

Time resolved spectroscopic observations of an M-dwarf flare star EV Lac during a flare

No. 176

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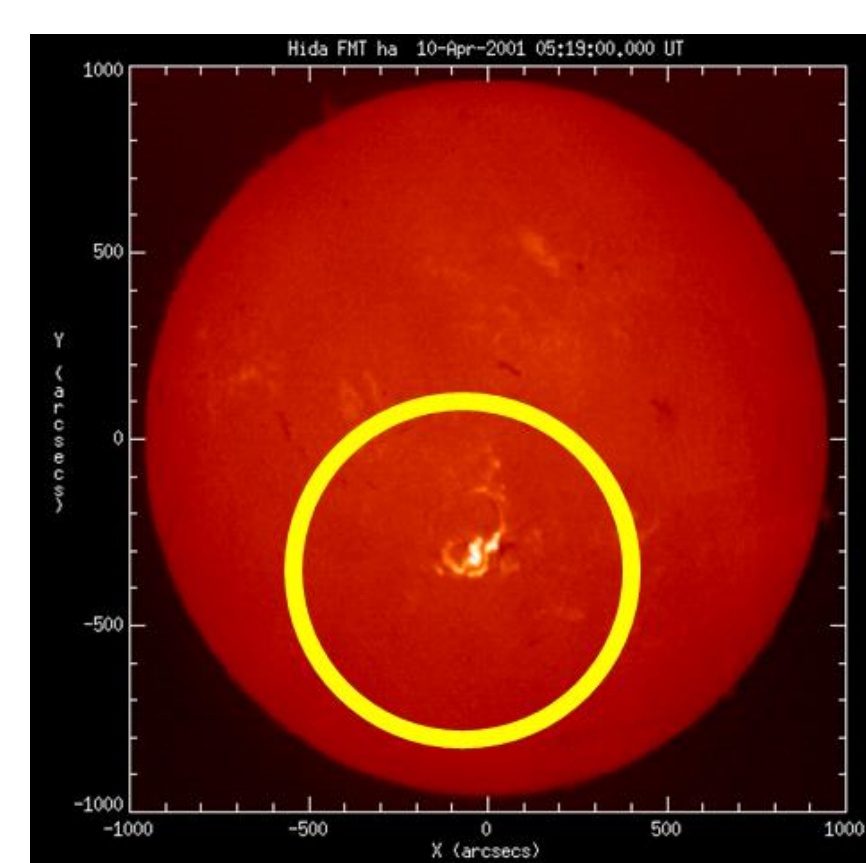
Abstract: Flares are explosions on the surface of the Sun and stars. We can find stellar flares frequently on M-dwarf stars. EV Lac, one of the M-dwarf flare stars, is a good target for investigation of stellar flares. We have carried out continuous spectroscopic observations of the H α line with medium wavelength resolution ($R \sim 10,000$) by using 2m Nayuta telescope at Nishi-Harima Astronomical Observatory in Japan from August to December, 2015. EV Lac always has H α emission line and it was stronger on 15 August than on the other nights. In this night, we observed a rapid enhancement (~ 20 min) and following slow decrease (~ 1.5 h) of the emission-line intensity of H α , which was probably caused by a flare. We also found an asymmetrical change in the blue region of the H α line. In many cases, red asymmetry has been observed in the H α line profile during solar flares, but blue asymmetry has been sometimes observed during stellar flares.

