

Magnetic fields and turbulent velocities in a limb solar flare by hydrogen, helium and ionized calcium lines



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The flare under study

We present simultaneous magnetic field measurements for the limb solar flare of 1981 July 17 using of the Ca II K, H δ , He I 4471.5 Å and H β lines [1]. For two moments during the flare, which differ in time by 16 min, we analyzed Stokes $I \pm V$ profiles of these lines from observations made on the Echelle spectrograph of the horizontal solar telescope of the Astronomical Observatory of Taras Shevchenko National University of Kiev.

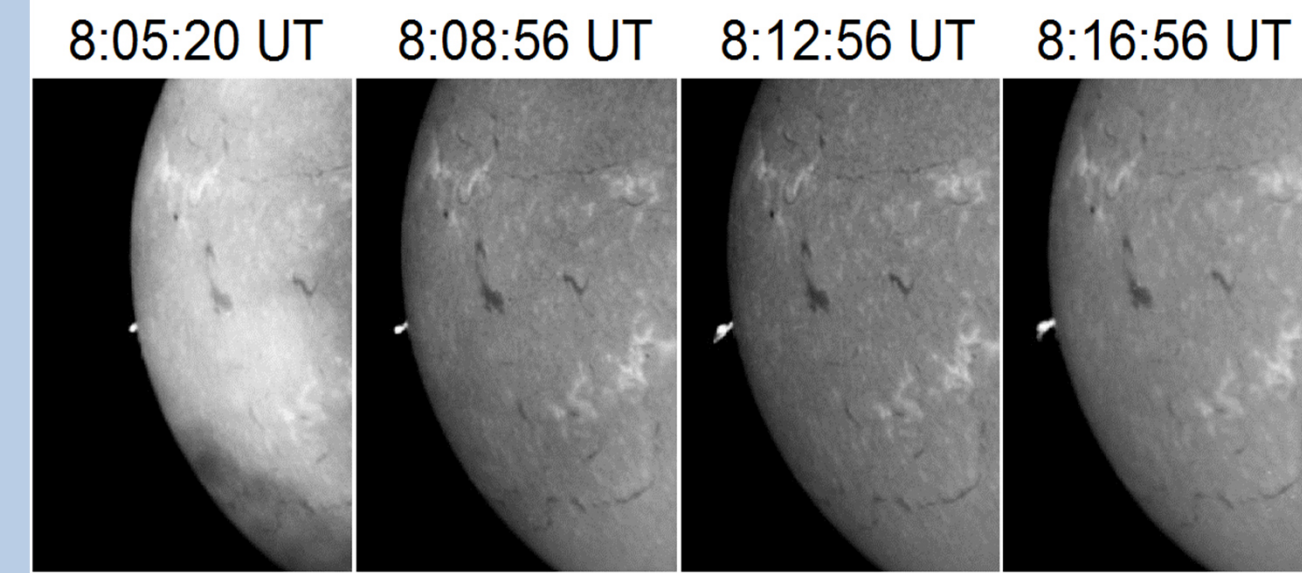


Fig.1. The development of the flare of 1981 July 17.

Observations

At the time step that was close to the peak phase of the flare, 08:17 UT, all spectral lines under study showed very wide emissions, with a full width at half maximum (FWHM) of 3.5–4 Å (Fig.2). A presence of narrow emission peaks with a FWHM of only 0.25–0.35 Å was observed in the blue wings of these lines.

At 08:33 UT, i.e., at the post-peak phase of flare, at least three separate emission components were present in the lines under study (Fig.3). These emissions correspond to the heights in range of 5–20 Mm above the photosphere.

