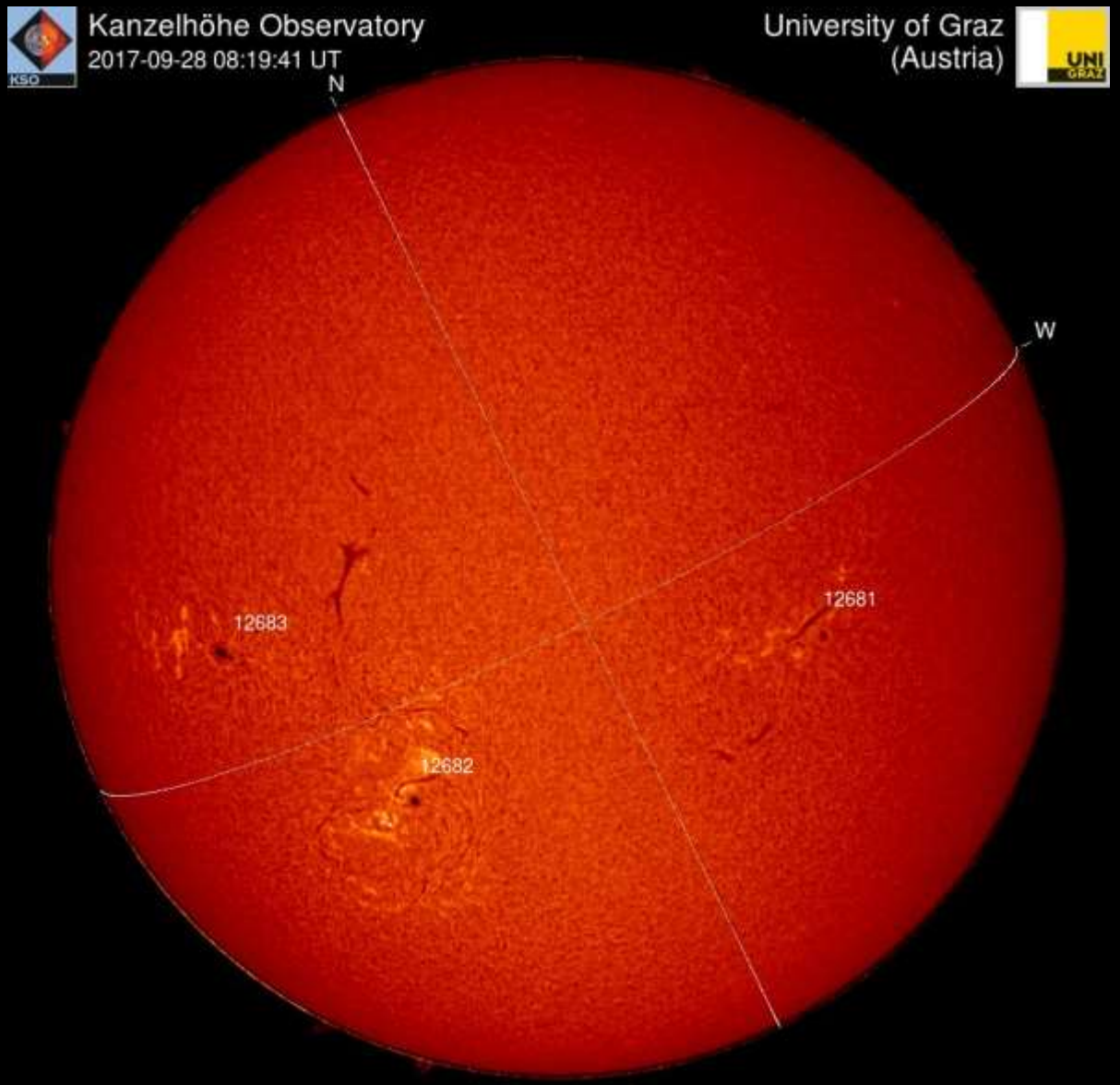
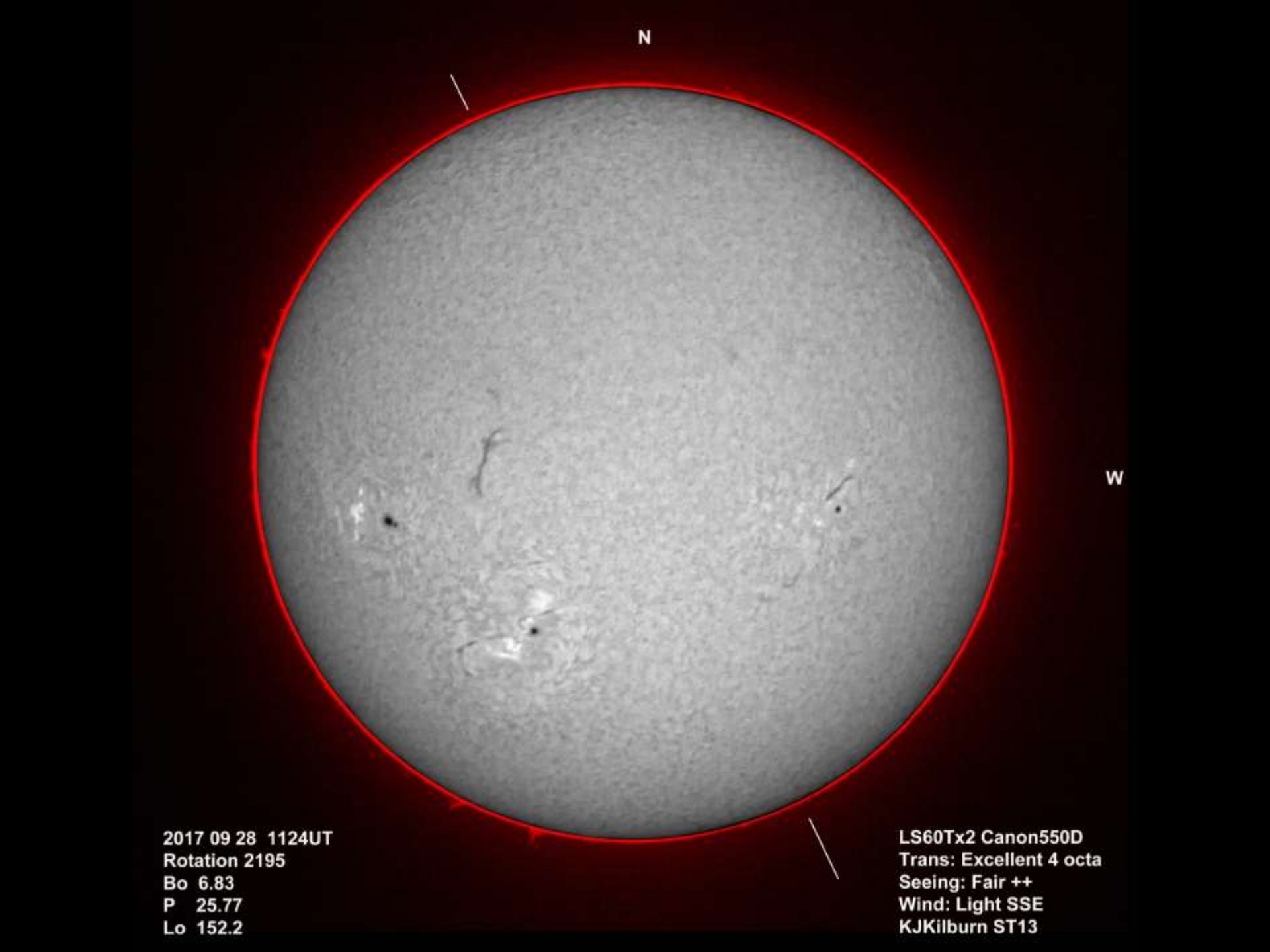
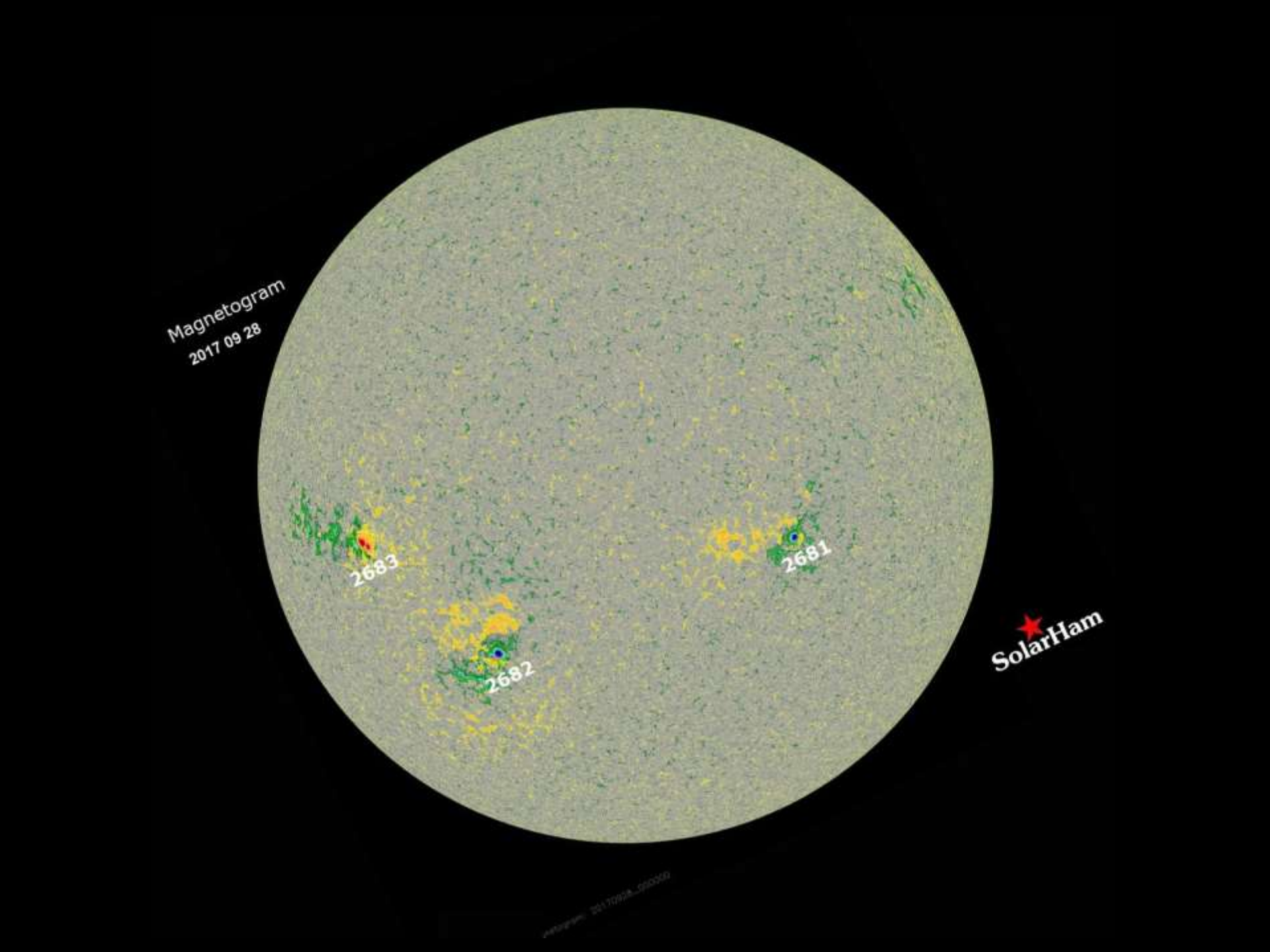
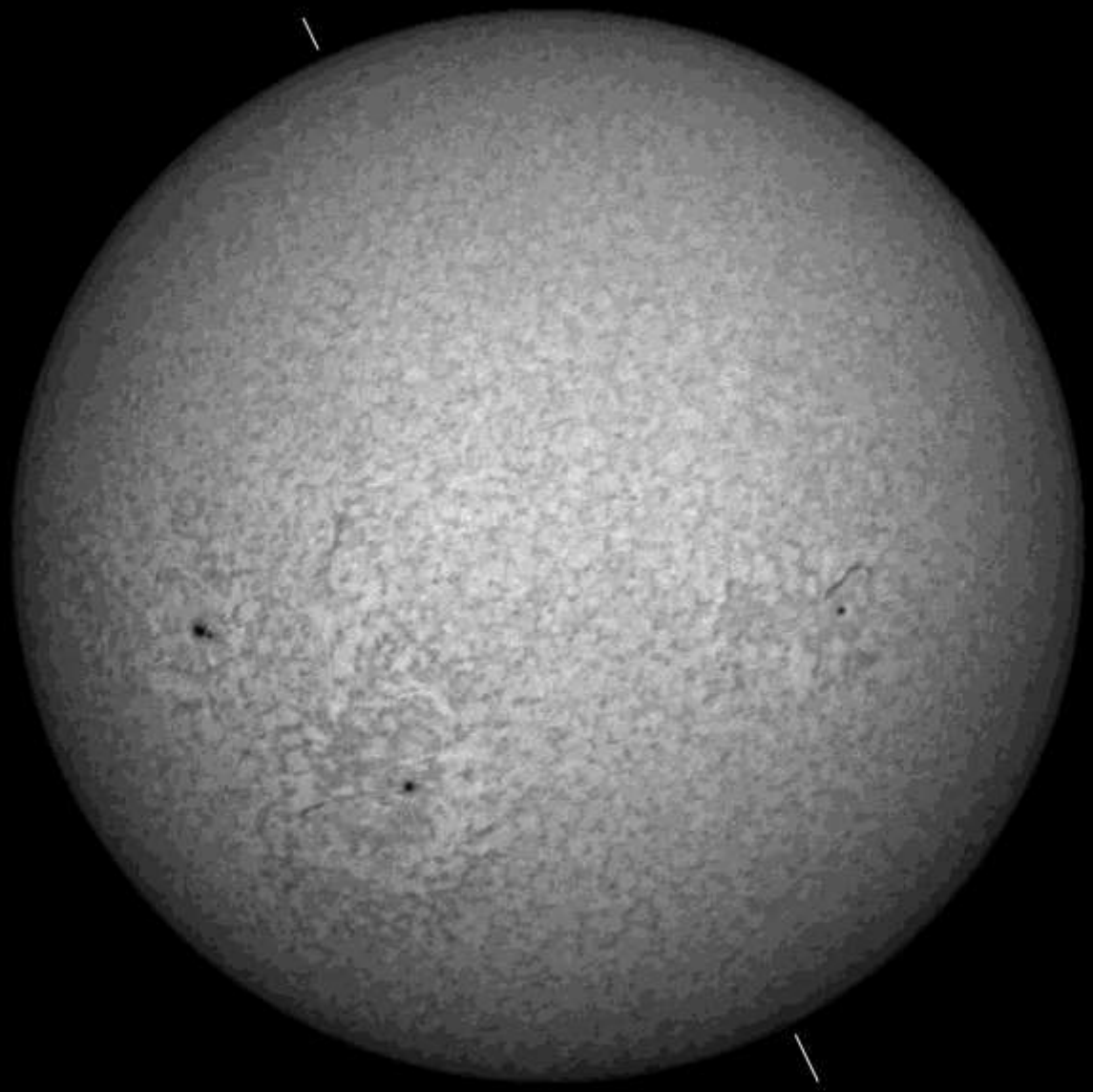
Bipolar Magnetic Regions BMRs