Solar and Stellar flares

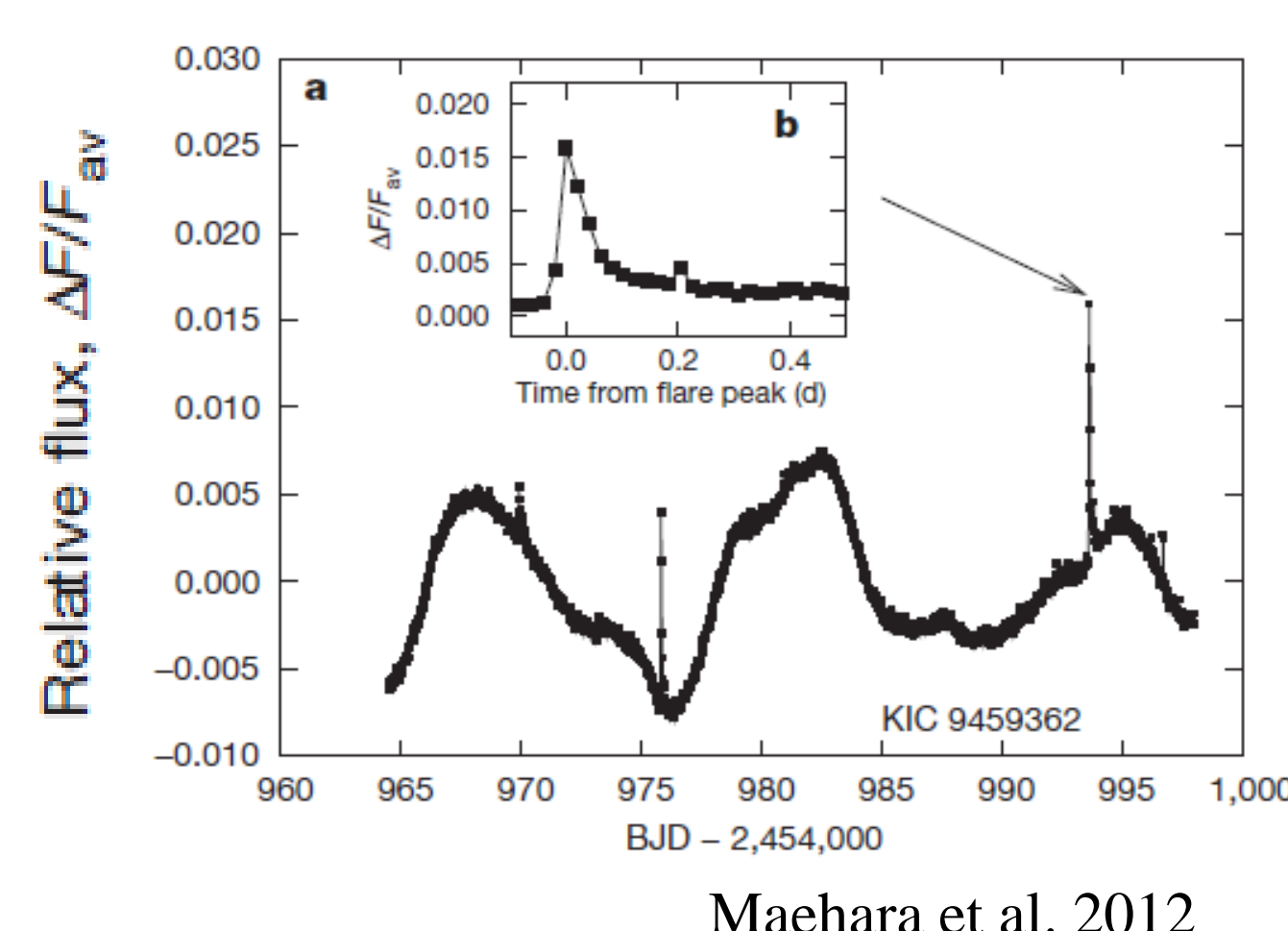
Solar flares are energetic explosions in the solar atmosphere. However, its mechanism is still unknown. The stellar flares are also unknown.

Young stars, close binary stars, and dMe stars sometimes produce “superflare”, flares whose total energy is $10 - 10^6$ times larger than the largest flares on the Sun. Recently, Maehara et al. (2012) analyzed the photometric data from Kepler spacecraft, and discovered 365 superflare events on 148 solar-type stars.

The concern with stellar flares has been growing.



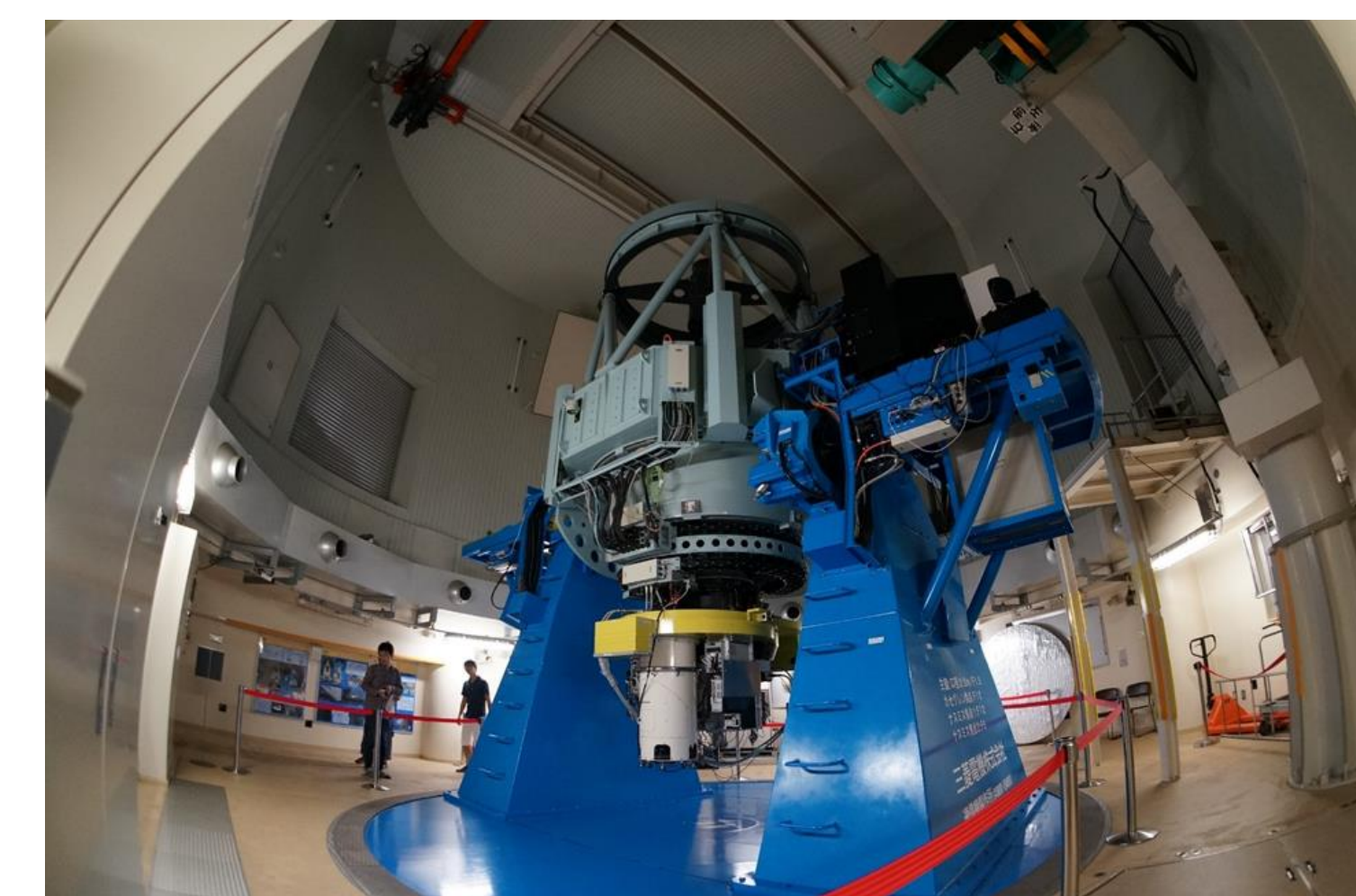
Hida observatory, Kyoto Univ.



