Black-Light Flares

Yan Xu

2012 July 11

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5876 Å (D3) & 10830 Å

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On the Sun?

Spectral lines	Continuum
5876 Å (D3) & 10830 Å	8542 Å & 15600 Å ?

D3 observations

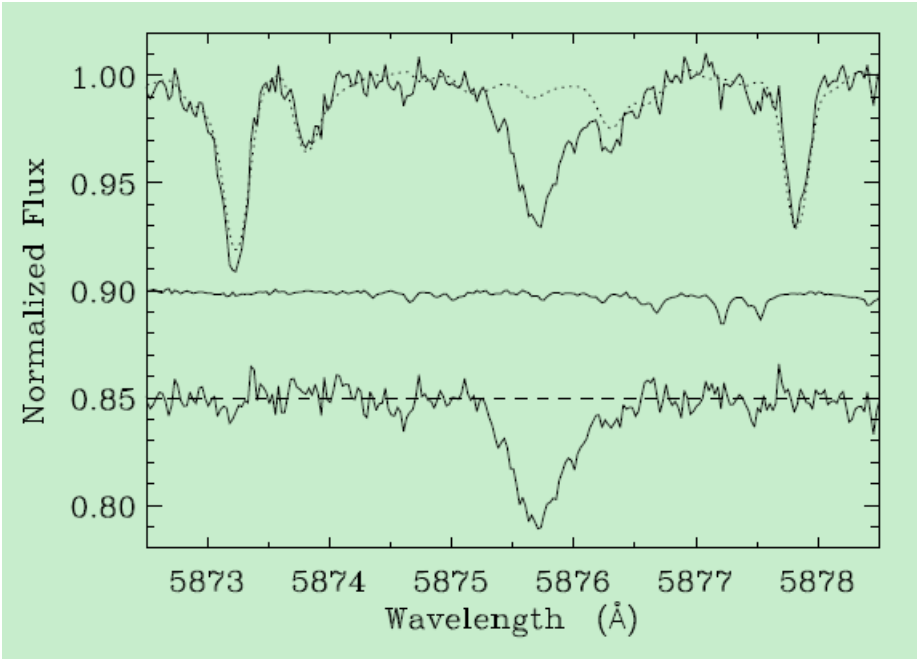
The unique of D3:

Optically thin

Not seen against the disk →
represent the main site of the flare

Sensitive to excitation

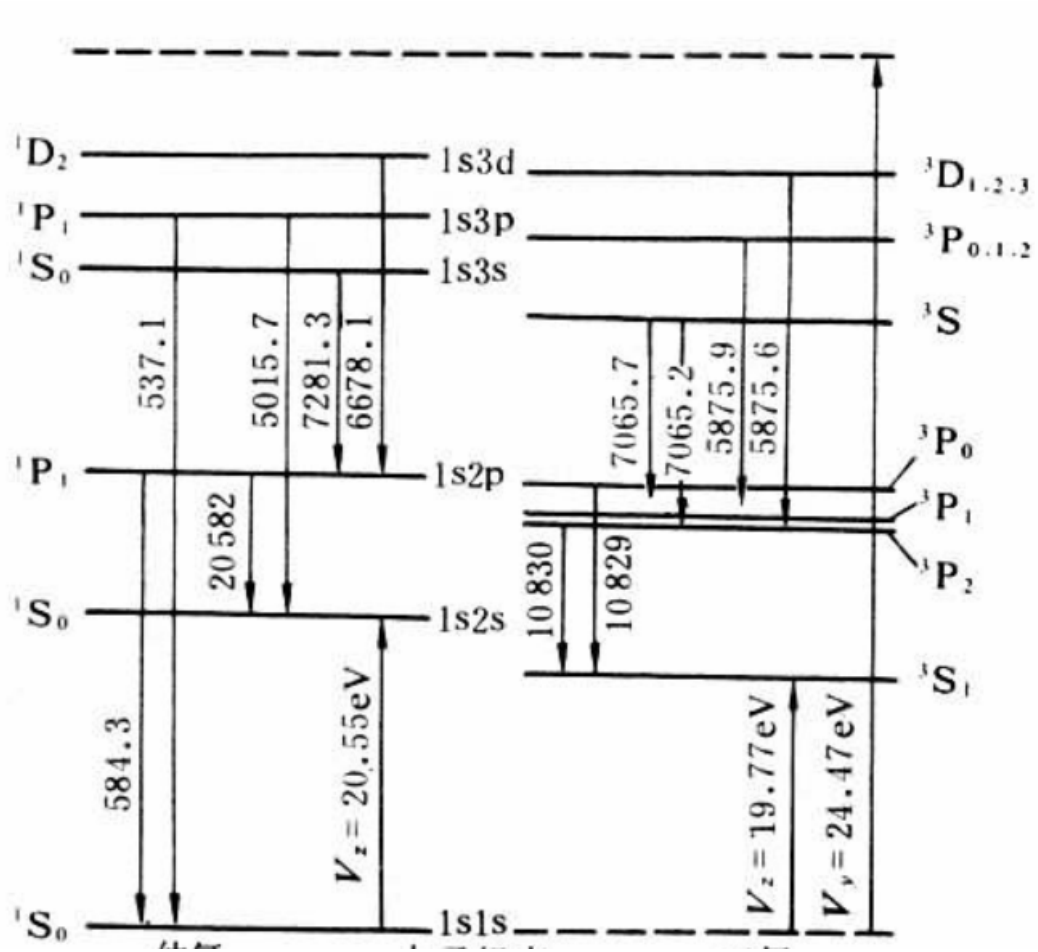
D3 observations



A spectrum of a G0V star (the Sum is G2V)
Saar et al., 1997

The upper levels of forbidden transitions are called metastable states. They have long lifetimes, of the order of seconds, compared to ordinary excited states with lifetimes in the nanosecond regime. In laboratory plasmas and stellar photospheres the particle density is so high that the probability for collisional deexcitation of atoms in metastable states is higher than the probability for a radiative decay. In other words, the time between collisions in the plasma is much shorter than the radiative lifetime of a metastable state. In dilute astrophysical plasmas with a large volume and low particle density, such as planetary nebulae and gas clouds around stars, the probability for collisions is low and radiation from forbidden lines is observed.

D3 observations



D3 observations

Zirin 1980:

1978-Jul-10

17:31:44 (typo 13:31?) Hα flare started
Roughly same time, D3 darkened

17:32:21 D3 emission was seen.

In order to have D3 absorption, $n<10^{12}$ cm^{-3} and T~25,000 K. The duration was 30 ~ 40 seconds.

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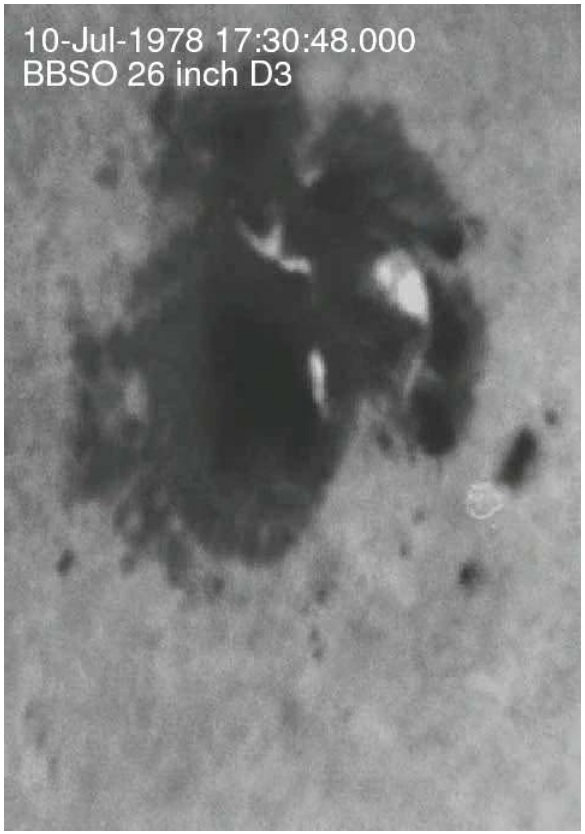
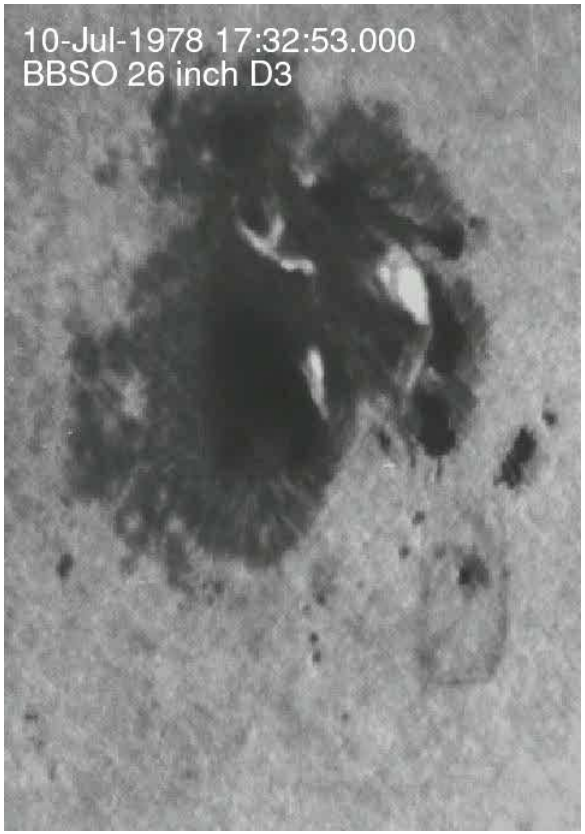
If it is caused by the chromospheric evaporation, then the height of D3 is about 1500 km (Liu et al., 2006, Fisher et al., 1985 (ApJ 289, 414).