Kevin J Kilburn



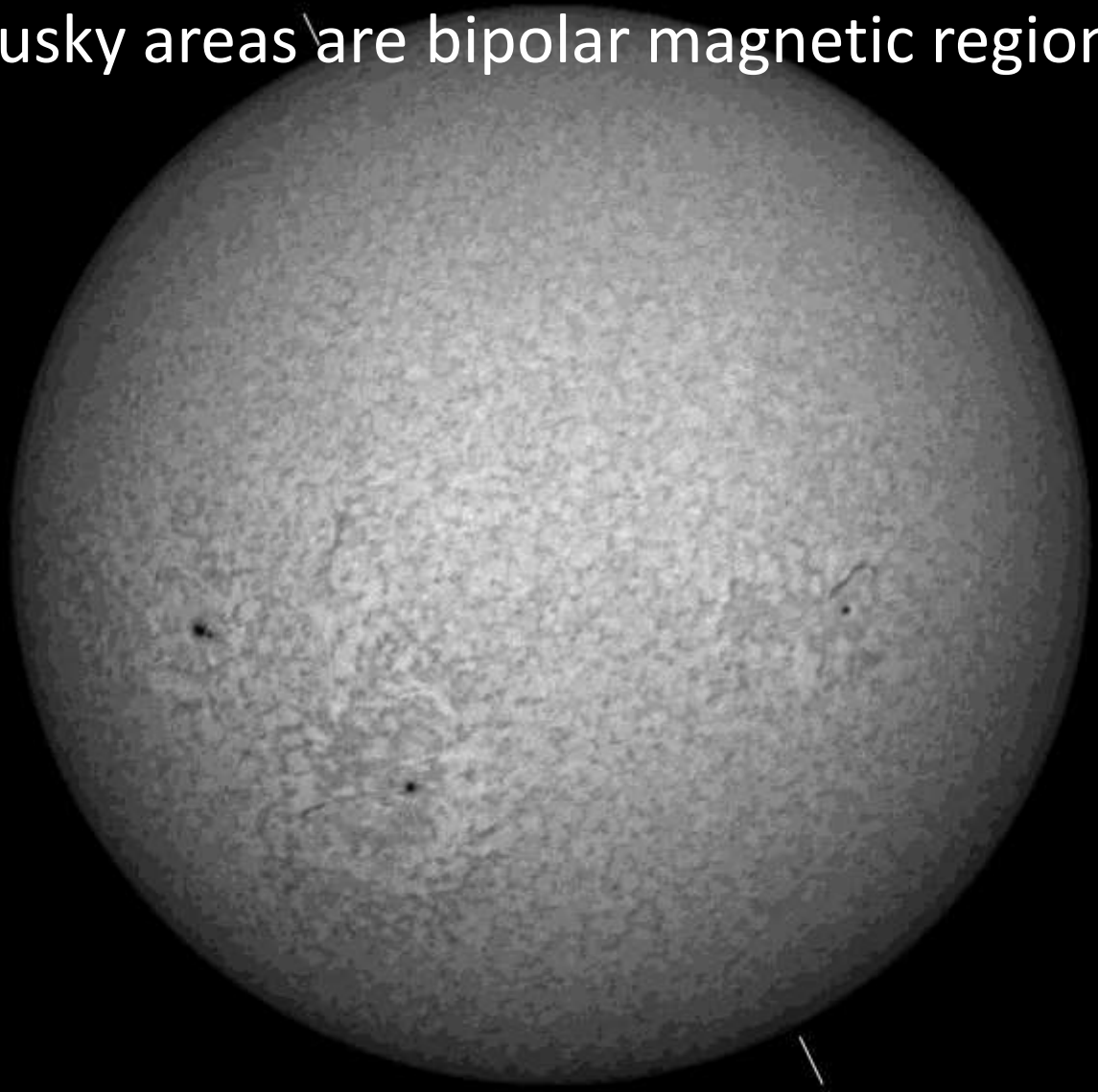

N
W
2017 09 28 1124UT
Rotation 2195
Bo 6.83
P 25.77
Lo 152.2
LS60Tx2 Canon550D
Trans: Excellent 4 octa
Seeing: Fair ++
Wind: Light SSE
KJKilburn ST13


Magnetogram
2017 09 28
2683
2682
2681
SolarHam

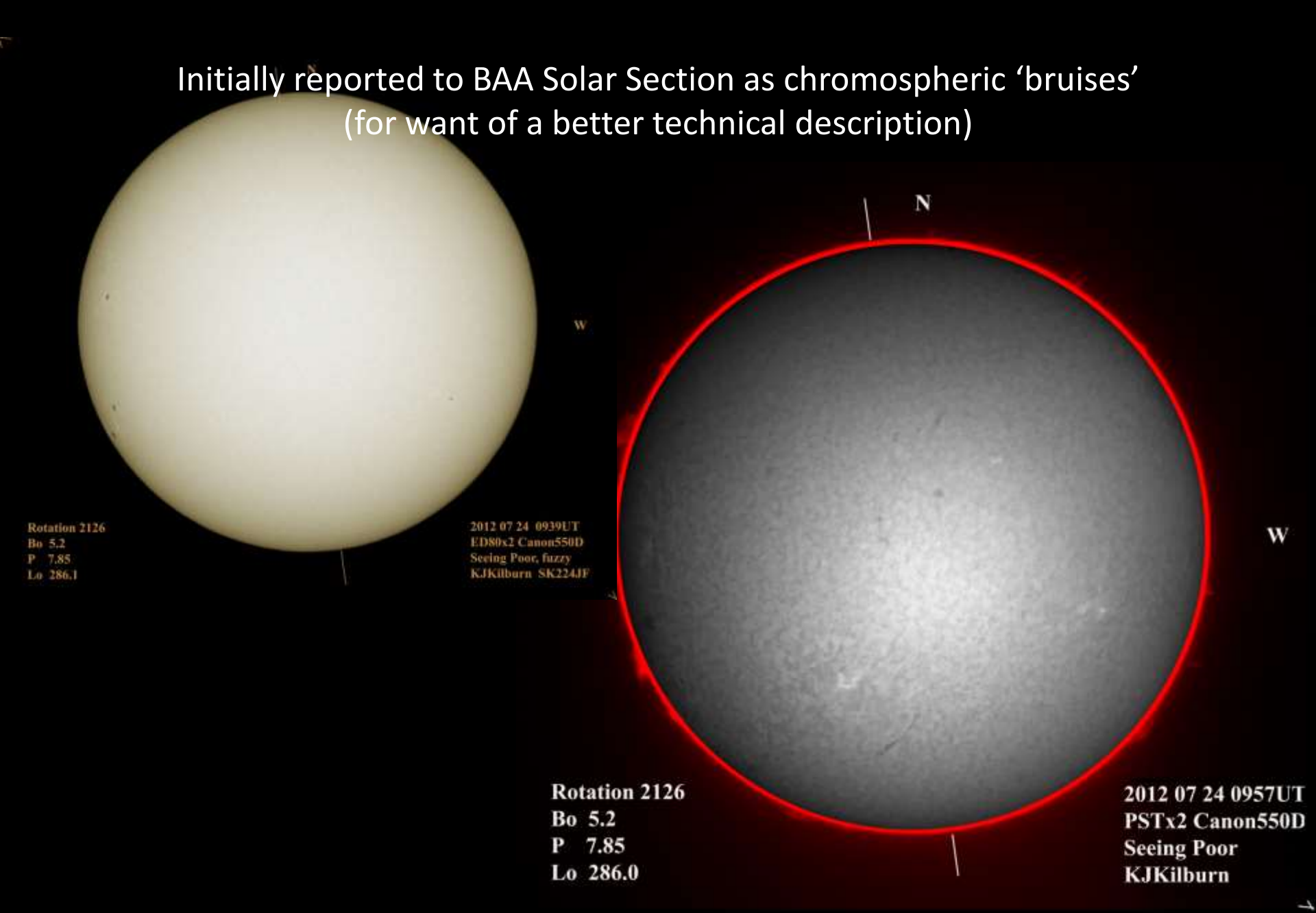


2017 09 28 1121UT LS60T tuned red-side CWL KJKilburn ST13

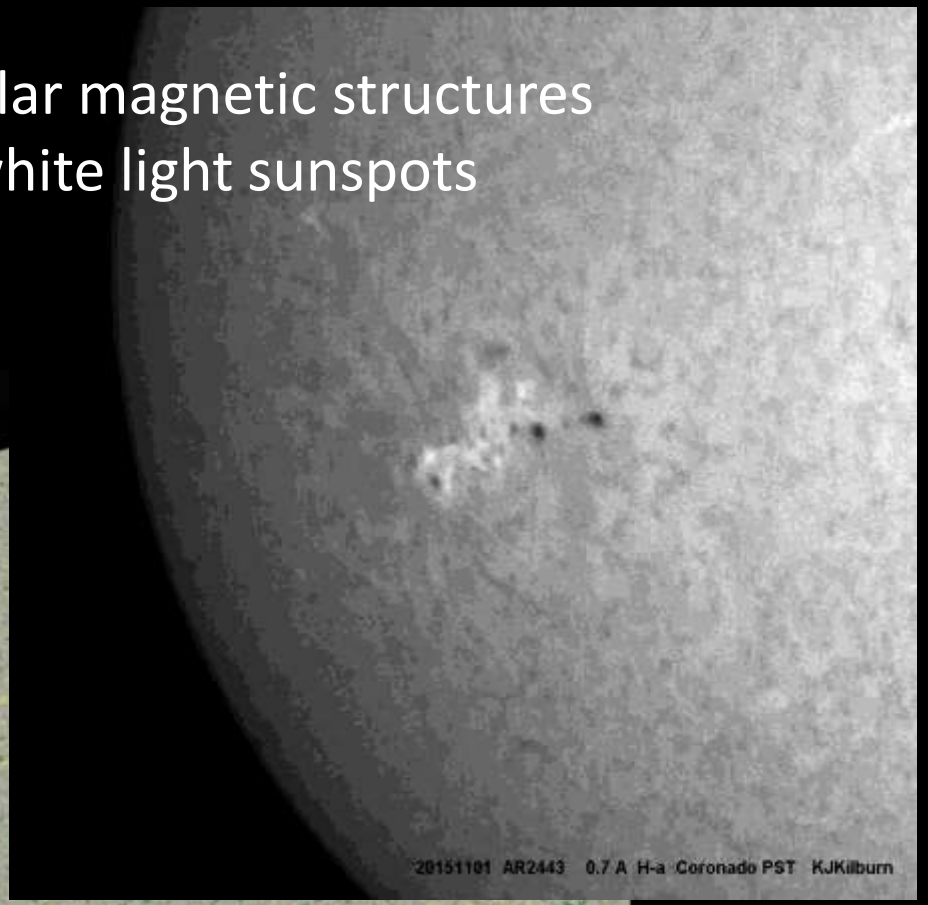
These dusky areas are bipolar magnetic regions: BMRs