Maehara et al. 2012

Time resolved spectroscopic observations

The spectroscopic observations were carried out with Nayuta 2m telescope at the Nishi-Harima Astronomical Observatory (Univ. of Hyogo, Japan).



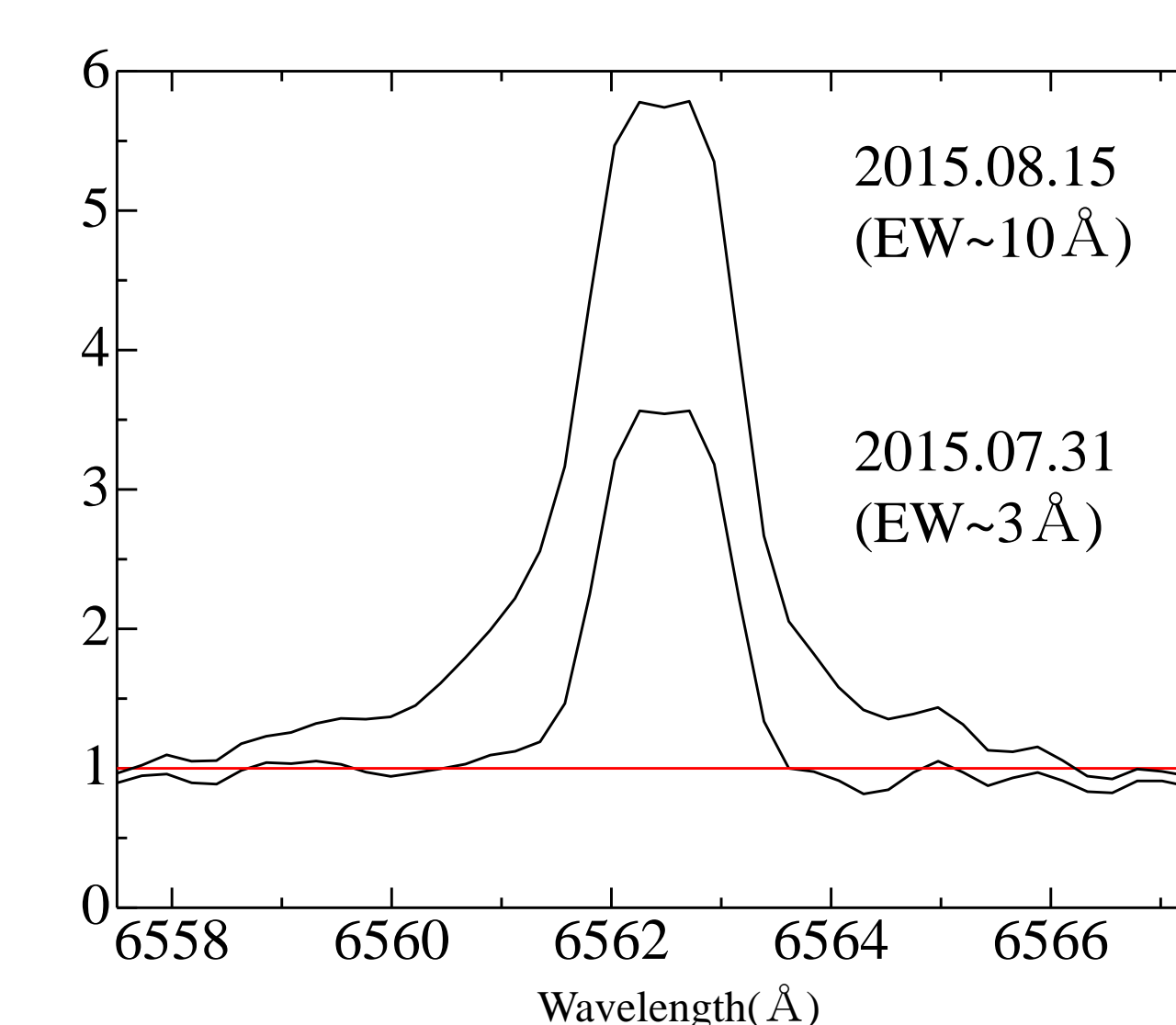
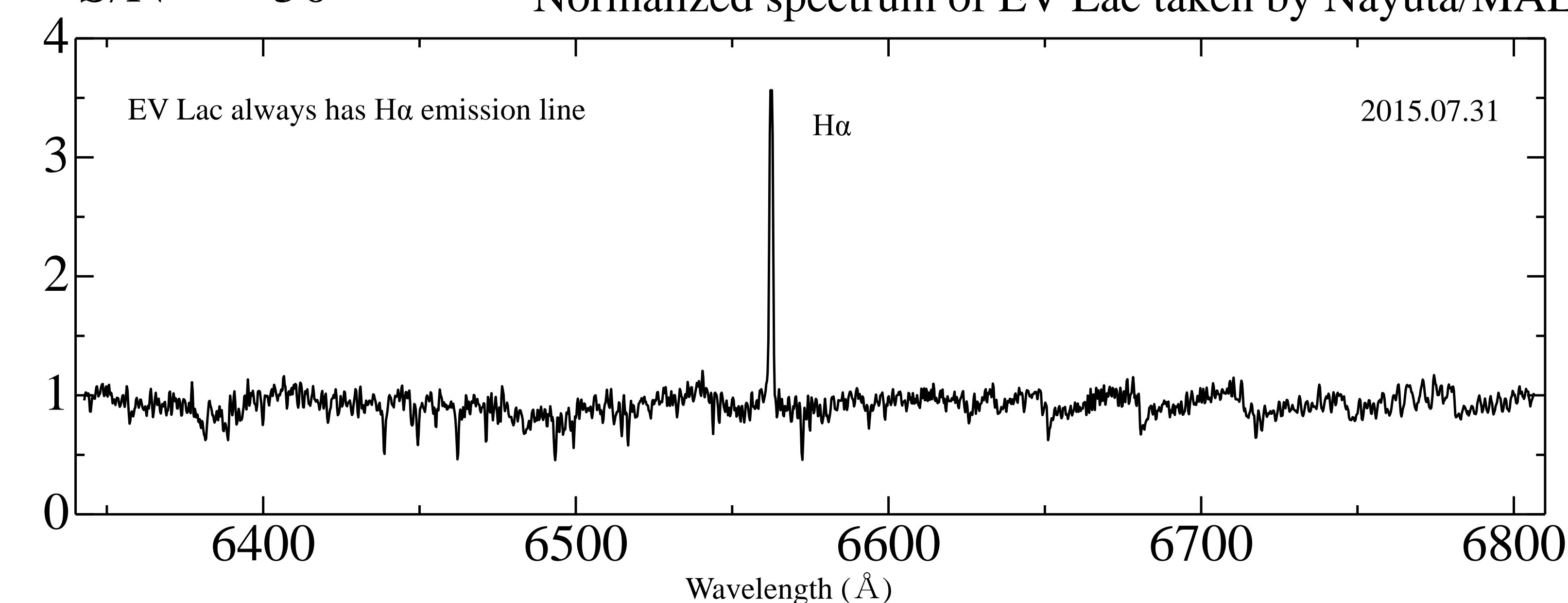
Nayuta telescope

The MALLS (Medium And Low-dispersion Long-slit Spectrograph)

was used with resolving power (R) of 10,000 @ 6500 Å.