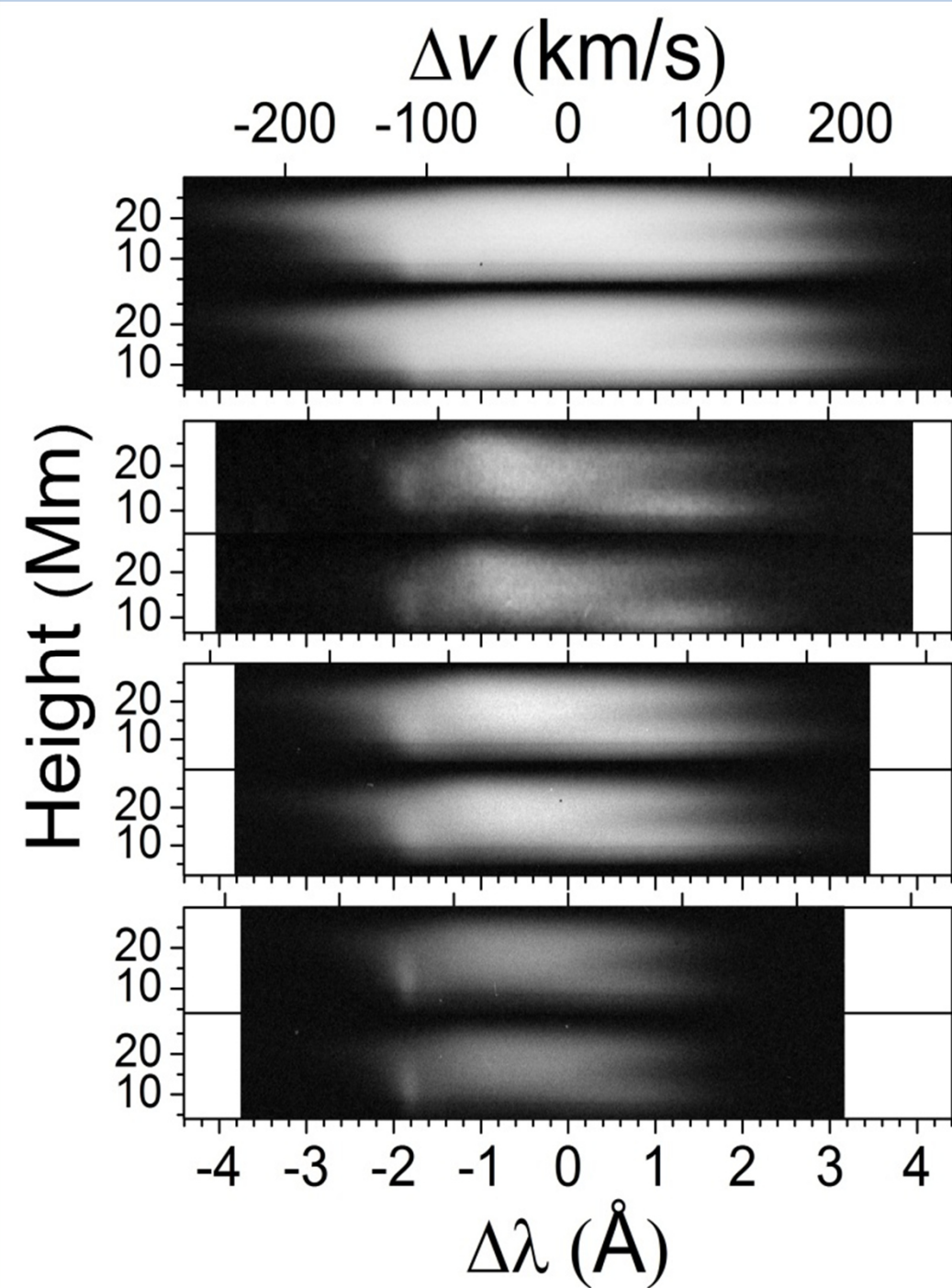


Fig.2. Spectrograms of the limb flare in the H β (top), He I 4471 Å (top middle), H δ (bottom middle), Ca II K (bottom) lines obtained on 1981 July 17 at 08:17 UT. The top and bottom half of spectrograms correspond to the $I-V$ and $I+V$ spectra, respectively.