10-Jul-1978 17:30:48.000
BBSO 26 inch D3


10-Jul-1978 17:32:53.000
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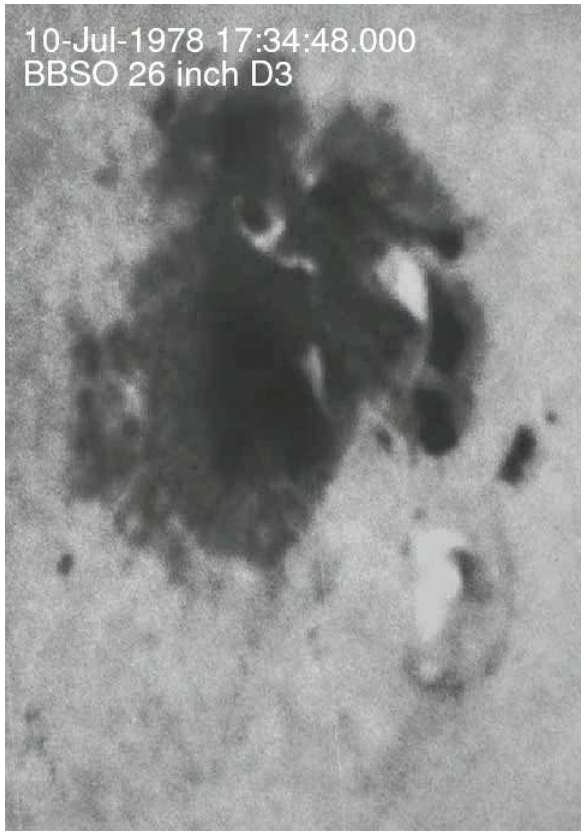
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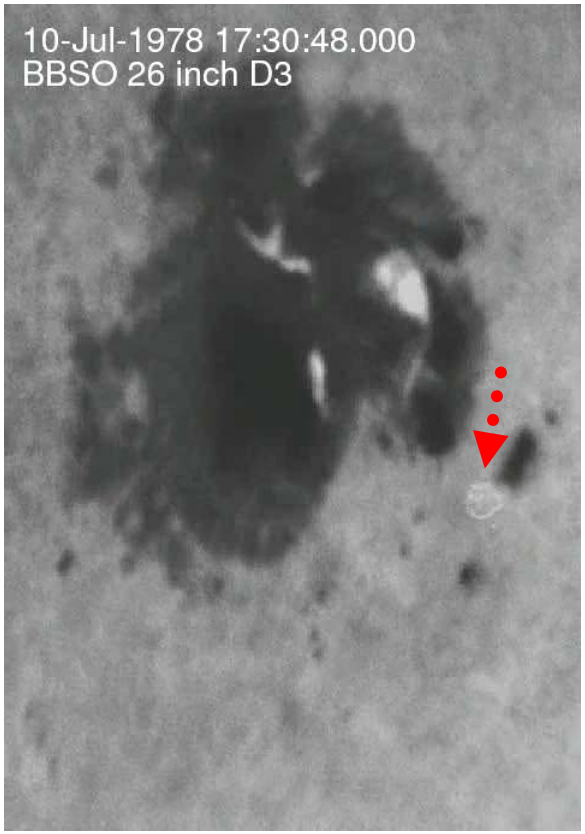
BBSO 26 inch D3

1978-07-10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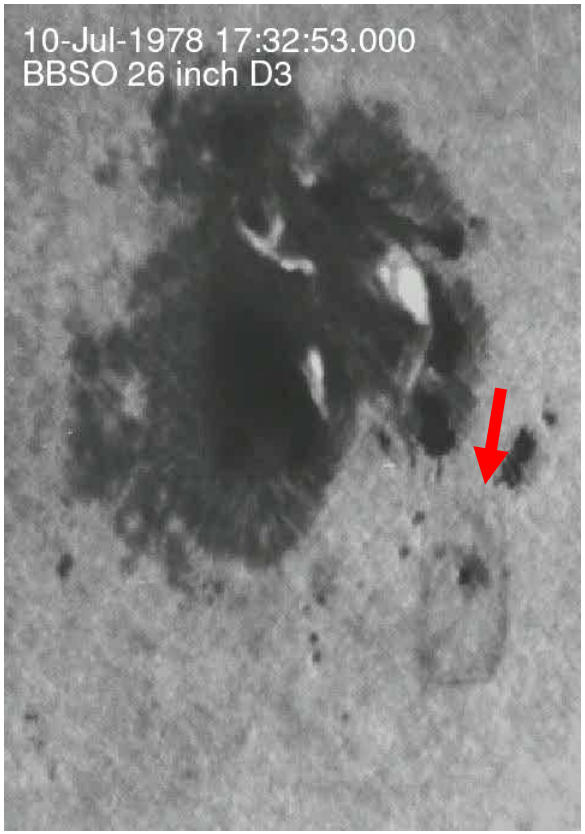
BBSO 26 inch D3