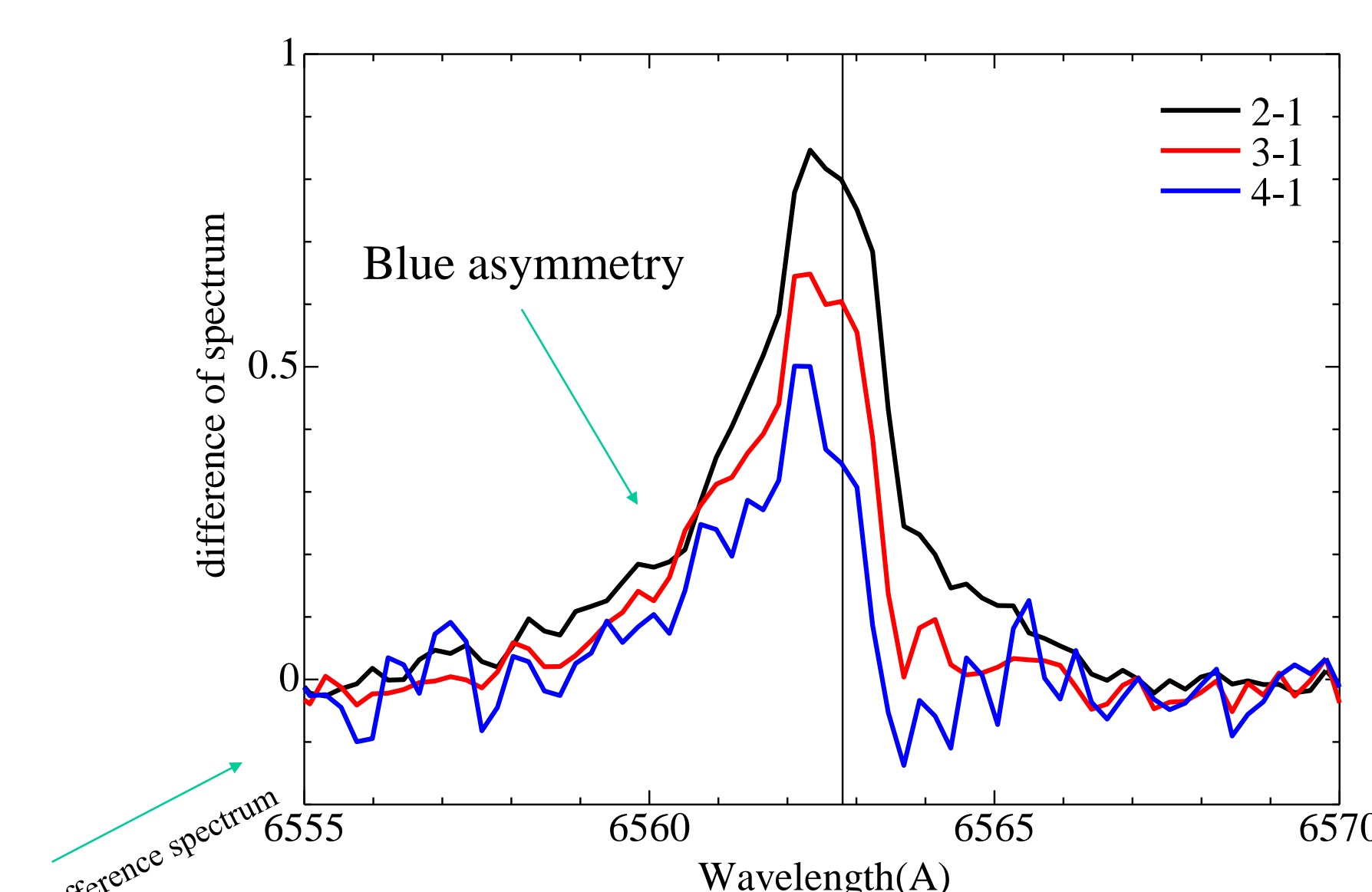
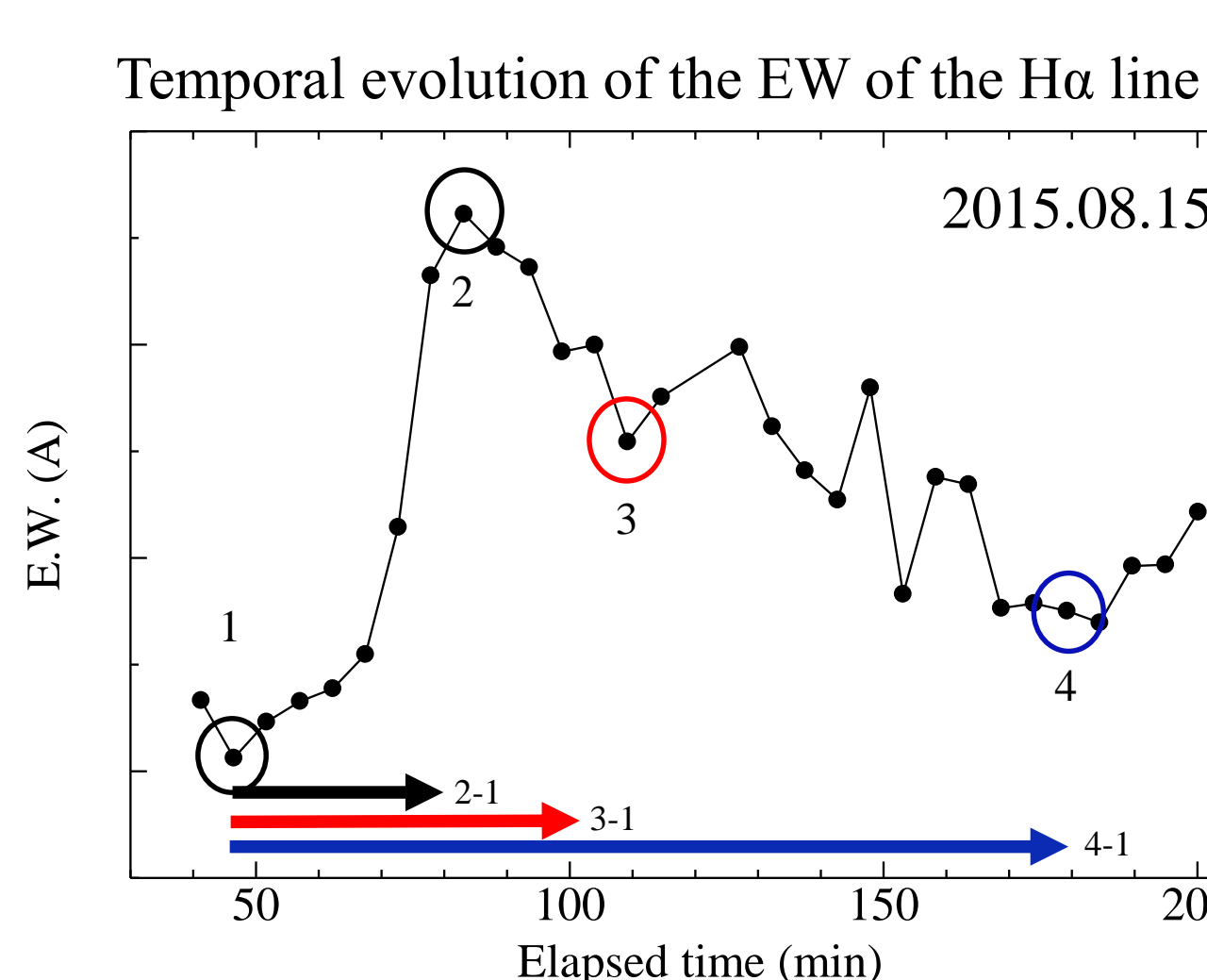
- Observation period : 2015.7.31 – 12.25 (22nights)
- Typical exposure time : 3-5 min ($\times 5-10$)
- Wavelength coverage : 6350 – 6800 Å
- S/N = ~ 50