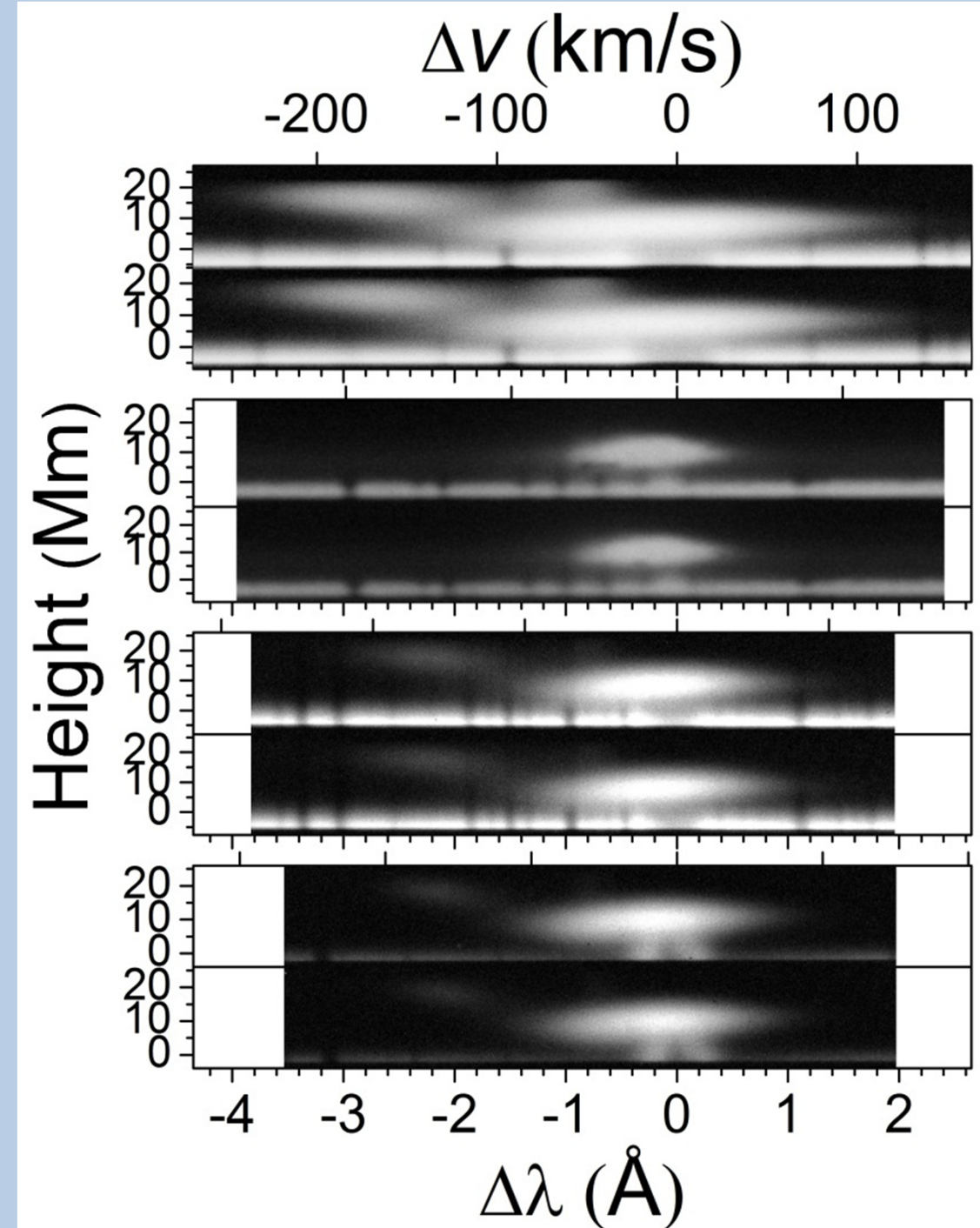


Fig.3. Spectrograms of the limb flare in the H β (top), He I 4471 Å (top middle), H δ (bottom middle), Ca II K (bottom) lines obtained on 1981 July 17 at 08:33 UT. The top and bottom half of spectrograms correspond to the $I-V$ and $I+V$ spectra, respectively.