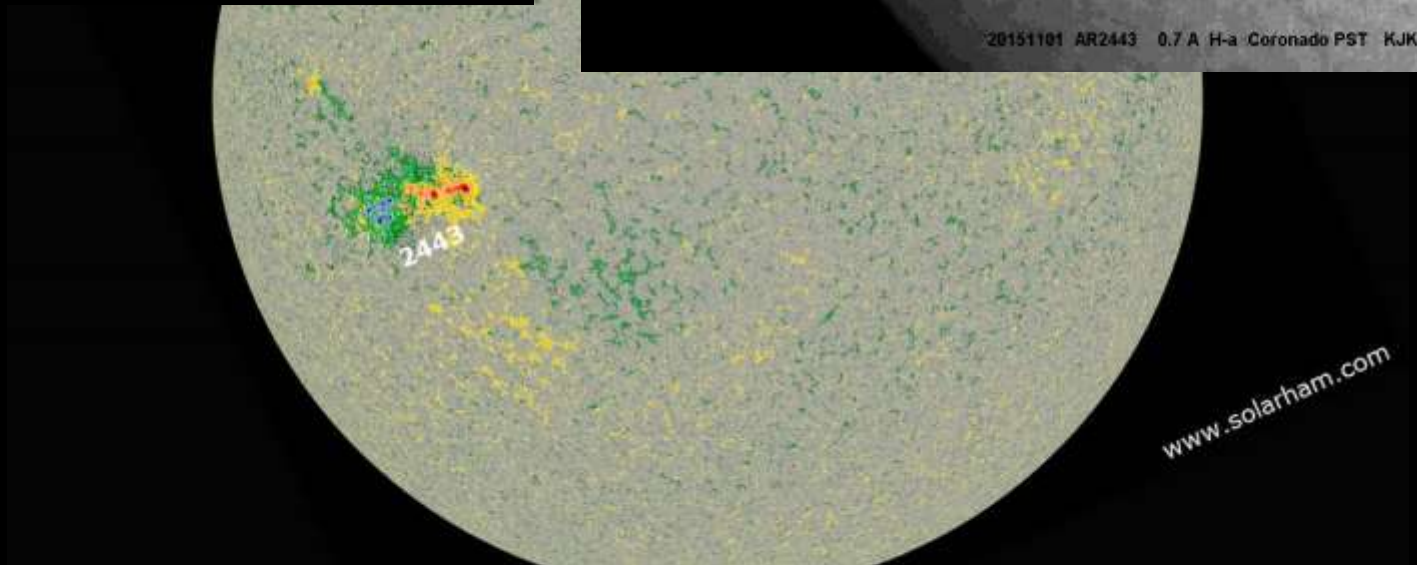


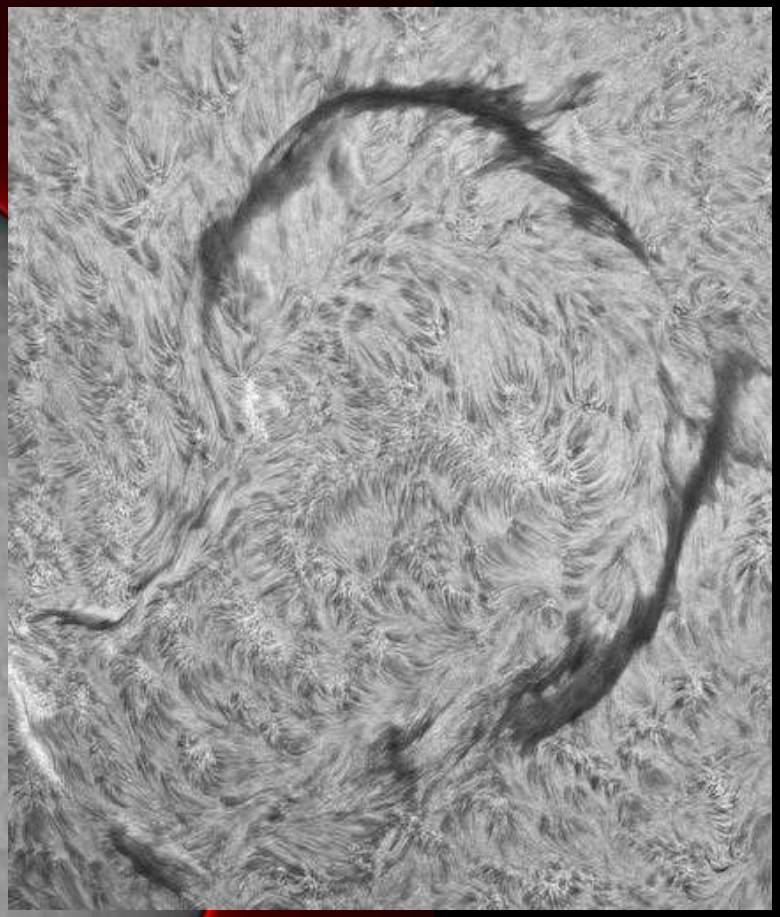
Initially reported to BAA Solar Section as chromospheric ‘bruises’
(for want of a better technical description)



They exactly match solar magnetic structures associated with white light sunspots







Spicules seen in absorption against the relatively brighter solar disc , the ‘bruise’ is outlined by dark filaments.

N

2015 11 13 1220UT
Rotation 2170
Bo 3.08
P 21.89
Lo 193.2

PSTx2 Canon550D
Trans: Excellent 6 octa
Seeing: V. good
Wind: 3-6mph W
KJKilburn ST13

So what ARE my ‘chromospheric bruises’?

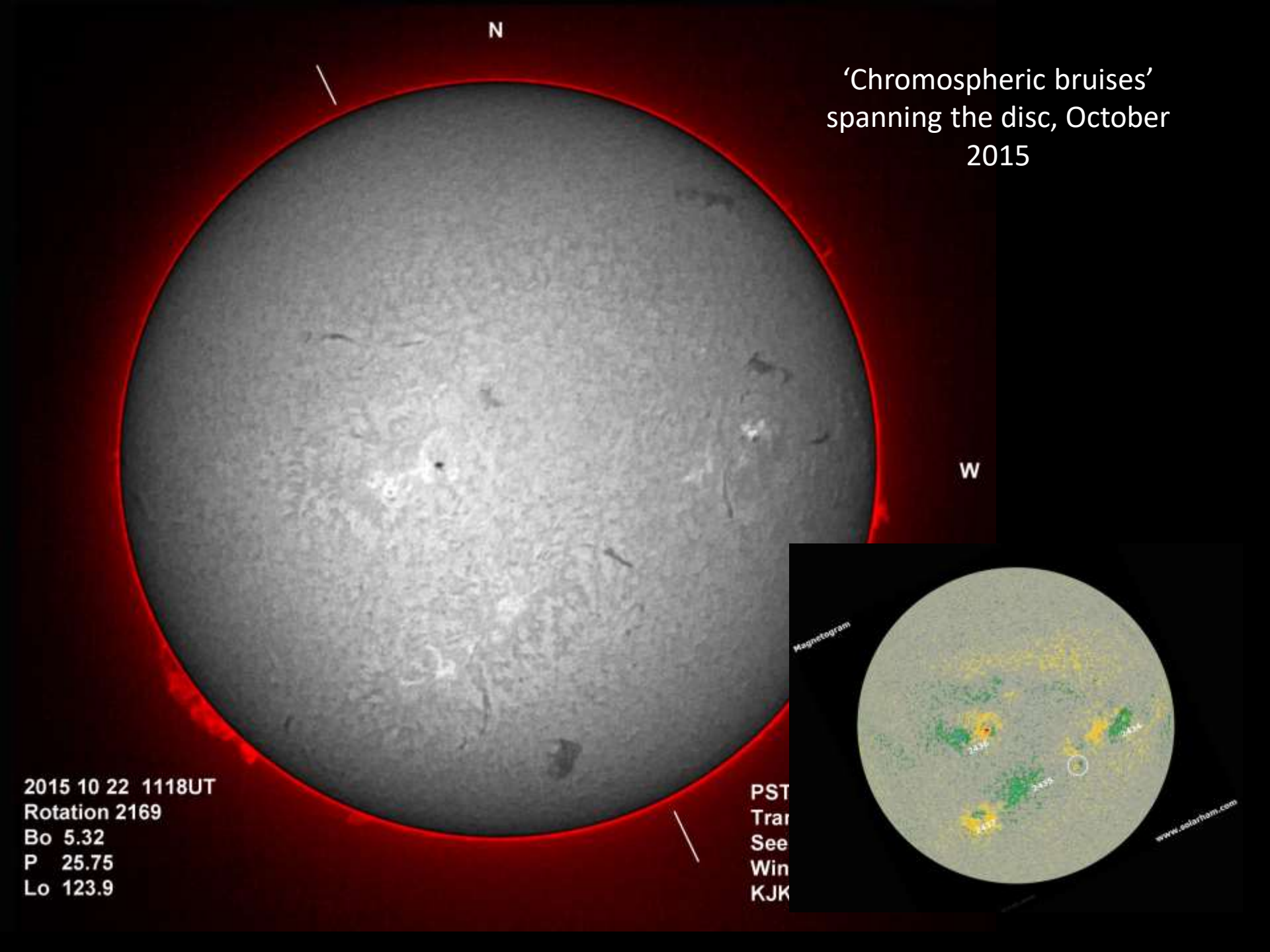
No mention of similar features in JBAA, Richard Baum did a search for me. Lyn Smith couldn’t understand what I was observing, she couldn’t see anything [visually they are very difficult].

Prof Jay Pasachoff referred me to Prof Peter Foukal…’they are mottles’ [no they’re not]

Prof Phillipa Browning [Manchester Uni] confirmed they arise due to the magnetic field, but couldn’t think of a name for them…”so it’s possible they’re just quite obscure”….

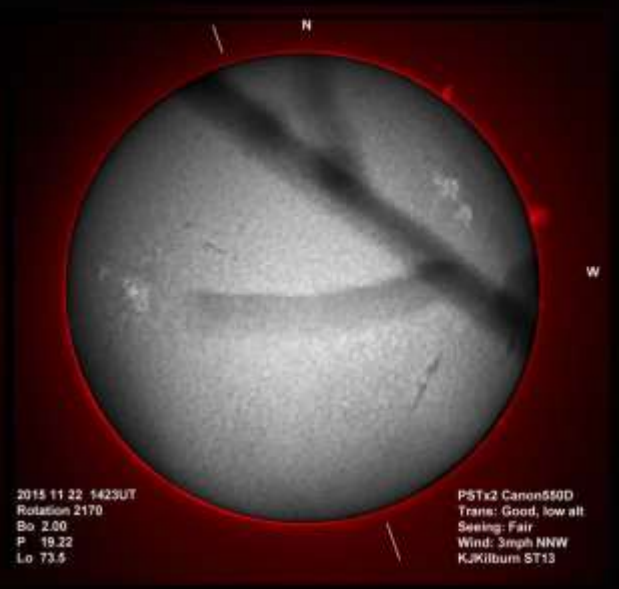
Dr. Lucie Green said that, “…the bruises do look like unresolved fibril structures”… [OK we knew that]…”People will use different names to describe them, as is often the case with solar observations. Hale saw them in his data and I have often heard people use the phrase ‘chromospheric whirls’ ” [not the same thing, Lucie].