10-Jul-1978 17:32:53.000
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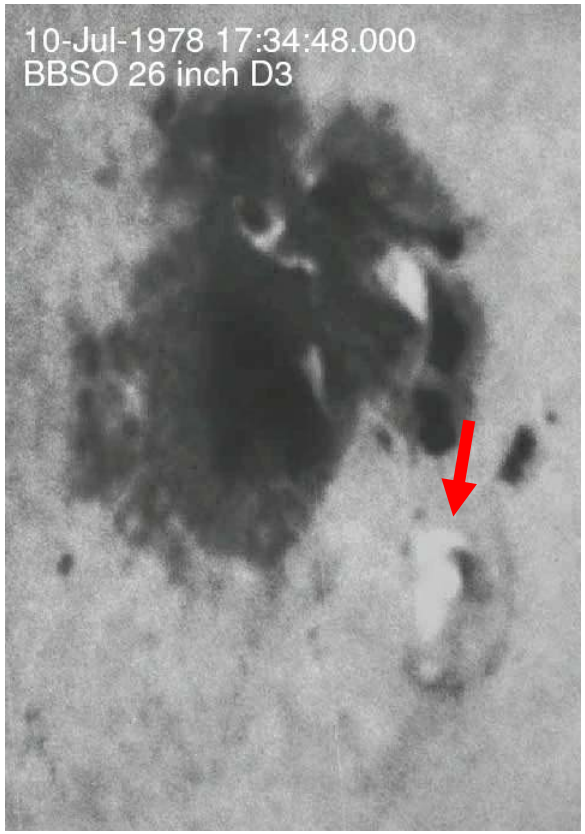
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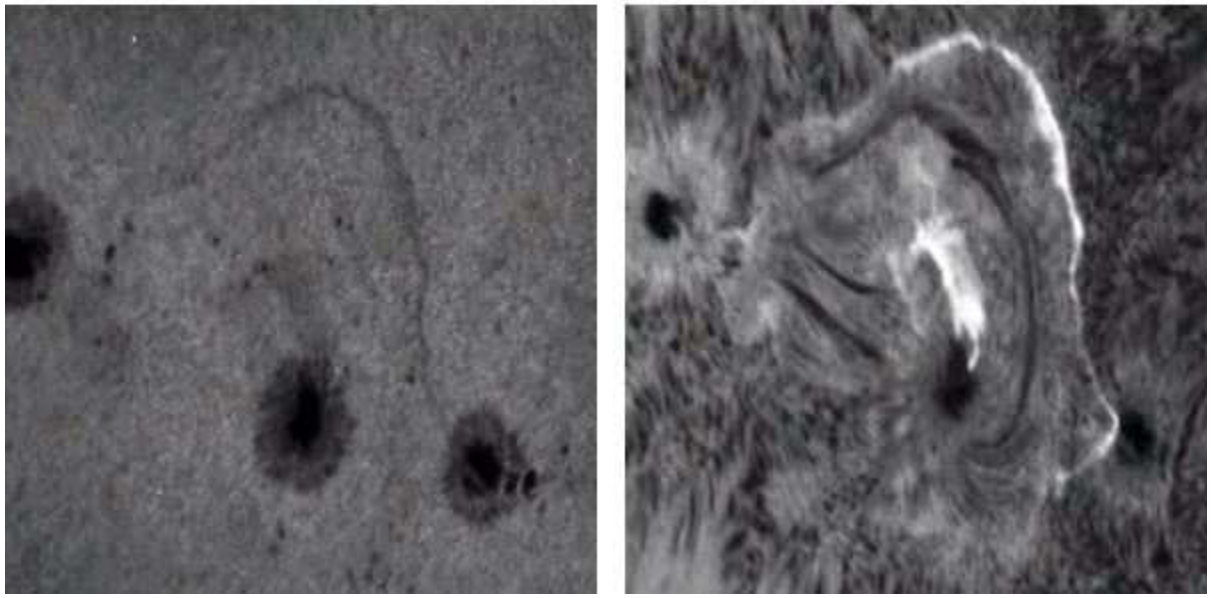
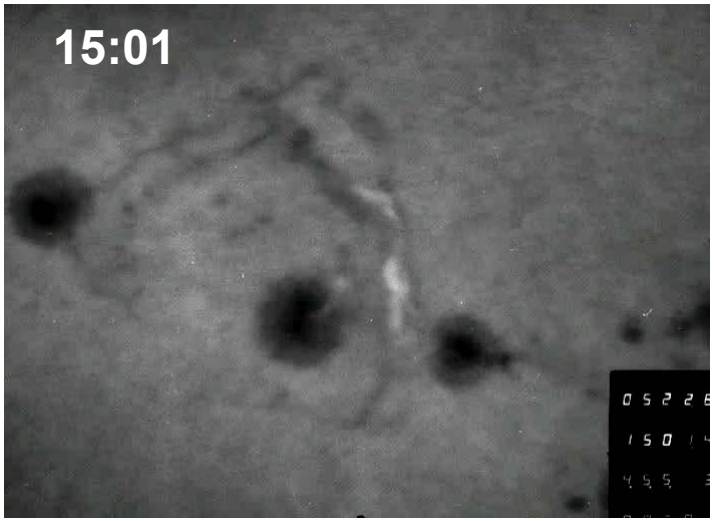
D3 observations

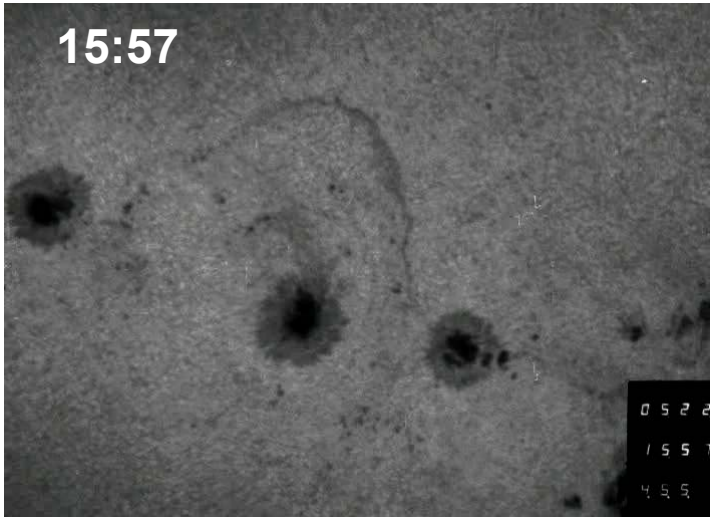
Digitized films:

May 22, 1984 Black Light Flare
Left: D3, Right: Halpha



D3 observations

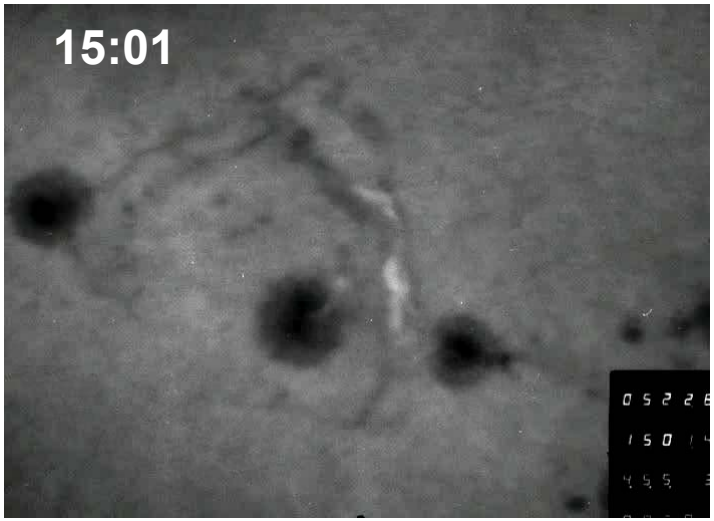


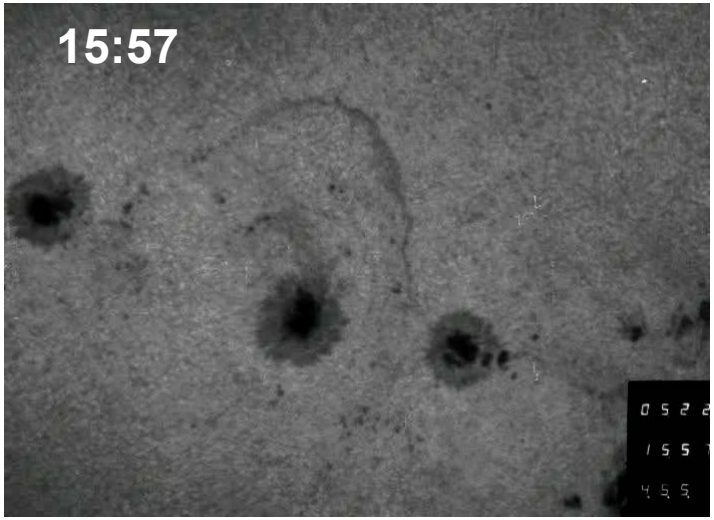


1984-05-22

continued

D3 observations