Spectral line profiles

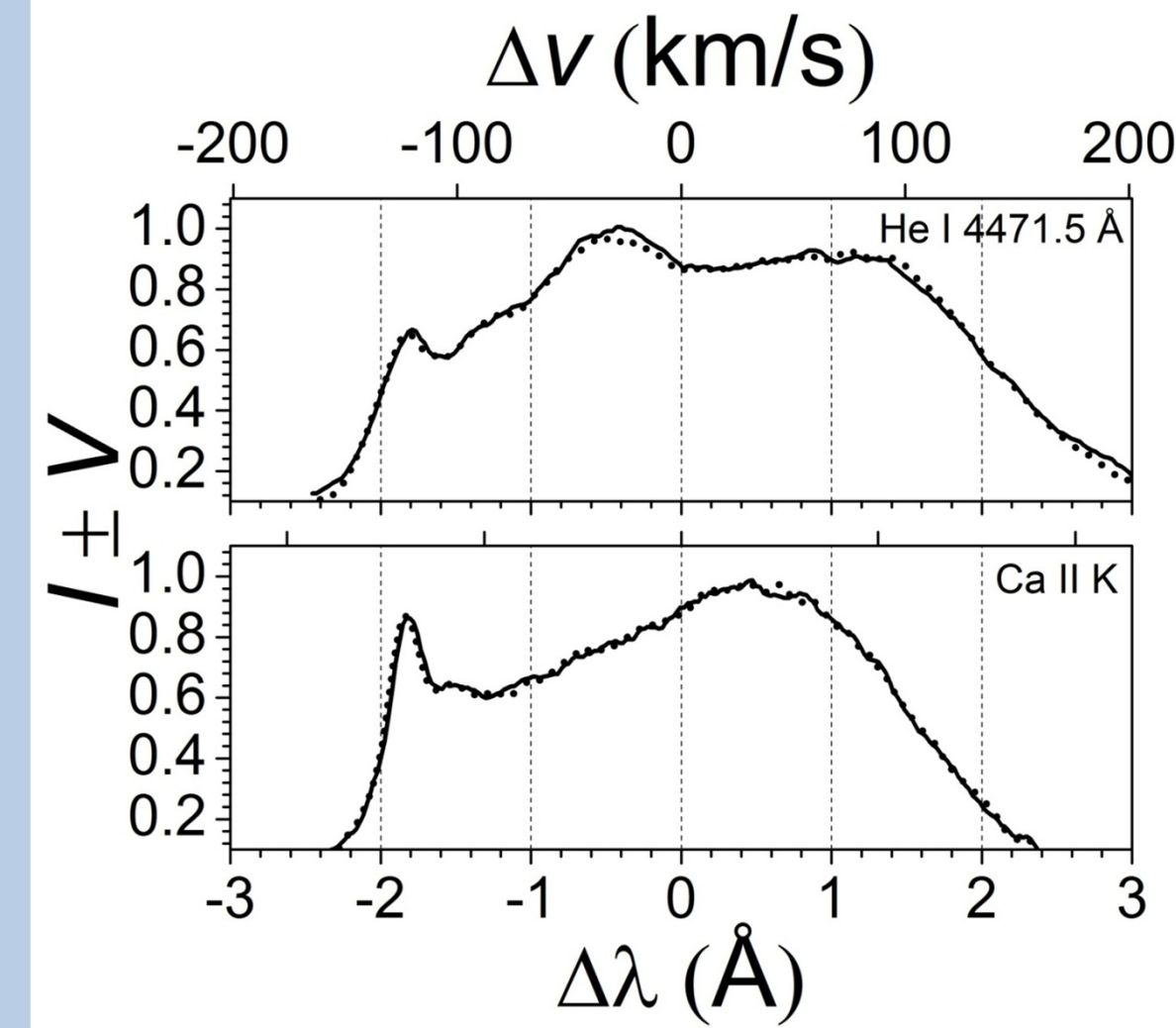


Fig. 4. The $I-V$ (solid) and $I+V$ (dashed) profiles of He I 4471 Å (top) and Ca II K (bottom) lines of the limb flare on 1981 July 17 obtained at 08:17 UT.