‘Chromospheric bruises’ spanning the disc, October 2015

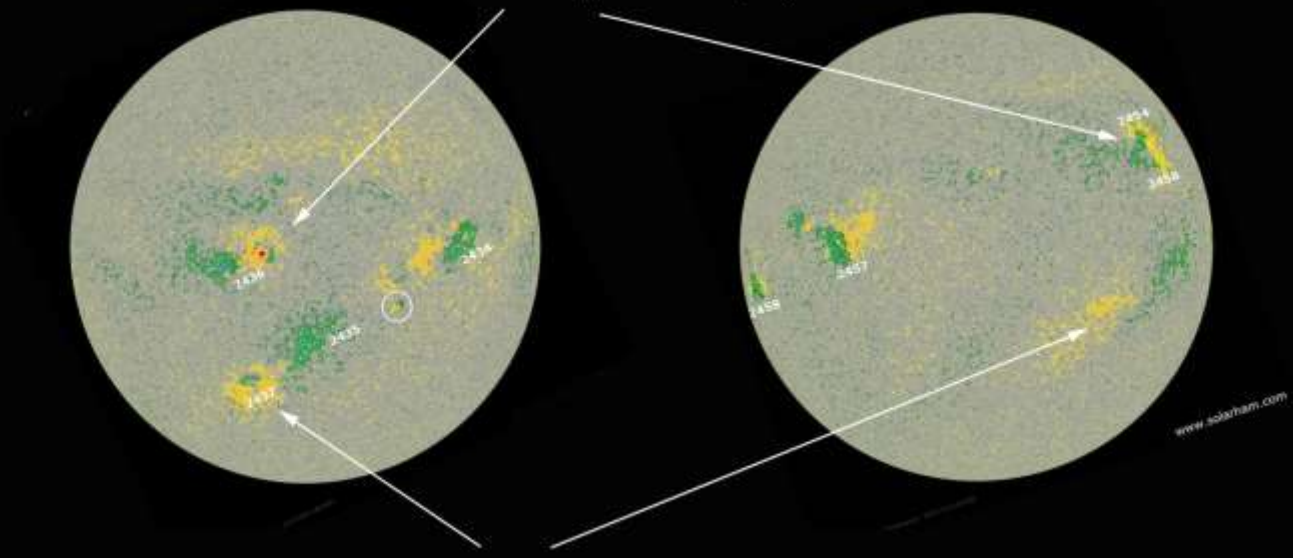


22 October 2015 CR2169

22 November 2015 CR2170

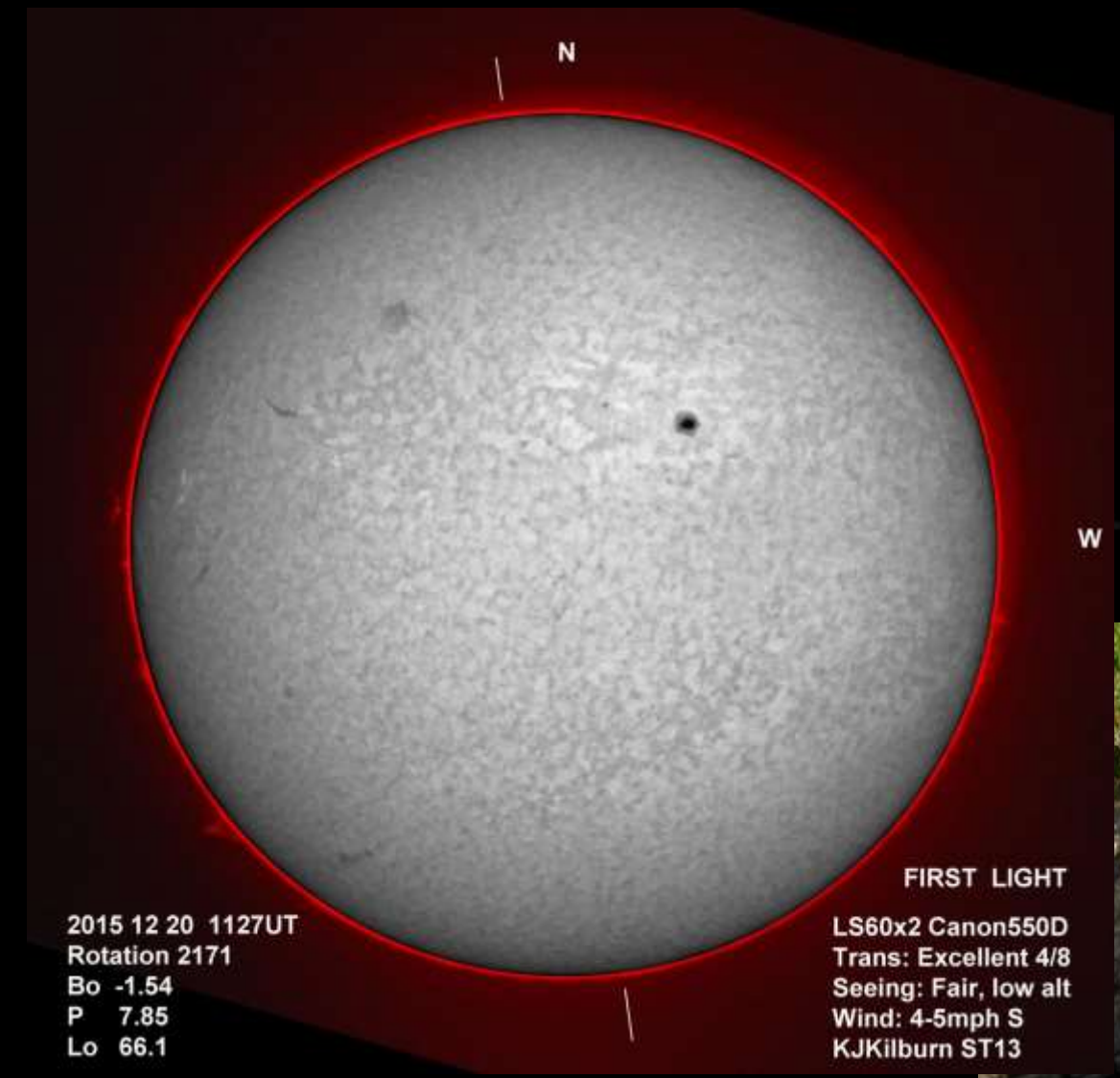


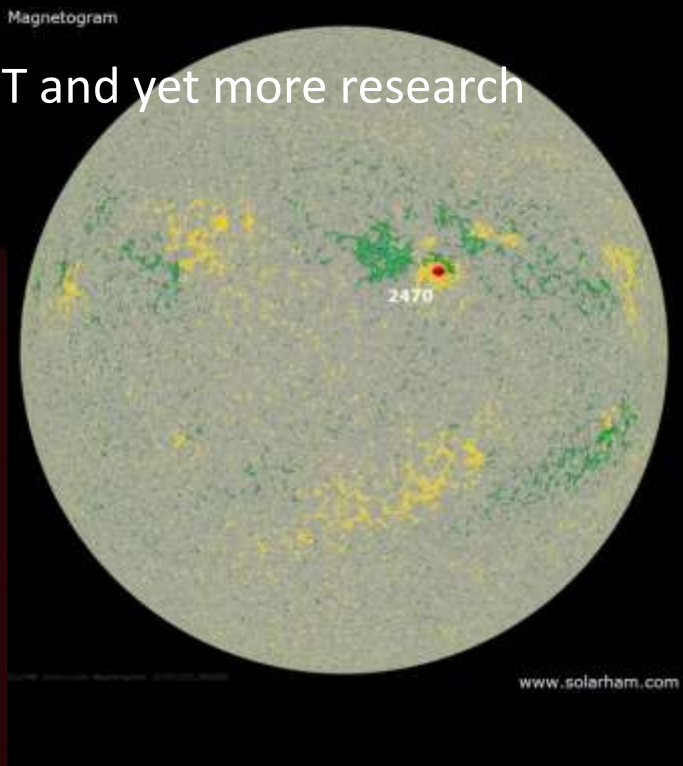
Same BMR at approx Solar Lat +15, Long 100-110



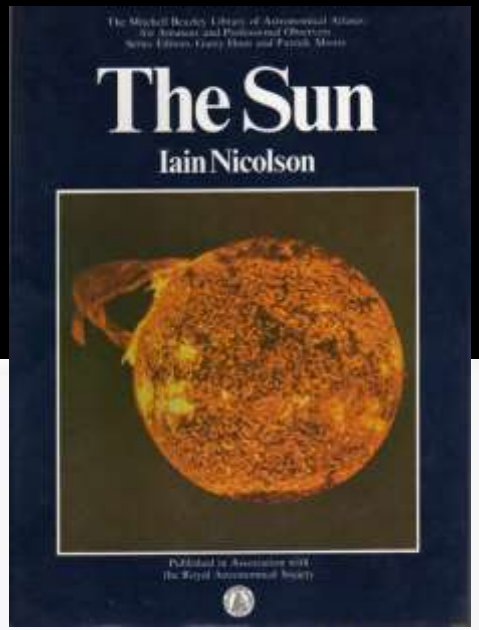
Same BMR at approx Solar Lat -25, Long 90-100

December 2015: Enter the pressure-tuned Lunt LS60T and yet more research

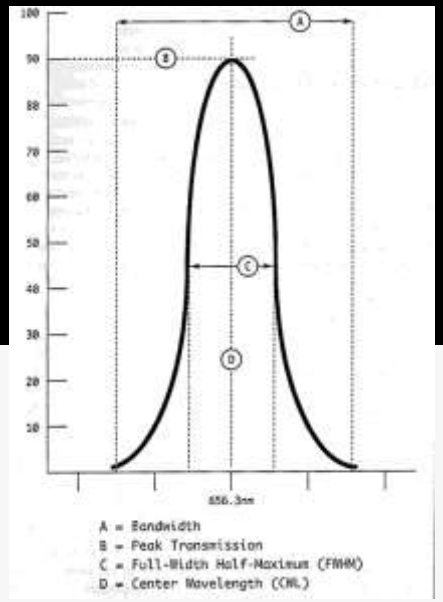




Solar kit line-up: Skywatcher ED80 and Canon 550D for white light imaging; Coronado PST and Lunt LS60T. The 127mm Mak-Cass is for high-res white light imaging but hasn't yet been used

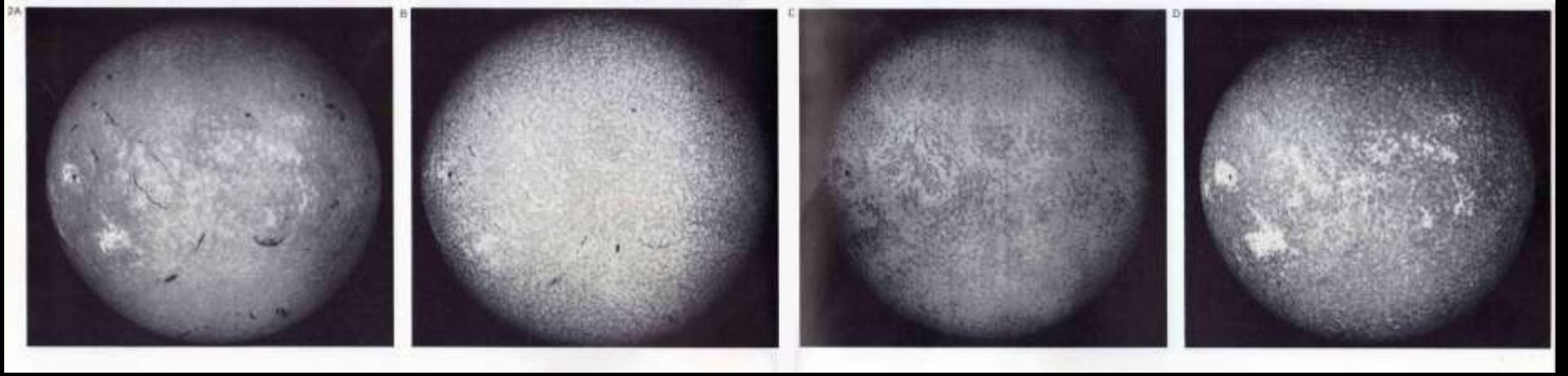


Off-band, red-side, H-alpha imaging
is the only way to see these features



2. Layers of the chromosphere
These spectroheliograms taken on 11 September 1961 show the different appearance of the chromosphere at four different wavelengths: Hα (**A**), Hα + 0.035 nm (**B**), Hα + 0.07 nm (**C**), and the K-line of calcium (**D**). At the center of the Hα line (**A**), areas of solar activity such as dark filaments and bright plages (also revealed in calcium K) are seen. The filaments curve towards the sunspots following the neutral line (*see* page 37). At slightly longer wavelengths (**B** and **C**) the filaments and plages fade from view. Structures at slightly higher levels of the chromosphere are shown up, since these features emit light over a relatively broad

wavelength; at Hα + 0.07 nm, for example, practically all that can be seen is the pattern of spicules outlining the chromospheric network. At the same time, however, the umbra and penumbra of the sunspots (which exist at deeper levels) can also be seen clearly, because the chromosphere is less opaque in the "wings" of the line than it is at the center of the Hα line. A band of plages appears concentrated near the equator (**D**).