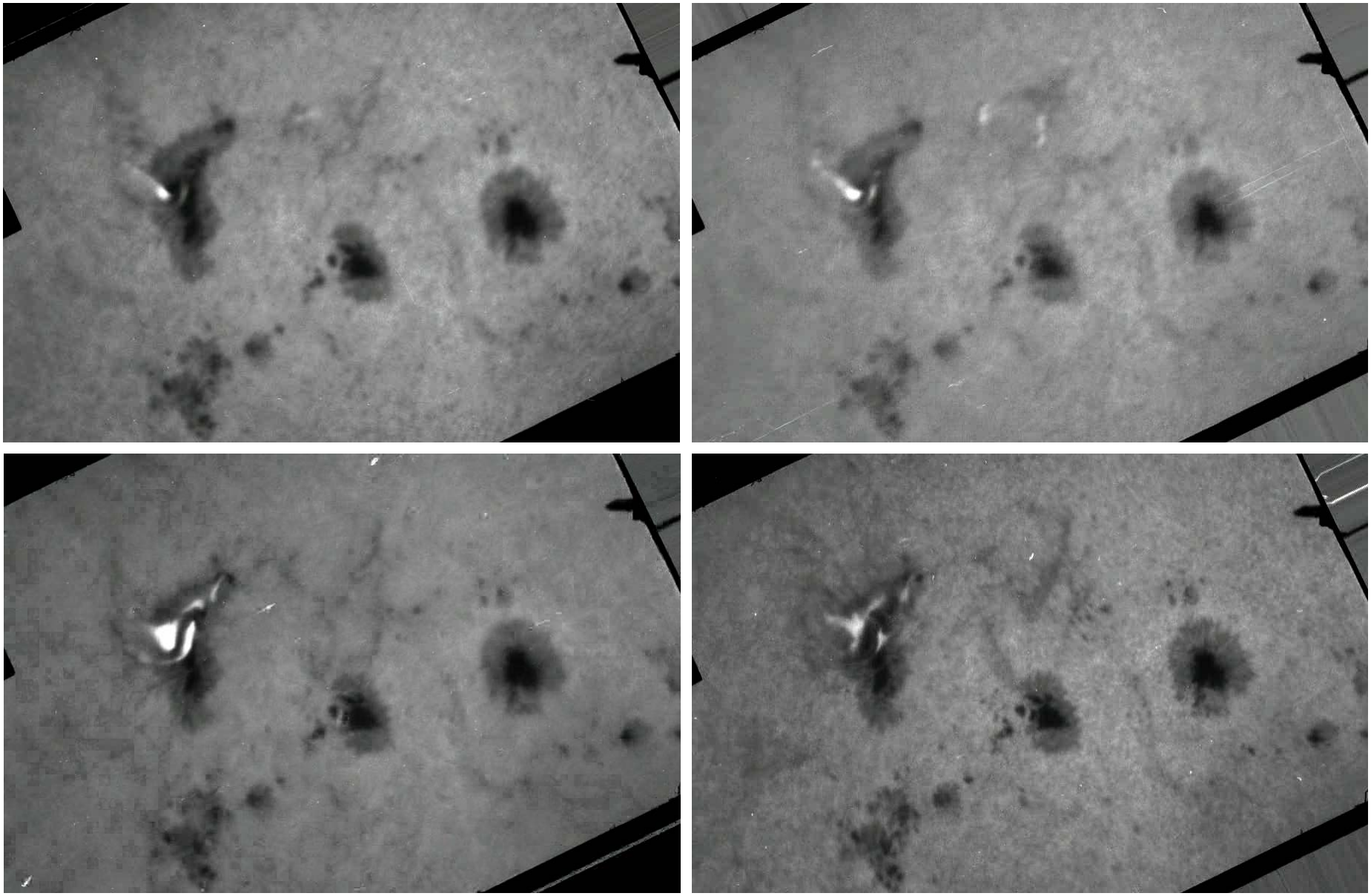


1984-05-22

continued

~ 1 hour

1984-05-21 ?



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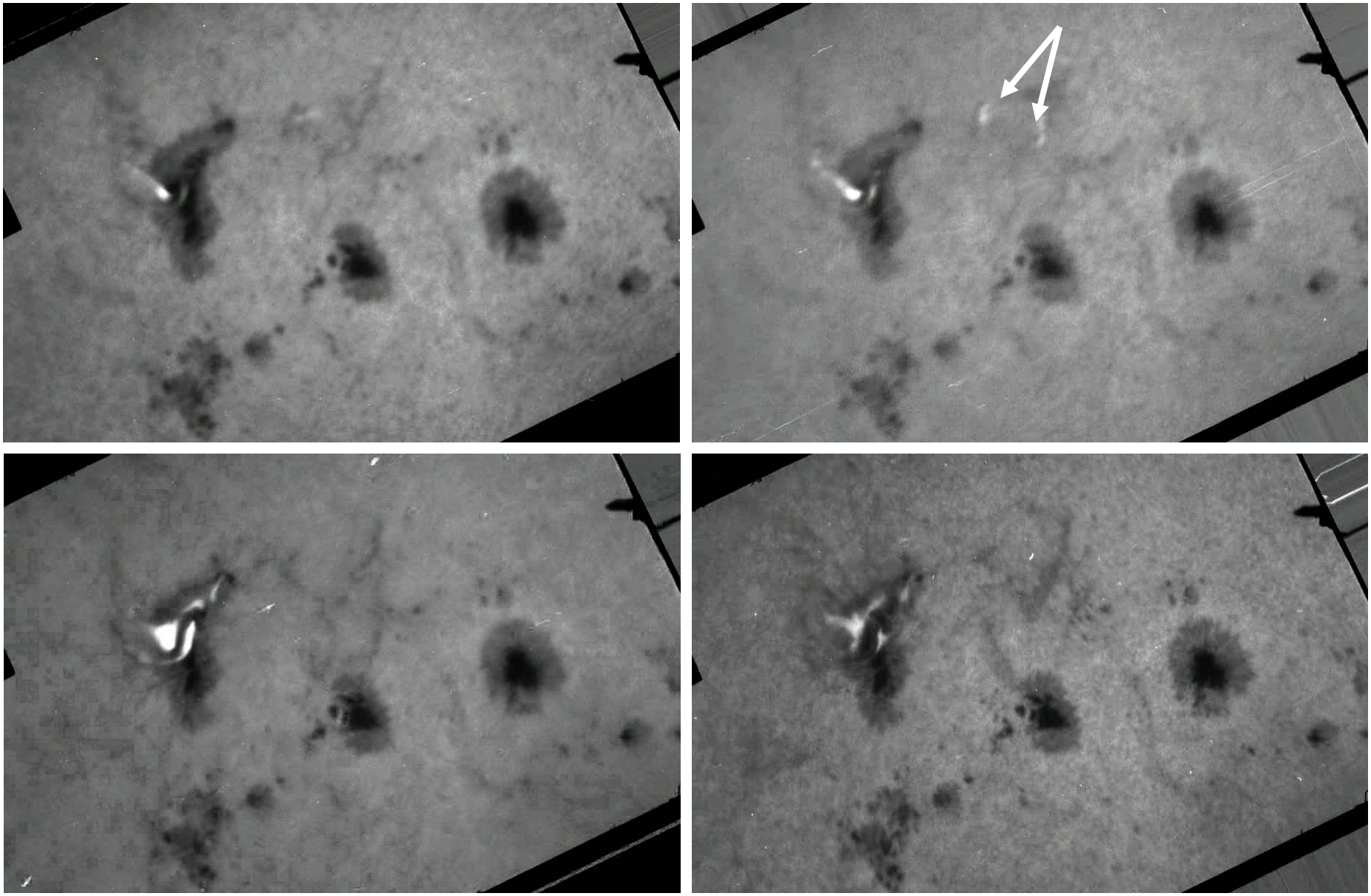
1984-05-21 ?



