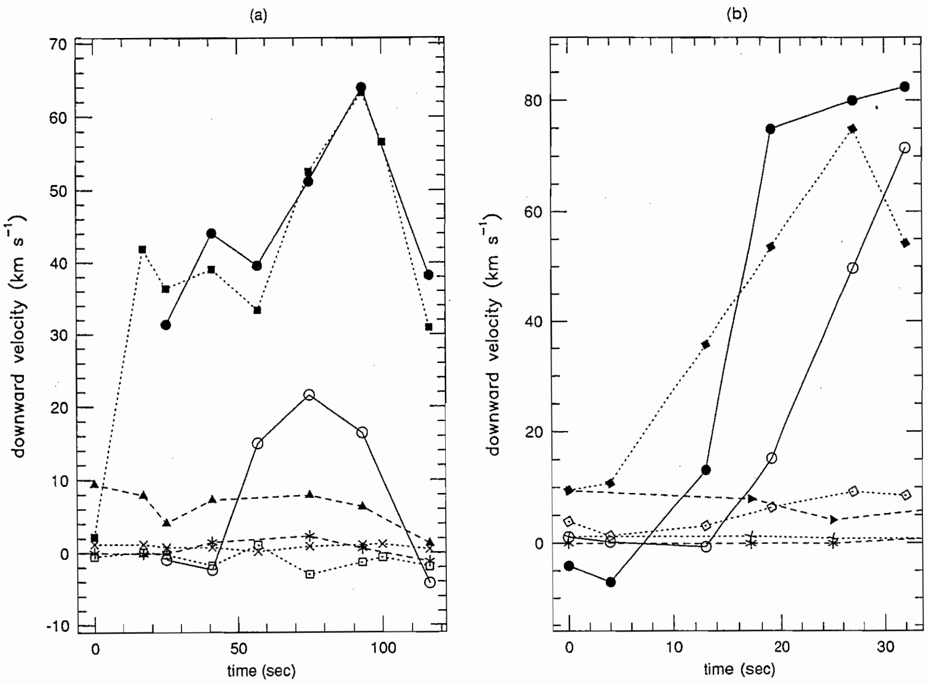

Fig. 1. Downward velocities of Hα wing (filled circles) and peak (open circles), K wing (filled squares) and peak (open squares), D_3 (triangles), D_1 (asterisks), and **Fe I** 3922.9Å(crosses). (a) is an example from flare A, (b) is from flare B. Time is referring to the beginning of each observation.

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