Ha on band Ha +0.035nm Ha + 0.07nm CaK

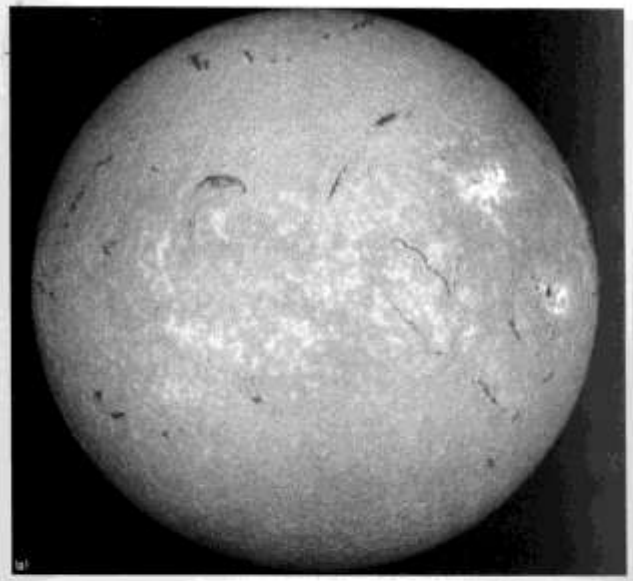
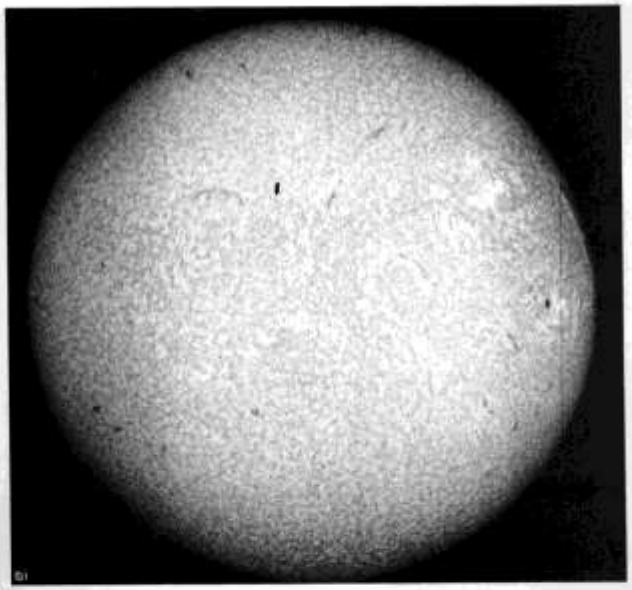
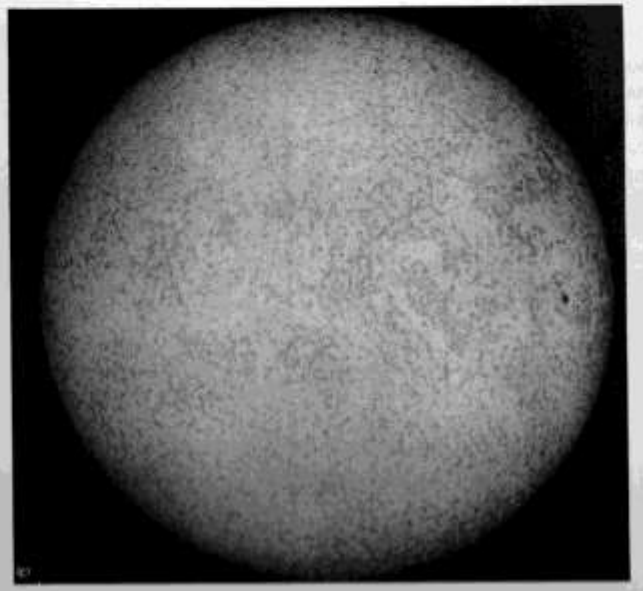


FIGURE 5–46.—Spectroheliograms taken on September 11, 1961. The structure in the equatorial band is dominated by solar activity. Above and below this band, a transition can be seen from detailed quiet-sun structure at line center to a sparse structure at +0.7 Å which outlines the chromospheric network. (*a*) Hα line center. (*b*) 0.35 Å to the red side of Hα line center. (*c*) 0.7 Å to the red side of Hα line center. (Courtesy of Mount Wilson and Palomar Observatories.)

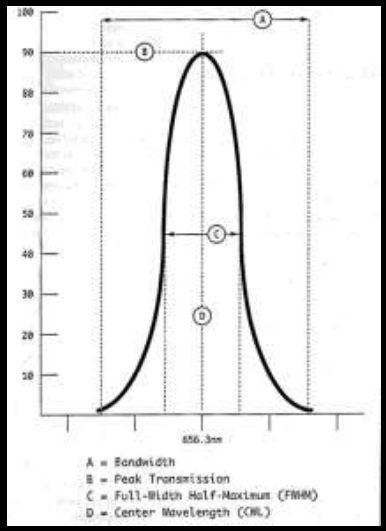
suggesting they coincide with the dark lanes and pores of granulation. These areas of locally strong magnetic field also correspond to areas of weakened Fraunhofer lines. In fact, when spectroheliograms are made in lines that are formed low in the photosphere, not only do these magnetically enhanced areas appear brighter, but a very fine bright network pattern is evident (Chapman and Sheeley, 1968). This network, called the photospheric network, also closely coincides with the magnetic field pattern but is finer in structure than the overlying chromospheric network. Both networks are manifestations of the magnetic-field structure which tends to spread out and become coarser with altitude. The photospheric network appears most readily in lines of ions with low ionization energies; that is, ions whose emission is most sensitive to temperature changes. The regions of the solar atmosphere where this network is formed are a few hundred degrees Kelvin hotter than their surroundings and the network of enhanced emission results. These hotter regions also appear at the limb in white light as photospheric faculae (Chapman and Sheeley, 1968).

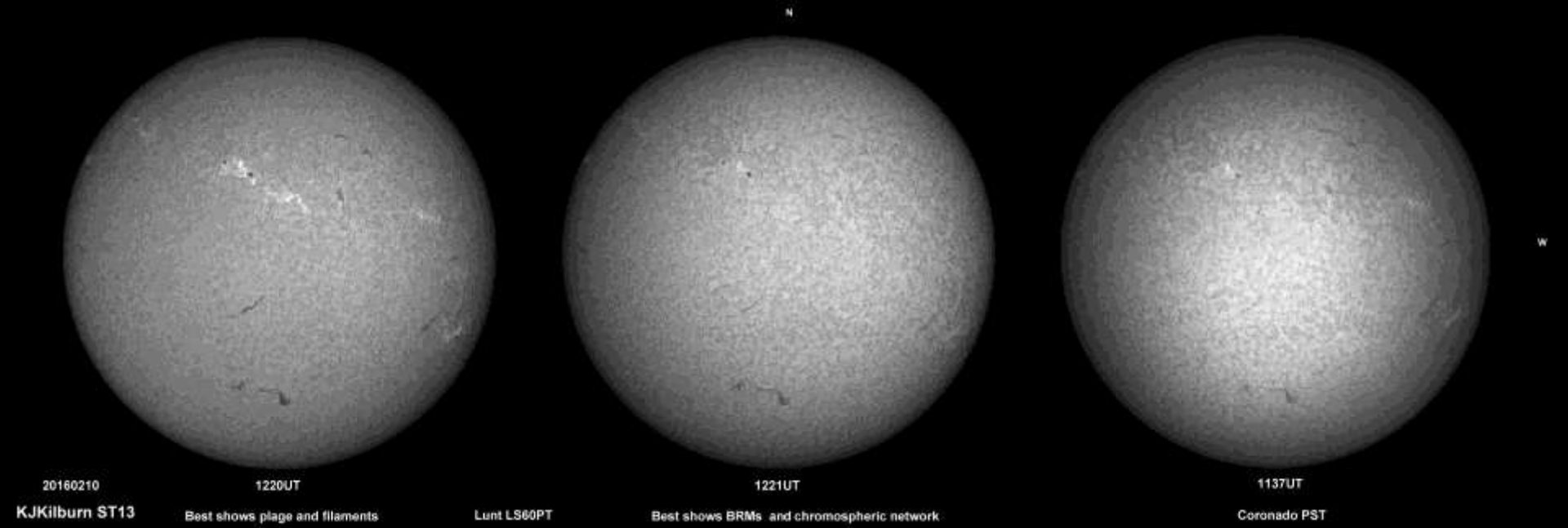




On- and off-band H-alpha images:

The Lunt 60mm has a bandwidth < ~ 0.7 Angstroms.
The Coronado PST is < ~ 1 Angstrom





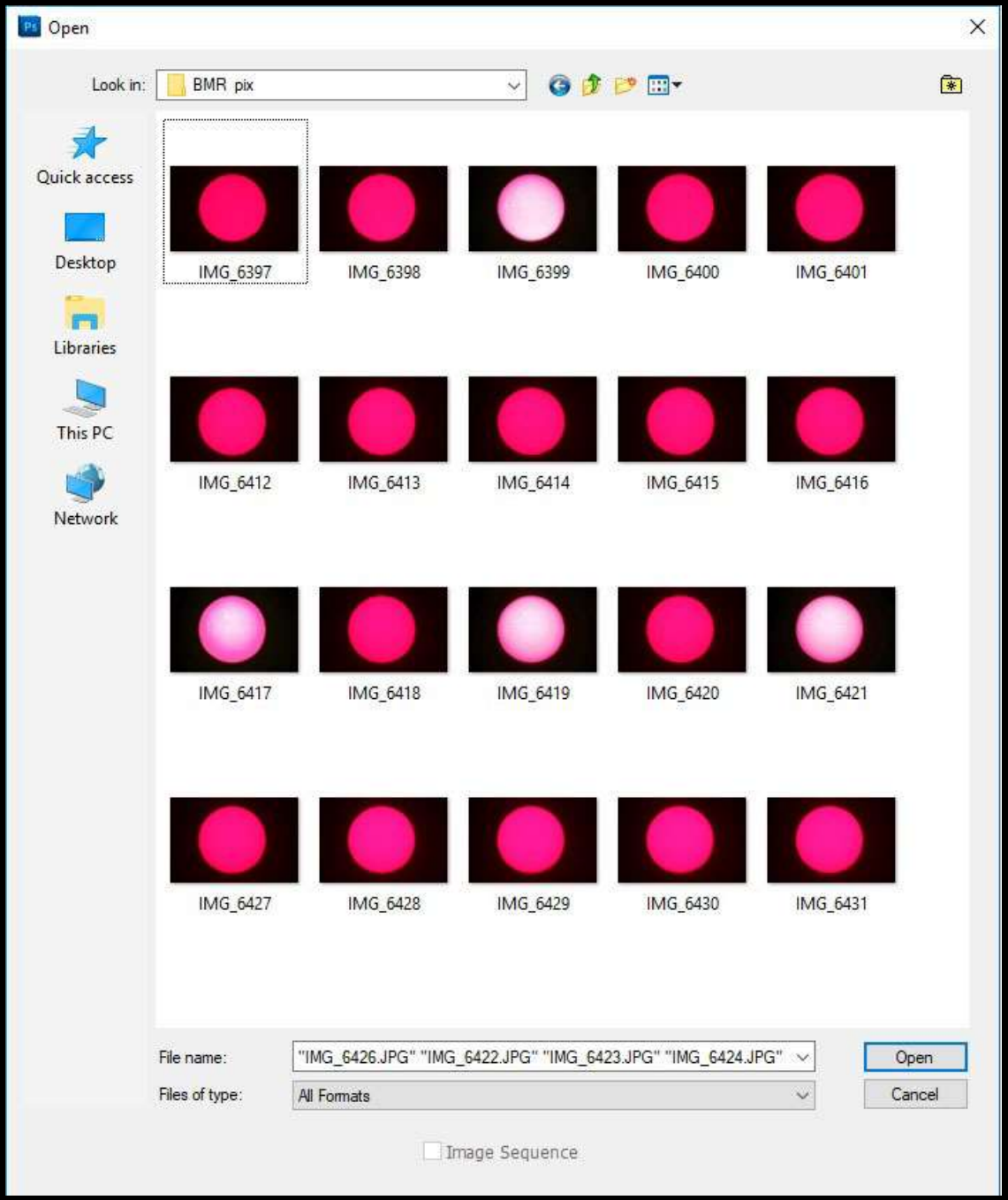
20160210
KJKilburn ST13

1220UT
Best shows plage and filaments

Lunt LS60PT

1221UT
Best shows BRMs and chromospheric network

1137UT
Coronado PST



How I identify red-side CWL in simultaneous jpg/RAW images:

The Lunt is first pressure tuned visually to show chromospheric detail; filaments, prominences, plage etc. (On centre wavelength, top set of images)

5 images are taken at this tuner setting

Then the tuner is tightened a couple of turns, and another 5 images taken ...repeating the process four or five times until visual assessment shows that filaments and prominences have been de-tuned too far red-side.

Each set of pix is examined as jpgs and the best ones identified and ‘levelled’ in Photoshop CS5.