Normalized spectrum of EV Lac taken by Nayuta/MALLS

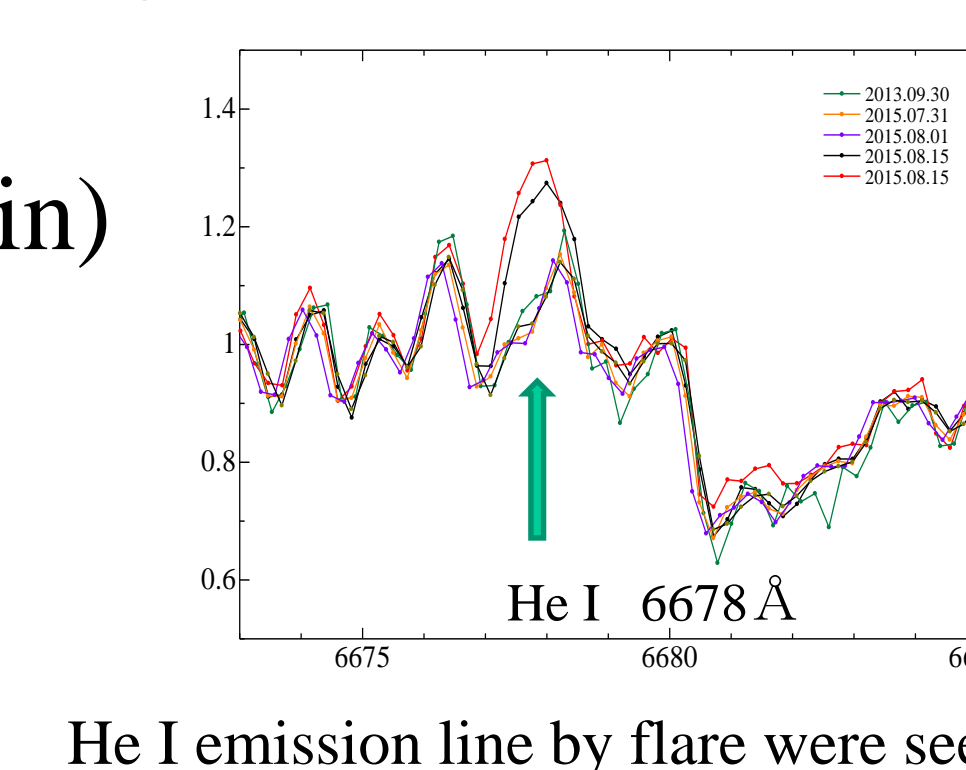


A large change of line intensity was seen between 2 weeks. (July31-Aug.15)

H α equivalent width (EW) of EV Lac
 - Quiescent state : 3.5 – 5.3 Å
 - Active state : 4.7 – 10.6 Å
 (Baranovski et al. 2001)



In Aug. 15, we observed a rapid enhancement (~ 20 min) and following slow decrease (~ 1.5 hour) of the emission-line intensity of H α , which was probably caused by a flare. We also found an asymmetrical change in the blue region of the H α line.



