ANOMALOUS DECREASE OF THE TURBULENT VELOCITIES IN SOLAR MAGNETOPLASMA WITH STRONG AND SMALL–SCALE MAGNETIC FIELDS

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The extremely narrow metallic emissions were observed in several solar flares of 1989, 1991 and 2000. Our analysis is based on the Stokes $I \pm V$ and $I \pm Q$ spectra obtained using the Echelle spectrograph of the Astronomical Observatory of the Taras Shevchenko National University of Kyiv. The careful data reduction for excluding the instrumental broadening effect shows that the intrinsic half width of the emission peaks in the Fe I lines was in the range from 1–2 to 10 pm. The extraordinary narrow peaks (nearly 1.5 pm) are inherent in 5–10 percents of a total number of observed profiles, mainly in the case of very weak flare emissions. The obtained data point out to some specific process like the "frozening" of plasma motions in the strong and small-scale magnetic fields.

INTRODUCTION

In this paper we present a very short description of some new results related to phenomenon of anomalous narrow flare emission in the metallic lines. This phenomenon was preliminary studied by Lozitsky, Lozitska and Gordovsky [1] on a base of two solar flares (namely on June 16, 1989 and July 25, 1991) observed with the Echelle spectrograph of the horizontal solar telescope of the Astronomical Observatory of the Taras Shevchenko National University of Kyiv. Detail description of this instrument and the Stokes $I \pm V$ and $I \pm Q$ observations are presented in [2].

OBSERVATIONAL DATA

We have investigated the flare of June 16, 1989 in more details. Two spectral lines, Fe I 5434.5 Å and Fe I 5446.9 Å with Lande factors − 0.014 and 1.25 were studied. The first line with Lande factor of near zero is the most suitable to determine turbulent velocities.

It was found that the observed half width of the emission peaks in cores of the Fe I 5434.5 Å line, $\Delta\lambda_{1/2}$, depends on the peak intensity I measured as their heights above Fraunhofer profile (Fig. 1). One can see that the regression linear dependence gives the value $\Delta\lambda_{1/2} \approx 3.4$ pm for $I = 0$, that is practically equal to the instrumental profile width (3.0 pm). It means that the true half width of the pure emission could be more less than 3.4 pm.

Similar narrow emissions were observed also in 2N flare of July 19, 2000. This flare had coordinates 14°S, 15°E, and peak of metallic emission nearly 7:20 UT.

To obtain the true profiles of spectral lines we used two different methods (see [1]) including the Fourier-regularization technique. Our reduction of the observed profiles shown that majority of the pure emission peaks in Fe I lines were 5–6 pm wide. The upper limit of the half width is of about 10 pm, but the lower – in the range 1–2 pm. Possible errors of the reduction are of about $\pm(0.5 - 1)$ pm, and depend mainly on the accuracy of the instrumental profile and method of interpretation of emission peak intensity. It is necessary to point out that the reduction procedures do not exclude an unlimited narrow profile like the delta-function. This problem needs, however, a special study and could be resolved in the future.

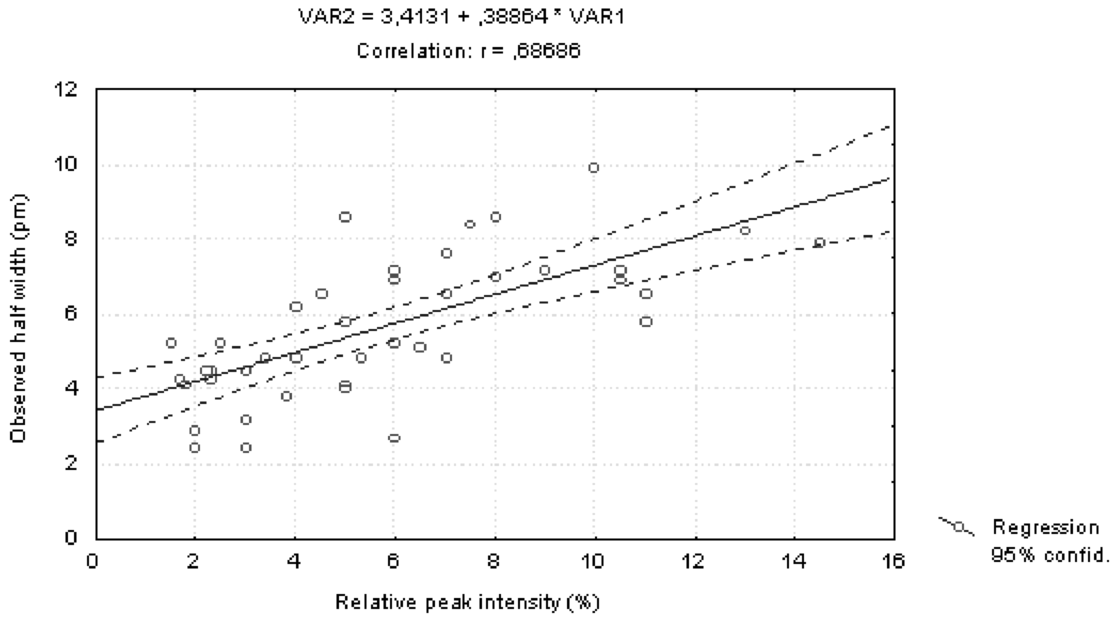

Figure 1: Observed half width of the emission peaks in cores of Fe I 5434.5 Å versus peak intensity measured as their heights above the Fraunhofer profile in the flare of June 16, 1989

WHY DO THE VERY NARROW EMISSION PEAKS ARISE?

It is obviously that such very narrow profiles (1–2 pm) indicate formally to the very low turbulent velocities ξ and temperatures T in flares. If $\xi = 0$, then T is *several times less than that in the undisturbed atmosphere* [1]. It may be assumed that some specific process like the "frozening" of motions occurs in flares. So long as magnetic fields in flares have subtelescopic structure [1, 2], such a process could be especially strong inside the small-scale magnetic fluxtubes with kG strengths.

As to possible theoretical interpretation, there is a sharp drop of the magnetic Reynold's number (a drastic increase in the Joule dissipation) in the reconnection zone [3]. Then the local growth of the magnetic field combined with this effect leads to the intense turbulence suppression, as observed, for instance, in laboratory MHD flows in the external magnetic field [4]. Simultaneously, owing to turbulent energy transformation into heat, the temperature increases in the reconnection zone and the additional ionization occurs. Plasma rejected from the diffusion zone along magnetic field lines recombines in the process of cooling, which leads to the formation of the emission lines. However, in this case the motion of plasma particles can considerably differ from the thermal ones. Thus, we can assume that the Joule dissipation in the diffusion zone, turbulence suppression, and change in the velocity distribution law in the process of magnetic field reconnection at the burst origin leads to the formation of anomalously narrow emissions in spectral lines.

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