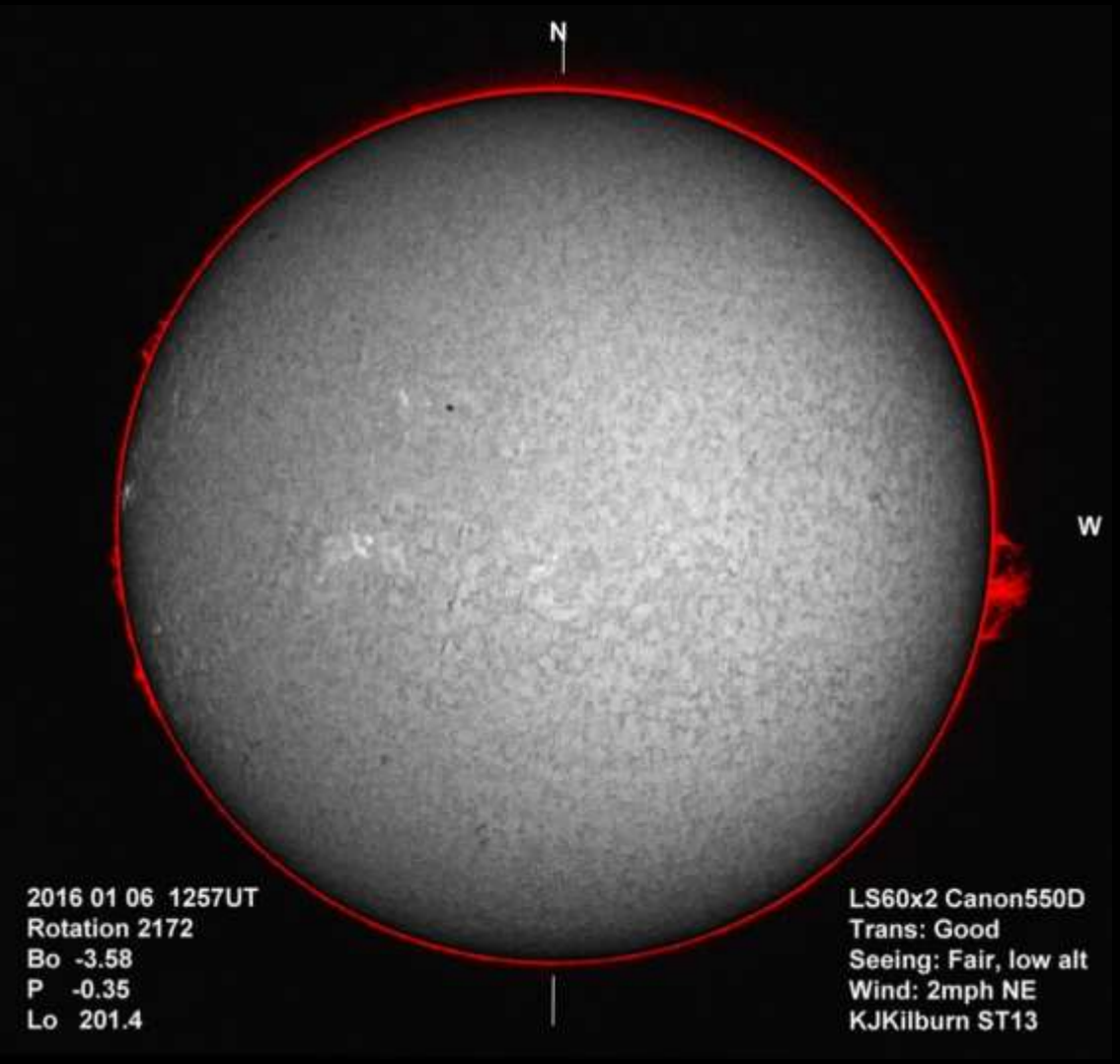
Re-examination of the images identifies the best on-band and the red-side CWL image best showing BMRs. (Third line)

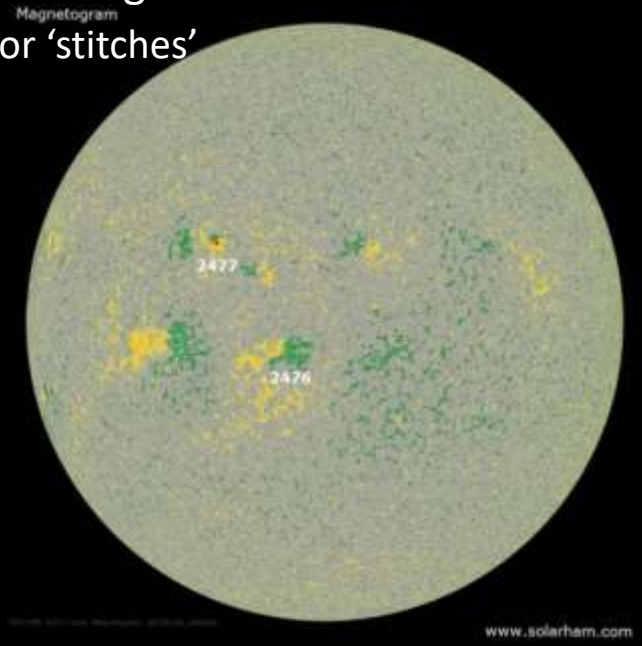
The corresponding RAW image is then processed via Adobe Camera Raw and Photoshop.

The Coronado PST on its EQ2 mounting lives in my study and was pre-tuned by trial and error in 2012 by selecting an optimal tuning position against a stuck-on scale, initially visually and then photographically, to show the most chromospheric detail, including BMRs. It was last focussed for the dedicated plug-in x2 Barlow and DSLR in 2012.

Chromospheric ‘bruises’ were eventually identified as

Bipolar Magnetic Regions (BMRs)…areas of opposite magnetic polarity at the break-through point at the roots of magnetic loops or ‘stitches’



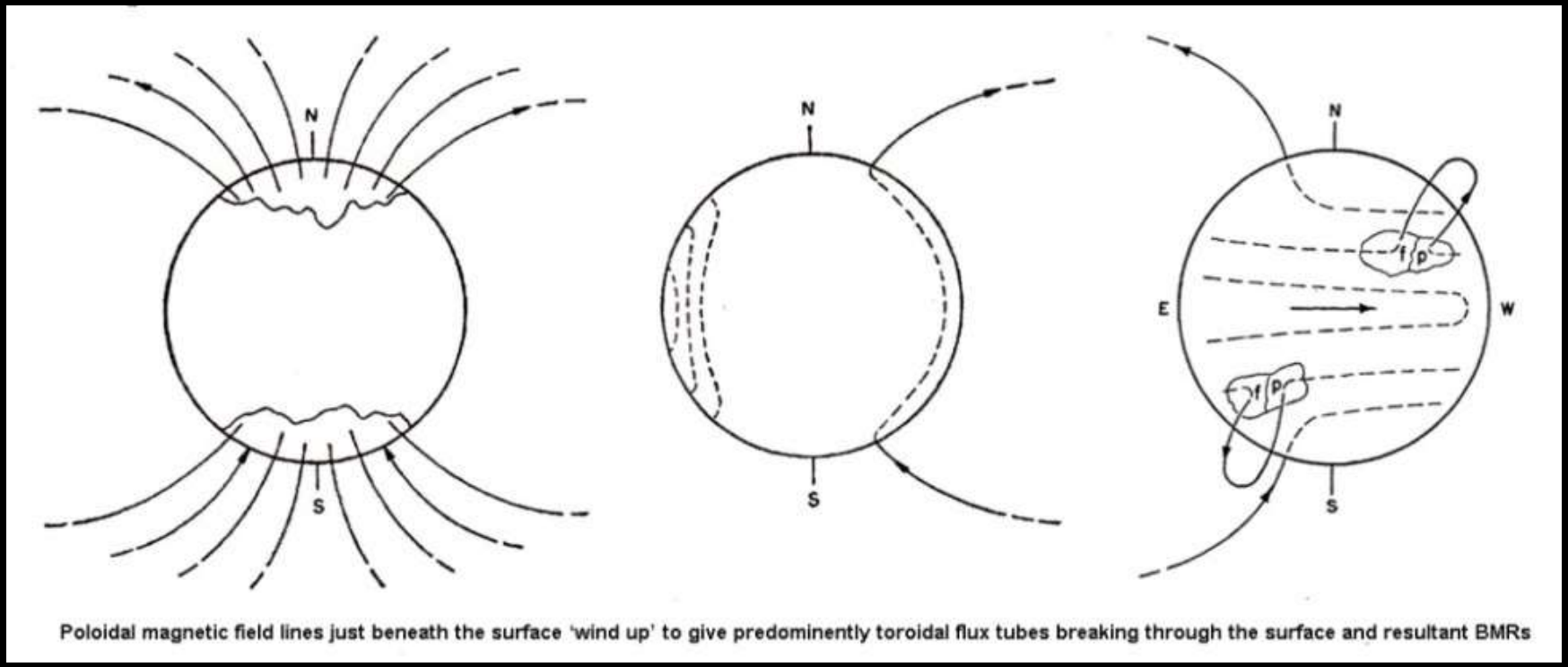


BMRs were eloquently described over 55 years ago. Yet since the availability of amateur-affordable H-alpha telescopes, over two decades ago, they have been poorly observed and hardly ever, if ever, described by amateur solar observers.

Shallow, submerged poloidal magnetic field lines are drawn out in longitude by differential rotation into increasingly stronger toroidal fields. “BMRs lie at the root of loops or ‘stiches’ that break through the solar surface and after, about 3years at the commencement of a solar cycle, may give rise to bipolar sunspots.”

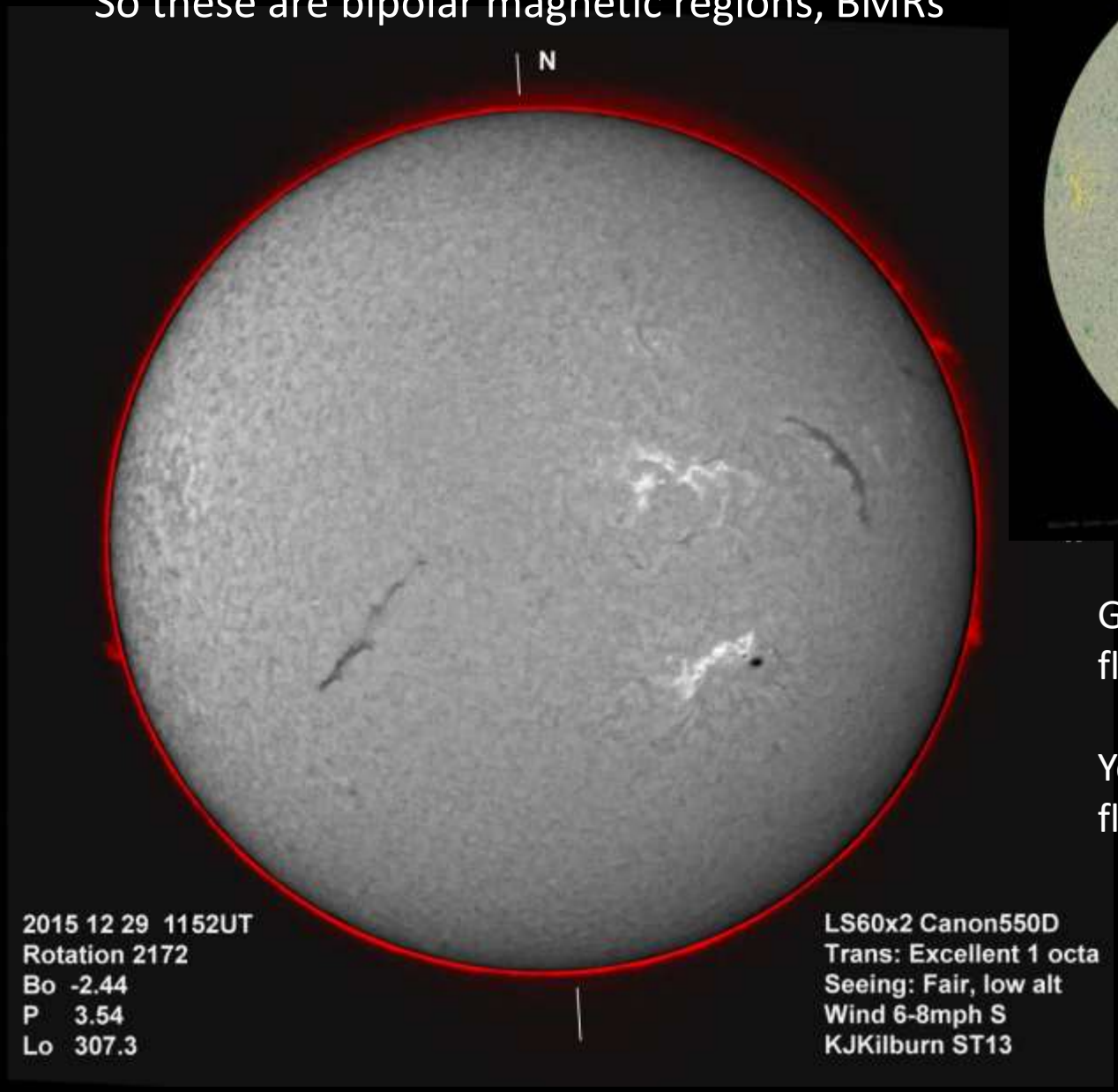
Horace W. Babcock and Harold D. Babcock etal.