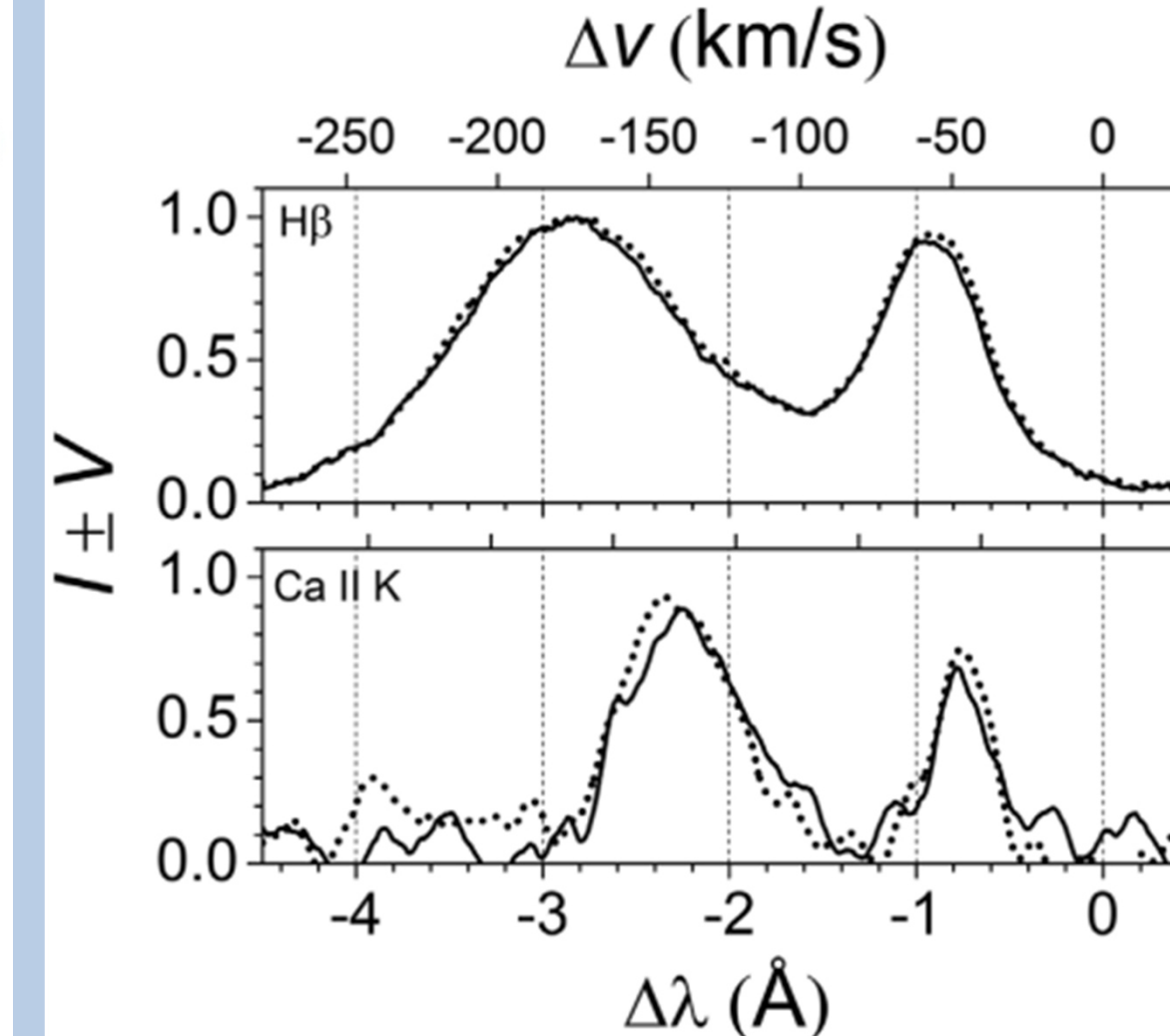


Fig. 5. The $I-V$ (solid) and $I+V$ (dashed) profiles of He I 4471 Å (top) and Ca II K (bottom) lines of the limb flare on 1981 July 17 obtained at 08:33 UT.