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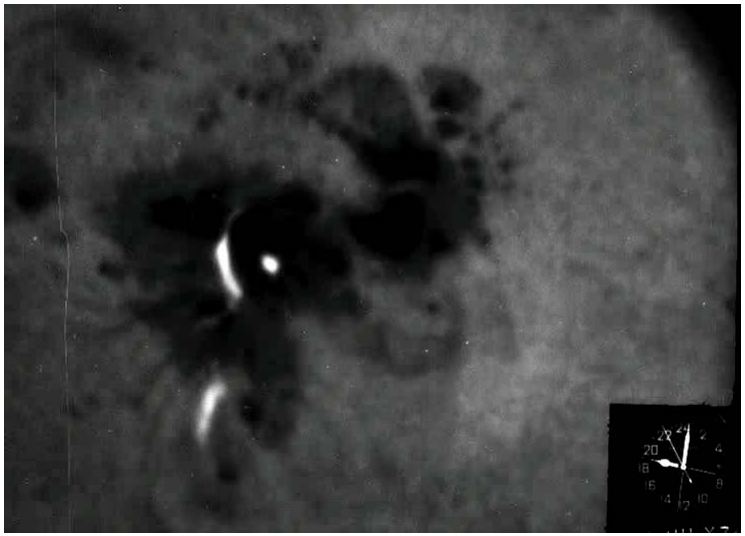
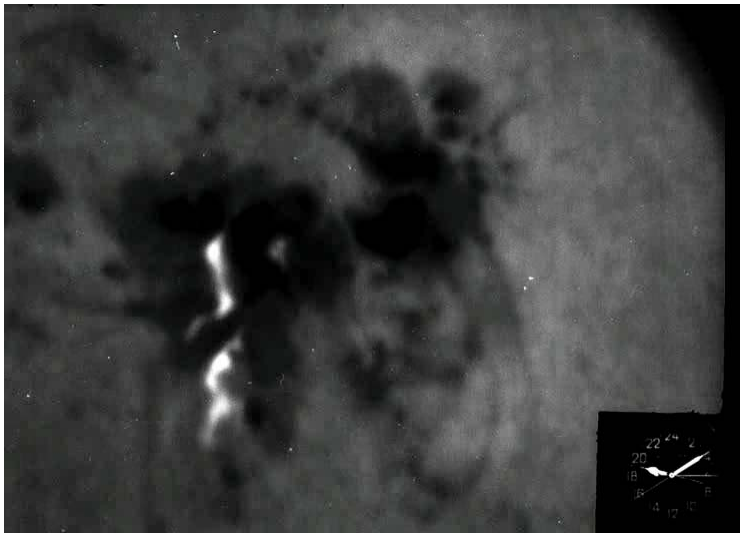
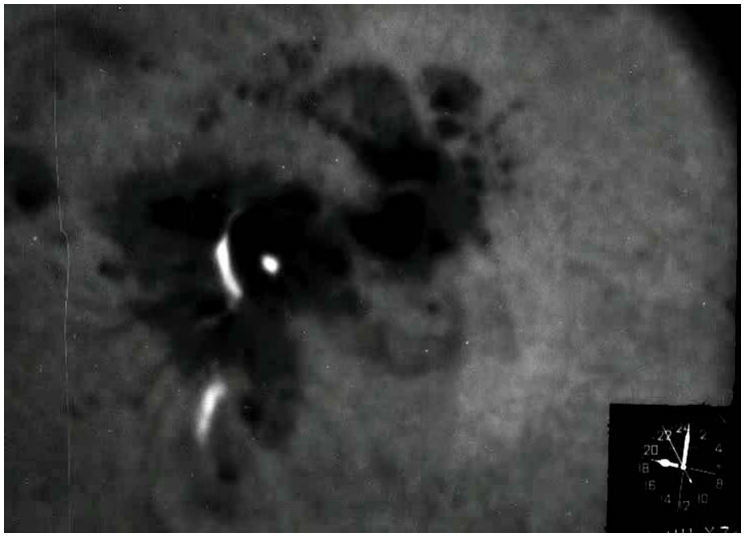
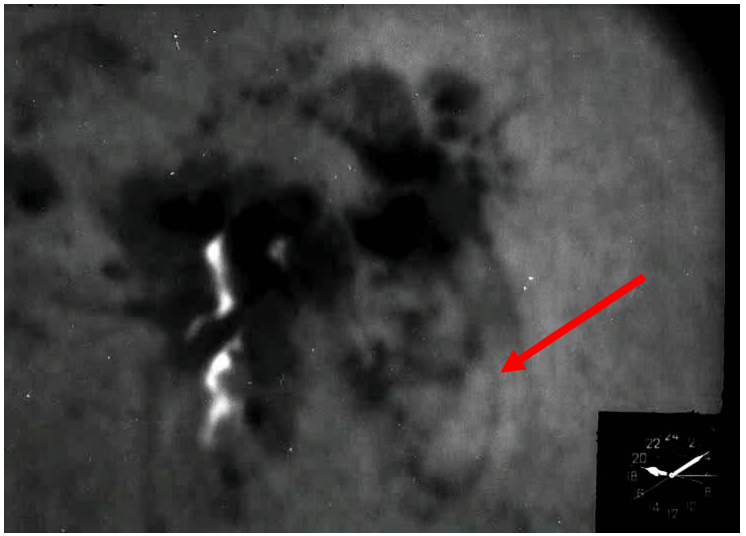
1974-07-06 ?