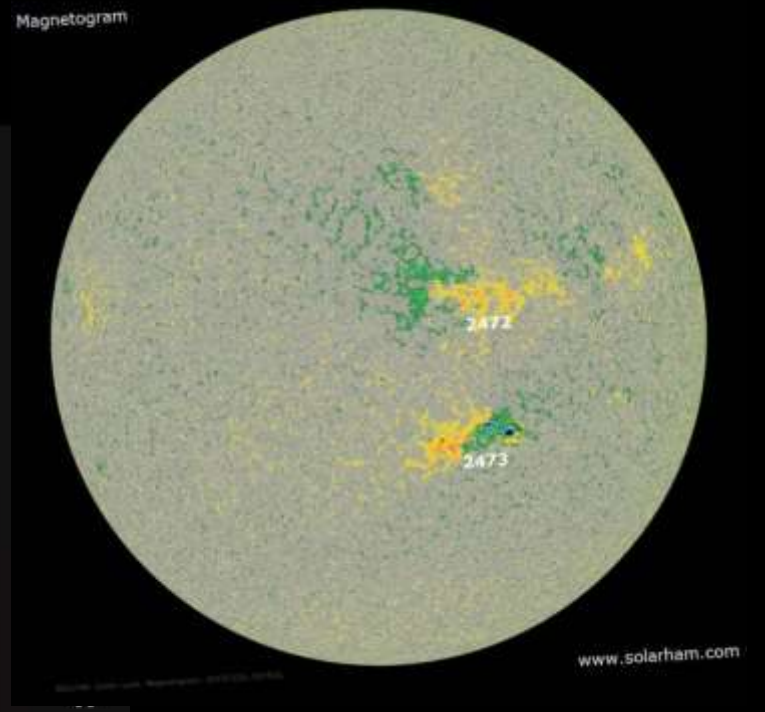
Mt Wilson and Palomar Observatories



Poloidal magnetic field lines just beneath the surface 'wind up' to give predominently toroidal flux tubes breaking through the surface and resultant BMRs

So these are bipolar magnetic regions, BMRs





Green = N polarised, outward flowing magnetic field

Yellow = S polarised, inward flowing, magnetic field.

2016 01 14 1315UT
Rotation 2172
Bo -4.44
P -4.18
Lo 95.9

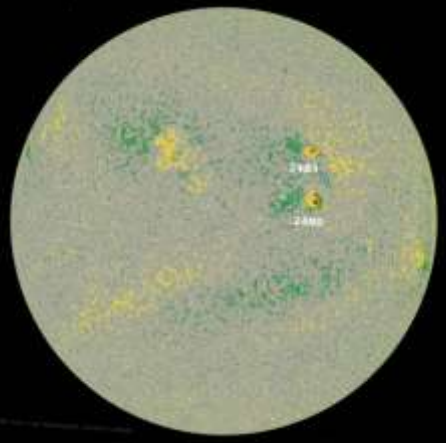
ED80x2 Canon550D
Trans: Excellent, 2/8
Seeing: fair, low alt
Wind: 3-4mph NW
KJKilburn ST13

2016 01 14 1308UT

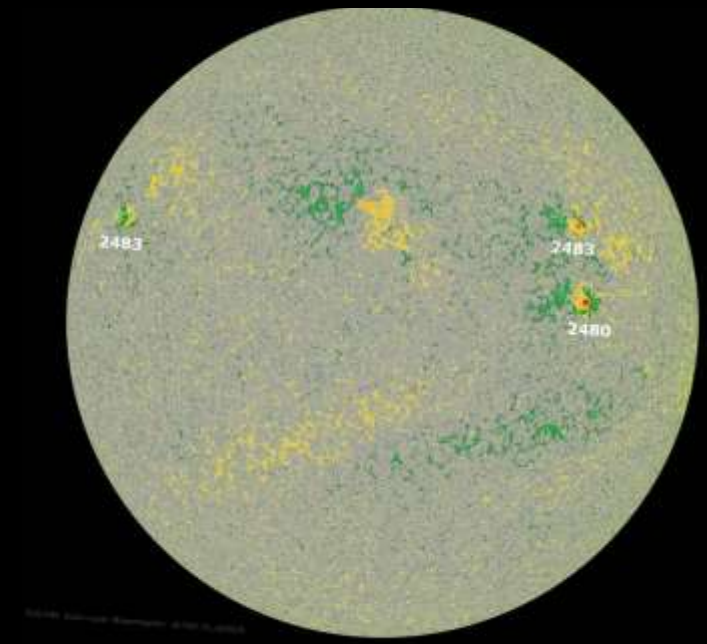
PSTx2 Canon550D

2016 01 14 1331UT
Rotation 2172
Bo -4.44
P -4.19
Lo 95.7

LS60PTx2 Canon550D
Trans: Excellent 1 octa
Seeing: fair, low alt
Wind: 1-2 mph NE
KJKilburn ST13

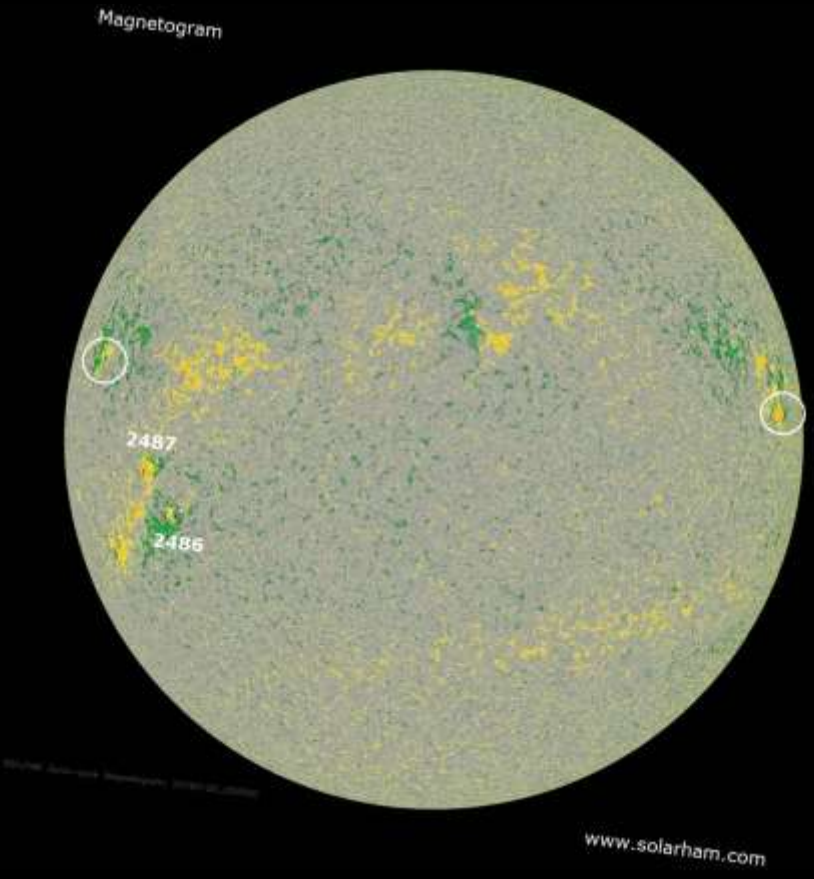



N
W
2016 01 15 1105UT
Rotation 2172
Bo -4.53
Po 4.61
Lo 83.9
ED80x2 Canon550D
Trans: Excellent 1 octa cloud
Seeing: Good, low alt
Wind: 3-4mph W
KJKilburn ST13

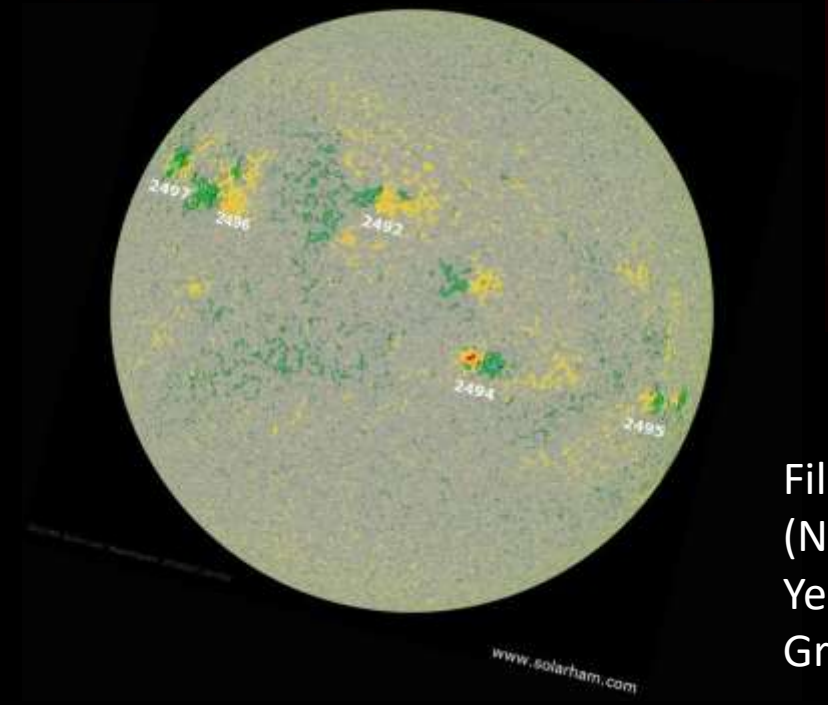

2483
2483
2480
www.solarham.com


N
W
6 01 15 1057UT
ation 2172
-4.53
4.61
84.0
PSTx2 Canon550D
Trans: Excellent 1/8
Seeing: Good, low alt
Wind: 0mph W
KJKilburn ST13

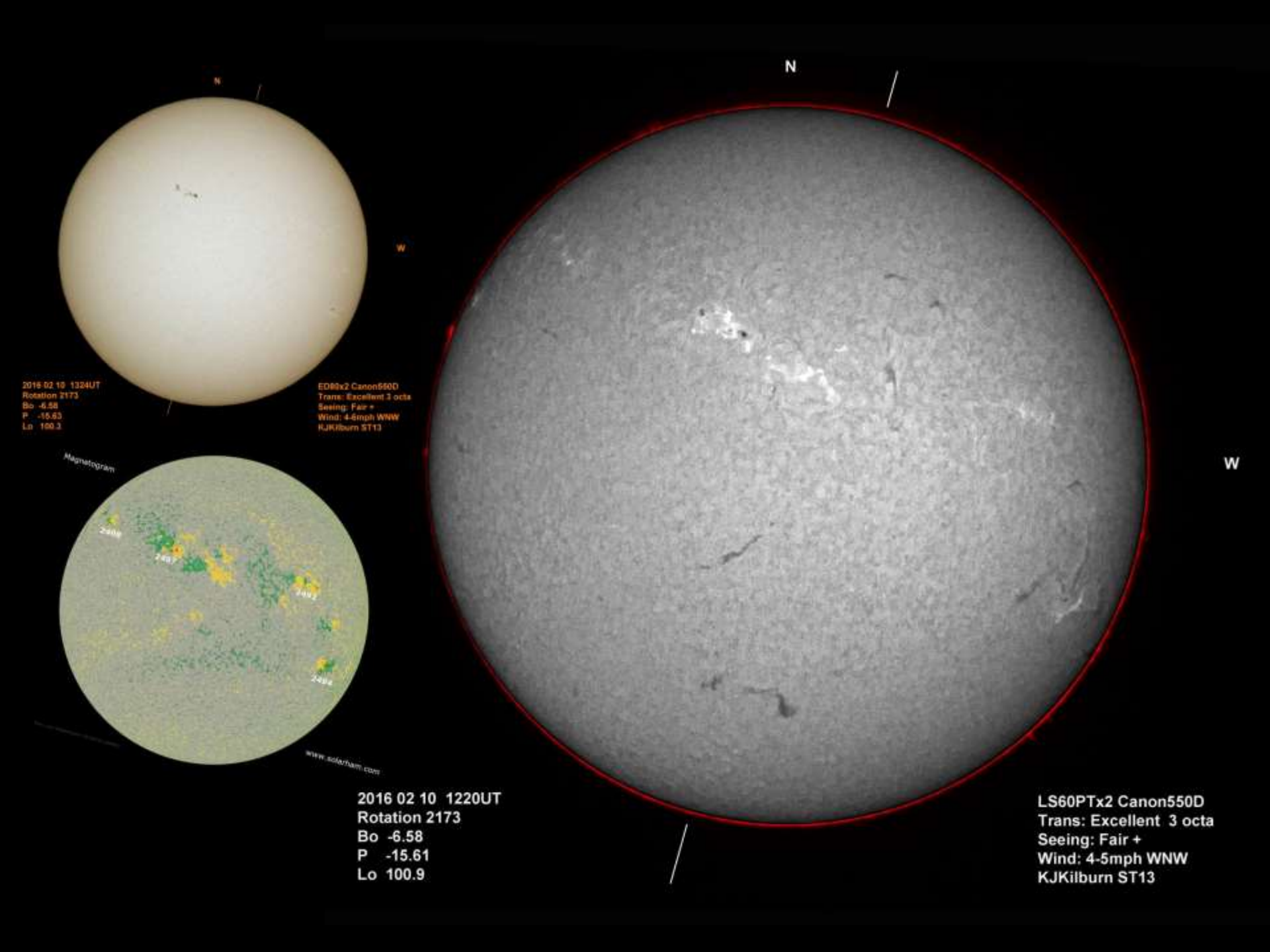
Stable, filamentary prominences , visible as dark filaments, frequently separate *p* and *f* parts of BMRs nearly at right angles to the lines of force along a magnetically neutral line.