EV Lac (GJ 873)

- M4.5e V, Single flare star
- $R_{\odot} = 0.41$, $M_{\odot} = 0.34$ (Sciortino et al. 1999)
- $B = \sim 11.45$, $V = \sim 8.28$, Distance = 5pc, $P = 4.4$ days
- 3-4 kG (Shulyak et al. 1997)
- An extreme X-ray flare observed by ASCA in 1998
 –Favata et al. 2000
- Detection of a Superflare by Swift in 2008
 –Osten et al. 2008
- Frequency of the flare : 0.094[events/hours]
 –Schmidt et al. 2012



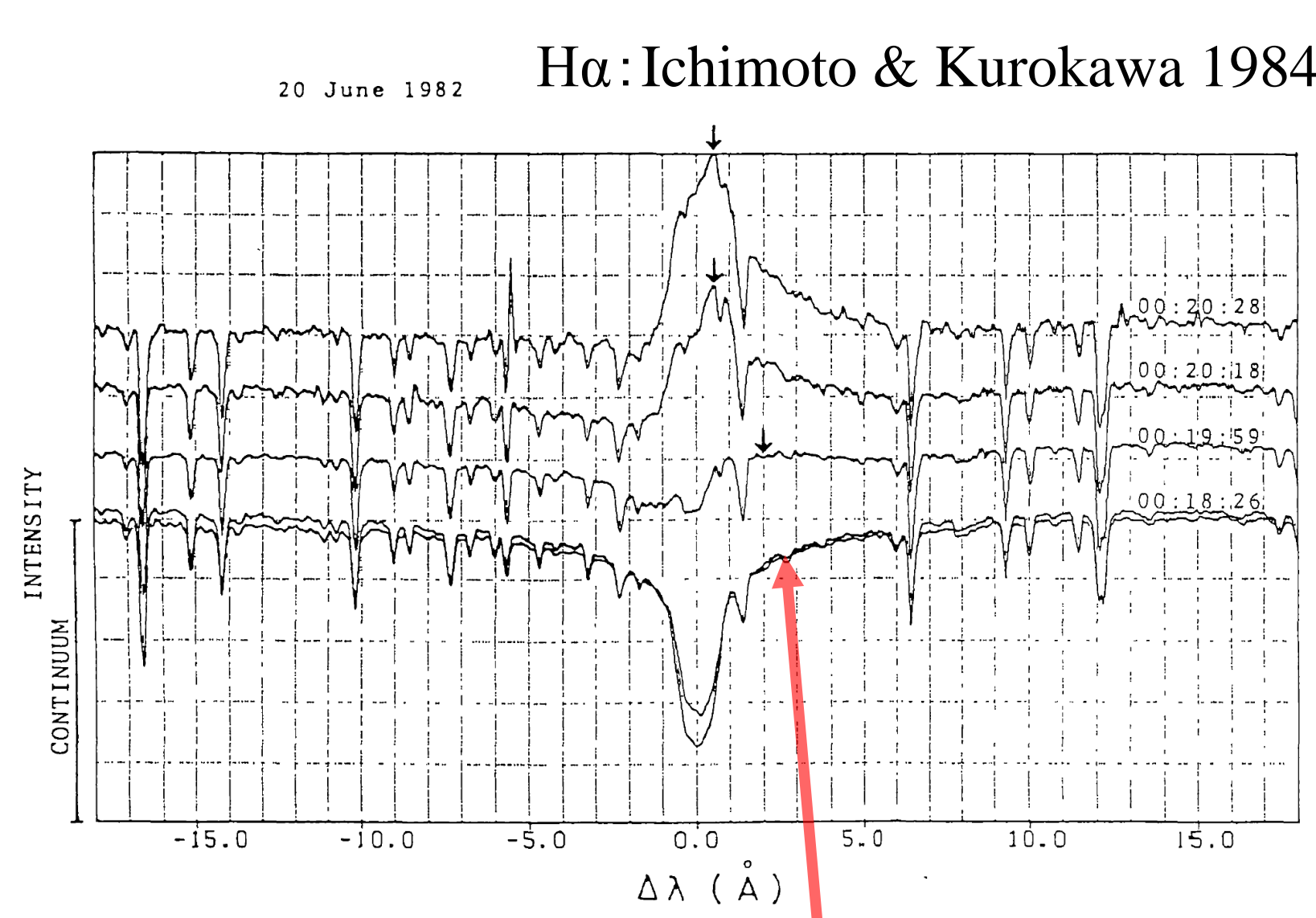
EV Lac, (Taken from DSS)