Magnetic fields

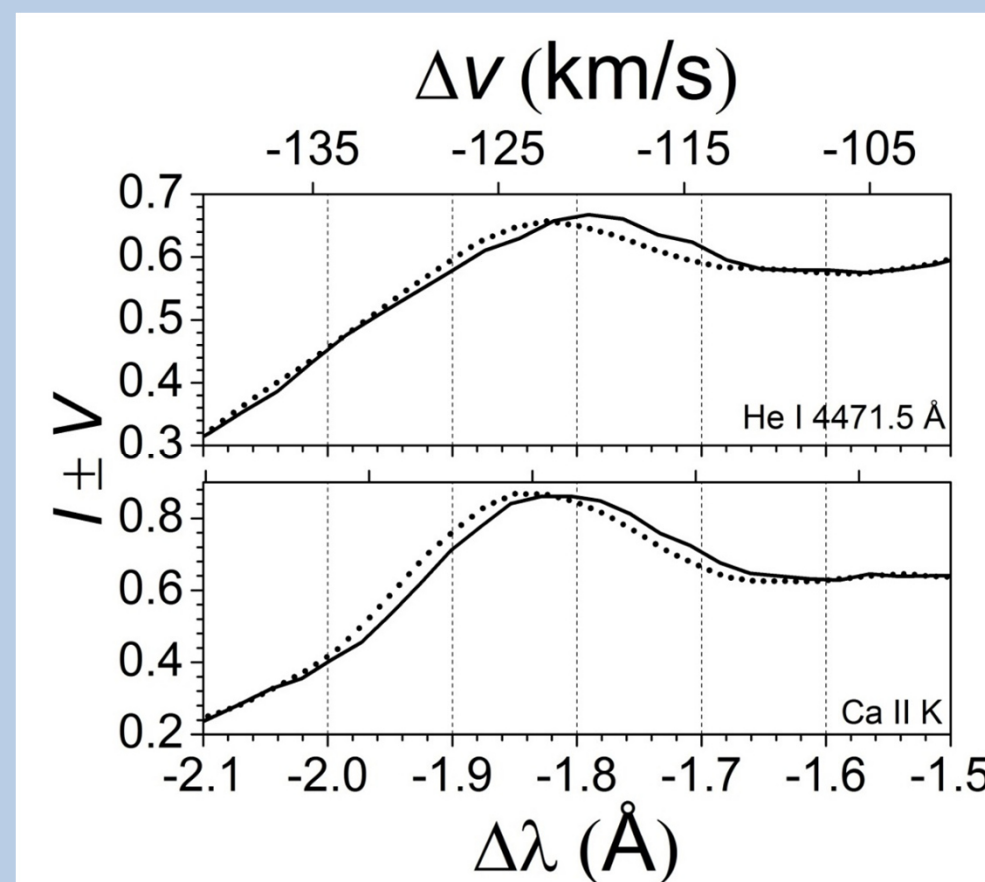


Fig. 6. Details of highly Dopplershifted profile components (Fig. 4) and the Zeeman split of $I-V$ (solid) and $I+V$ (dashed) profiles.

- Very strong magnetic fields (up to about 3 kG) existed at both moments of the flare.
- The strongest fields, measured by different spectral lines, are in general located at different heights.
- The polarities of the magnetic field for different spectral lines in most cases are the same.
- The true local magnetic fields in the flare could be even larger, since the obtained results represent a longitudinal component of the magnetic field assuming that the filling factor equals unity.
- The data obtained indicates a significant inhomogeneity of the magnetic field in the flaring corona and the probable presence of the conditions necessary for magnetic reconnection of field lines.

Turbulent velocities

Figure 6 shows the turbulent velocities and temperatures that correspond to the thin emission component at $\Delta\lambda \approx -1.8\text{Å}$ of the 08:17 UT moment, measured by comparing different pairs of spectral lines.

- There is a tendency to anti-correlation between temperature and turbulent velocity.
- A possible explanation is that there is significant magnetic broadening of the spectral lines. The corresponding estimates lead to values of 7–8 kG.

For more details please refer to [2].