1974-07-06 ?





D3 observations

Digitized films:

Feldman et al., 1983

TABLE 1

FLARES STUDIED, AND MAXIMA IN He D_3 AND THERMAL X-RAYS

Date	Flare Class	XR Maxima (UT)	D_3 Maxima (UT)	(D_3-SXR) (s)
79 Jun 02 ...	SB	144850	144848	−2
79 Oct 22 ...	SB	154328	154315	−13
79 Oct 22 ...	SB	182000	182010	+10
79 Nov 05 ...	2B	214905	214906	+1
79 Nov 05 ...	1B	234830	234834	+4
79 Nov 06 ...	SB	190204	190234	+30
80 Jan 25 ...	2B	2100[a]	210009	
		210734	210729	−5
80 Jul 01	1B	162900[b]	162849[c]	−11
80 Jul 13	SB	171840	171822	−18
80 Jul 13	SB	[a,d]	191948[e] to 192108	
80 Nov 01 ...	1B	191914	191919	+5
80 Nov 05 ...	1B	164028	164011	−17
80 Nov 05 ...	1B	222719[f]	222659[c]	−20
80 Nov 06 ...	2B	172634	172630	−4
80 Nov 06 ...	1B	222150[g]	222133[c]	−17
80 Dec 15 ...	1B	1925[e]	192410	
80 Dec 28 ...	1B	190805	190806	+1
81 Jul 27	1B	172628[b]	172620[c]	+1

[a] Difficult to determine thermal maximum.
[b] 20–37 keV and 12–20 keV *ISEE 3* data.
[c] D_3 not measured with photodiode.
[d] 28–55 keV and 55–102 keV *SMM* data.
[e] Broad maximum.
[f] 29–58 keV and 58–133 keV *SMM* data.
[g] 29–512 keV and 28–58 keV *SMM* data.

Another list → **Zirin, 1978 Soph. 58, 95**

Continuum Observations

Previous Observations: Flesch & Oliver 1974 (stellar)

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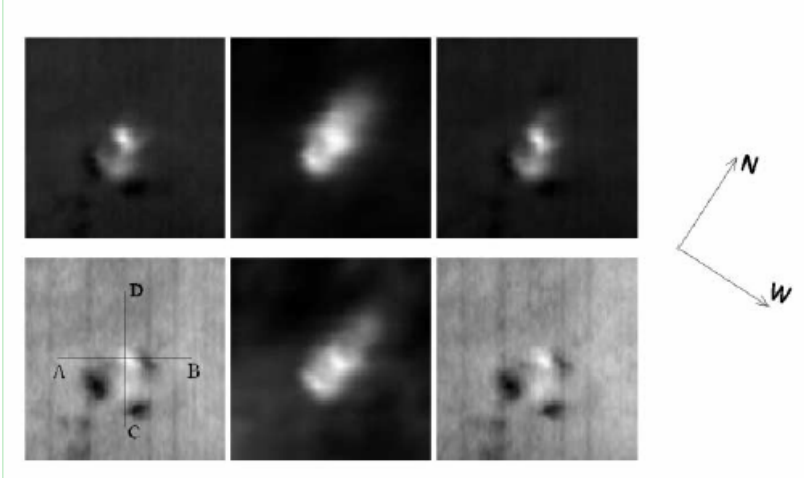
H-alpha

8542



-10 **+10**

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Compton up-conversion **Hα absorption** **H^- enhancement**

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X

Engergy budget

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Compton up-conversion ✗

Hα absorption ✗

H^- enhancement ✓

Engergy budget

Continuum Observations

Advantages of solar observations:

1. **Spatial resolved structures.**
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Disadvantages:

1. **Relative weak particle flux**
2. **Less sensitive to temperature change**

Continuum Observations

Searching for BLF on the Sun:

1. **~20s before the impulsive phase of a normal flare**

   $t = (3/2)\ (kN_H \Delta T)/(dE/dt)$,

2. **Sharp increase in LC, no precursors**

3. **Intense HXR, hard spectrum**

4. **Wavelength dependence: long side of discontinuities**

5. **Limb observations**

6. **In the boundary of penumbral area**

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?

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X

4. **In the boundary of penumbral area**

Our Schedule

Searching for BLFs on the Sun:

1. **High Cadence (~ 1s)**
2. **NIR (15600Å & 10830Å), D3?**
3. **Large FOV**

Thank You!