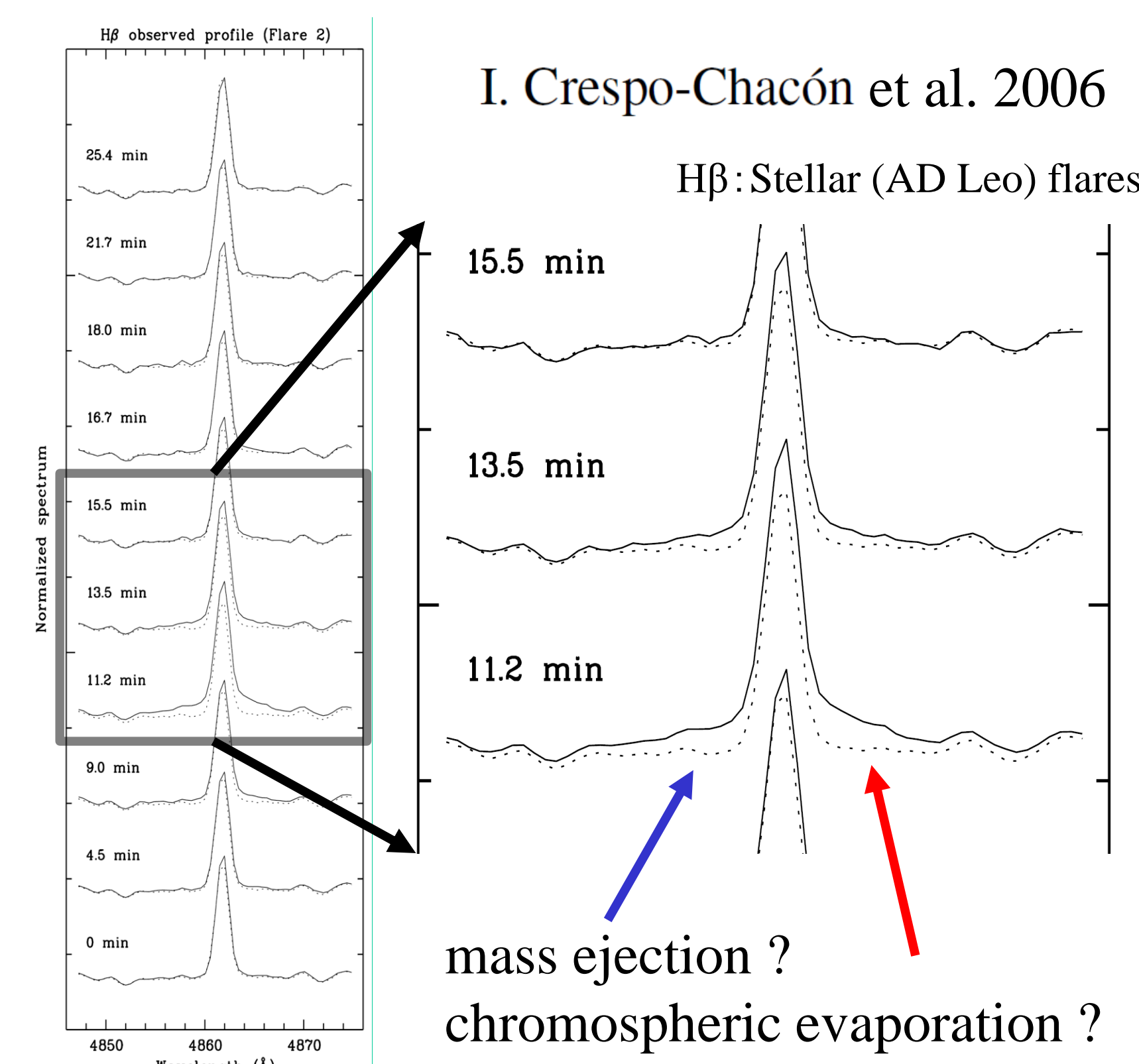
http://www.nasa.gov/multimedia/imagegallery/image_feature_1087.html

EV Lac is a good target for investigation of stellar flares.

Spectroscopic observations of flares



Red asymmetry (enhancement of red wing) has been observed in the H α line profile during solar flares. This will be due to chromospheric downward motion of condensations.



Blue asymmetry has been sometimes observed during stellar flares.

It is important to obtain the spectra of stellar flare.

Summary

- We have observed the dMe flare star (EV Lac) by Nayuta telescope.
- EW of H α line showed the very strong in Aug. 15.
- In Aug. 15, we observed a rapid enhancement and following slow decrease of the emission-line intensity of H α , which was probably caused by a flare.
- The flare spectrum shows (blue) asymmetry in the emission line of H α .