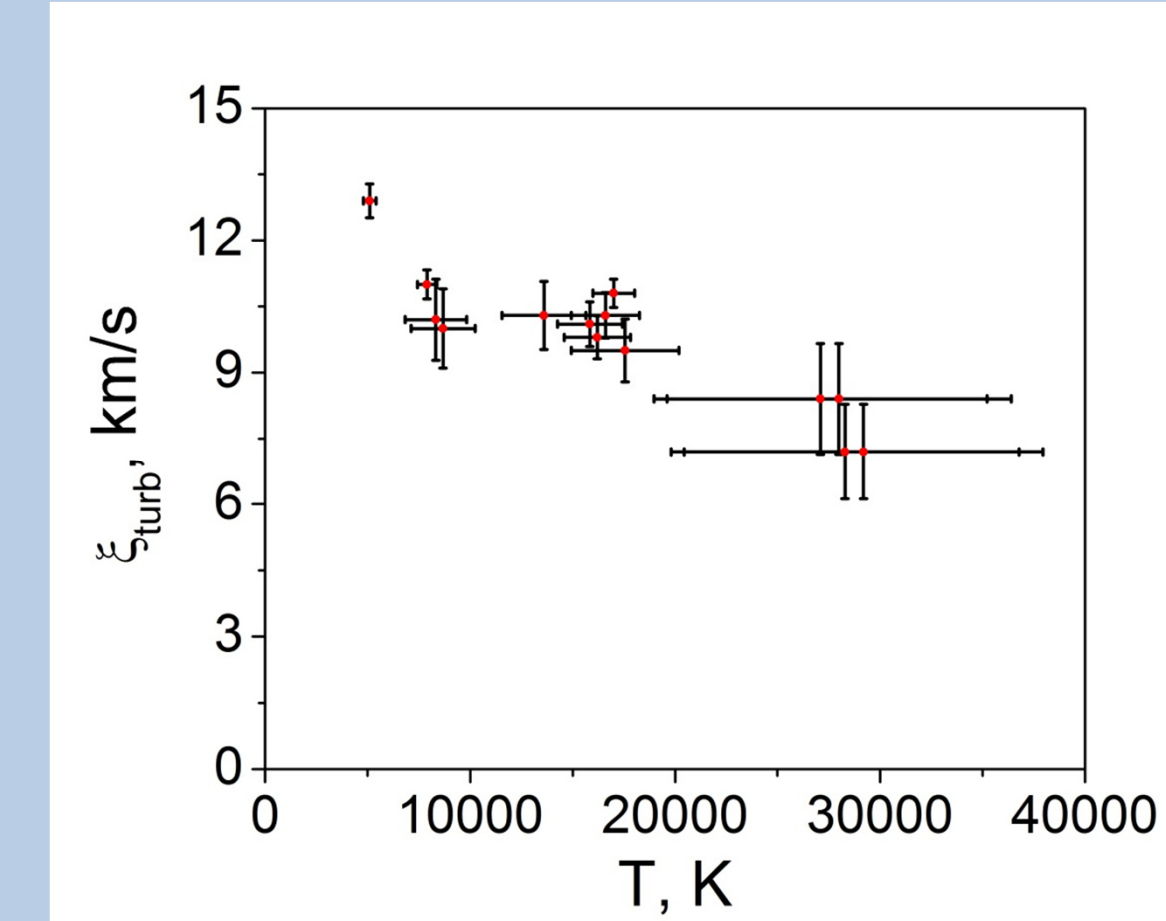


Figure 6: Comparison of temperatures and turbulent velocities in the explosive phase of the flare, found from the widths of the narrow component of the emission.

Conclusions

- On 17 July 1981 narrow emission peaks with widths of only 0.25–0.35 Å were observed in the Limb solar flare.
- The magnetic fields in the flare at heights of 10–15 Mm above the photosphere reach up to about 3 kG.
- The revealed certain anti-correlation between temperature and turbulent velocity can indicate the existence of very strong magnetic fields of mixed polarity up to 7–8 kG.

References

1. Yakovkin I.I., Veronig A.M., Lozitsky, 2021. Adv.Space Res. <https://doi.org/10.1016/j.asr.2021.03.036>
2. Yakovkin I.I., Lozitsky V.G., 2020. Odessa Astron. Publ. 33, 93. <https://doi.org/10.18524/1810-4215.2020.33.216453>