…from this, it's inferred that such filaments are supported in troughs or depressions in the magnetic arches.



Filaments may outline BMRs particularly their N edge (N hemisphere) or S edge (S hemisphere).
Yellow = S polarity, inward flowing, magnetic field,
Green = N polarity, outwards.

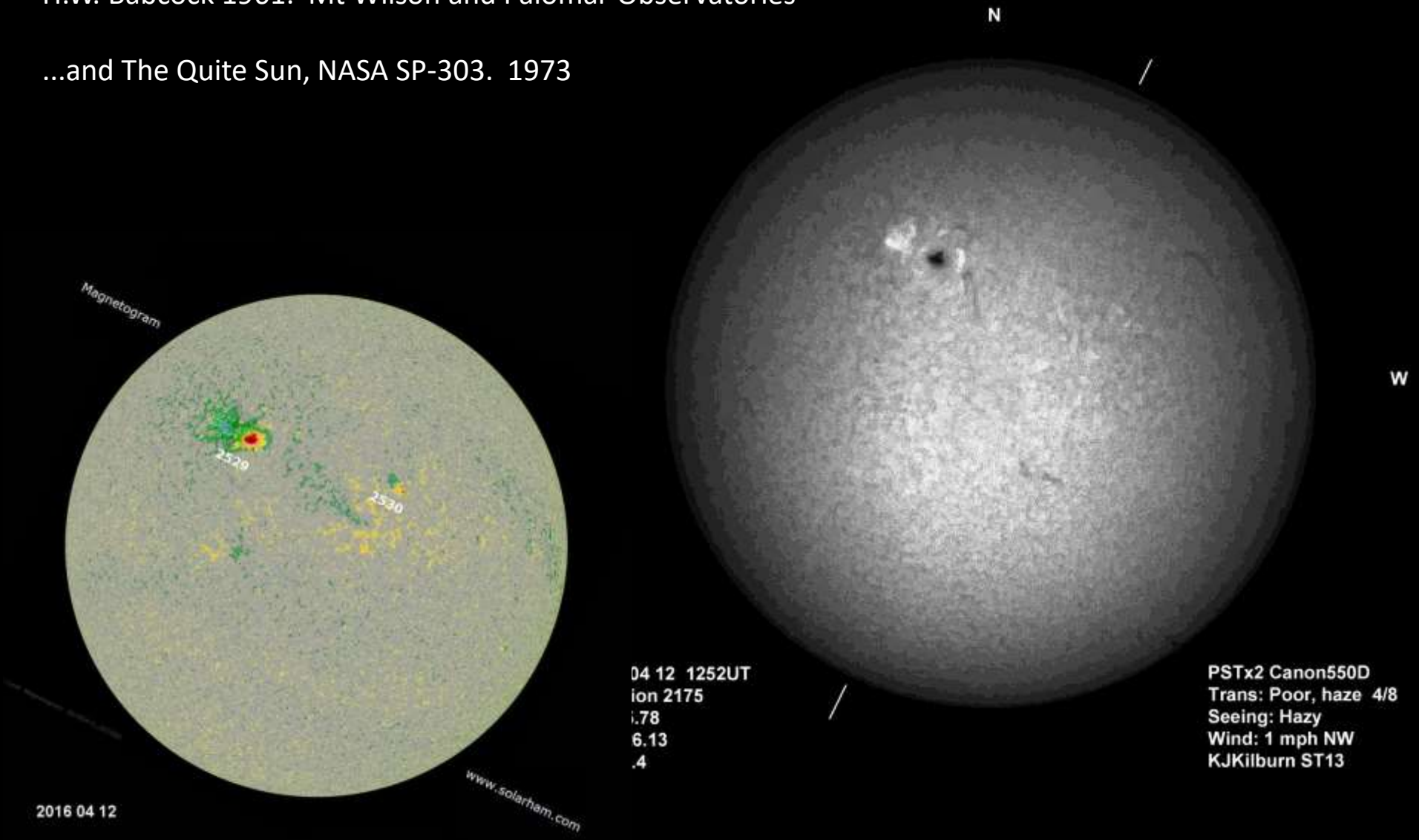

N
W
2016 02 10 1324UT
Rotation 2173
Bo -6.58
P -15.63
Lo 100.3
ED80x2 Canon550D
Trans: Excellent 3 octa
Seeing: Fair +
Wind: 4-6mph WNW
KJKilburn ST13
Magnetogram
2496
2497
2493
2494
www.solarham.com
N
W
2016 02 10 1220UT
Rotation 2173
Bo -6.58
P -15.61
Lo 100.9
LS60PTx2 Canon550D
Trans: Excellent 3 octa
Seeing: Fair +
Wind: 4-5mph WNW
KJKilburn ST13

Collapse of the stabilizing magnetic fields straddling the neutral line can result in the filament lashing upwards (disparition brusque) as in March 2016.

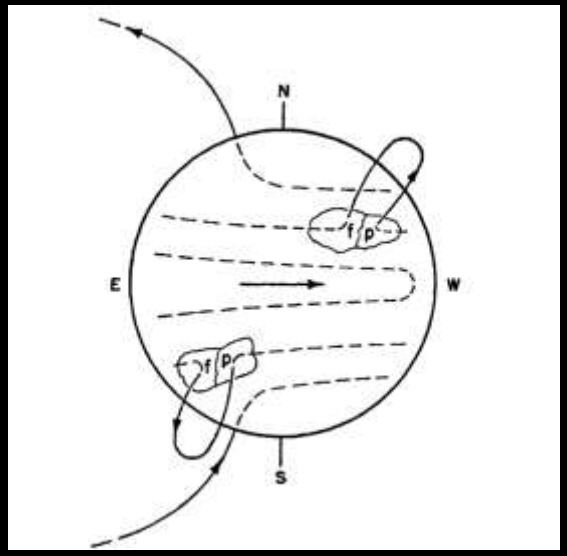
Chromospheric ‘bruises’ (Bipolar Magnetic Regions):

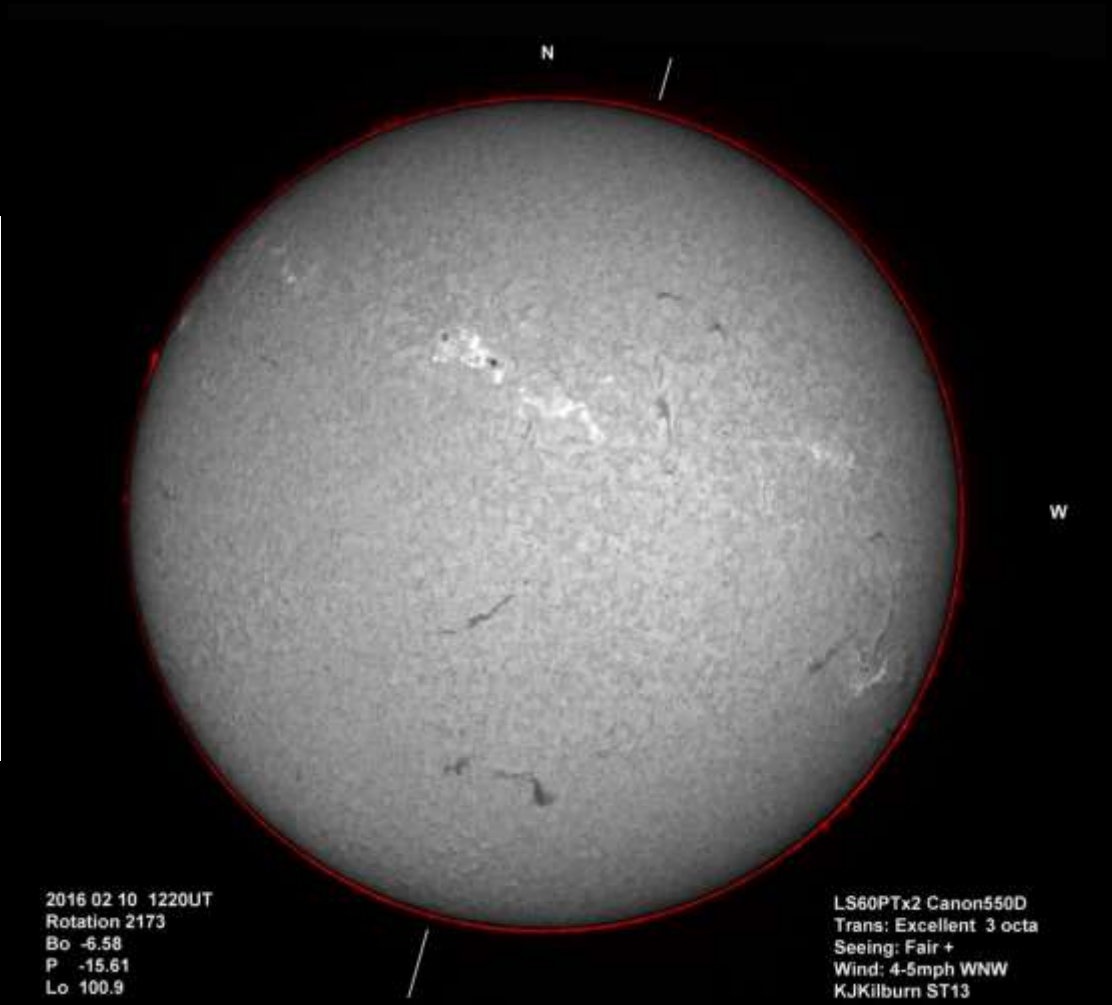
Ref: The Topology of the Sun’s Magnetic Field and the 22year cycle.
H.W. Babcock 1961. Mt Wilson and Palomar Observatories

...and The Quite Sun, NASA SP-303. 1973

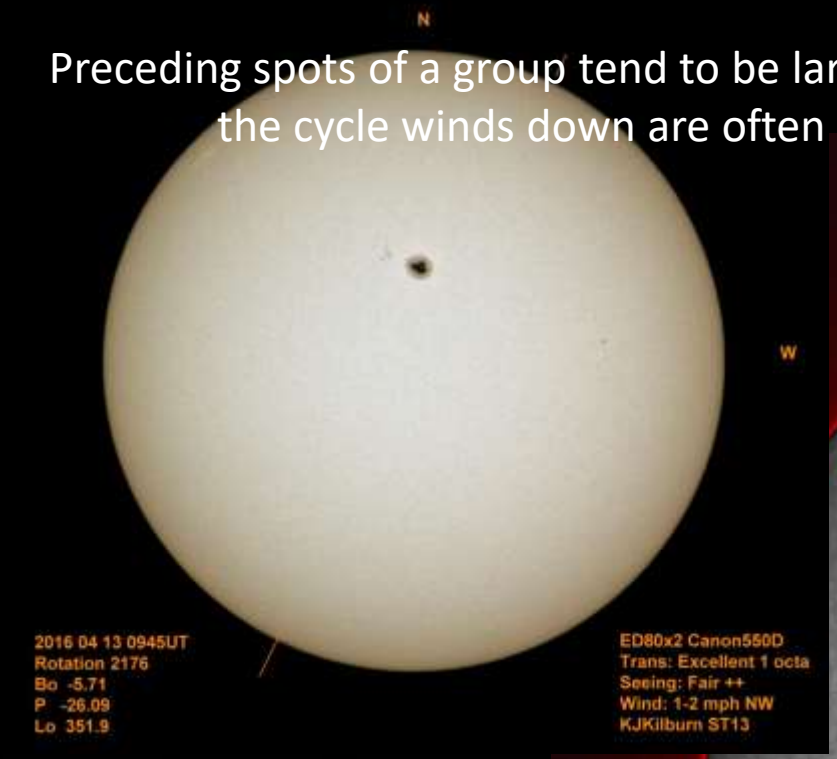


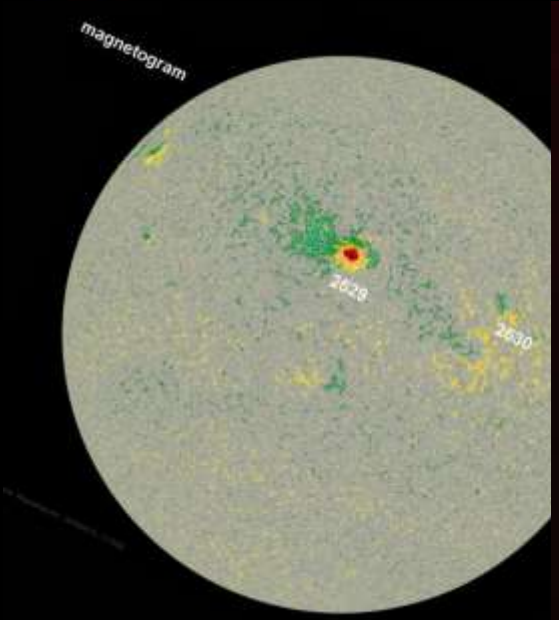
The orientation of spot groups is such that the p spot is generally closer to the equator than the f spot.

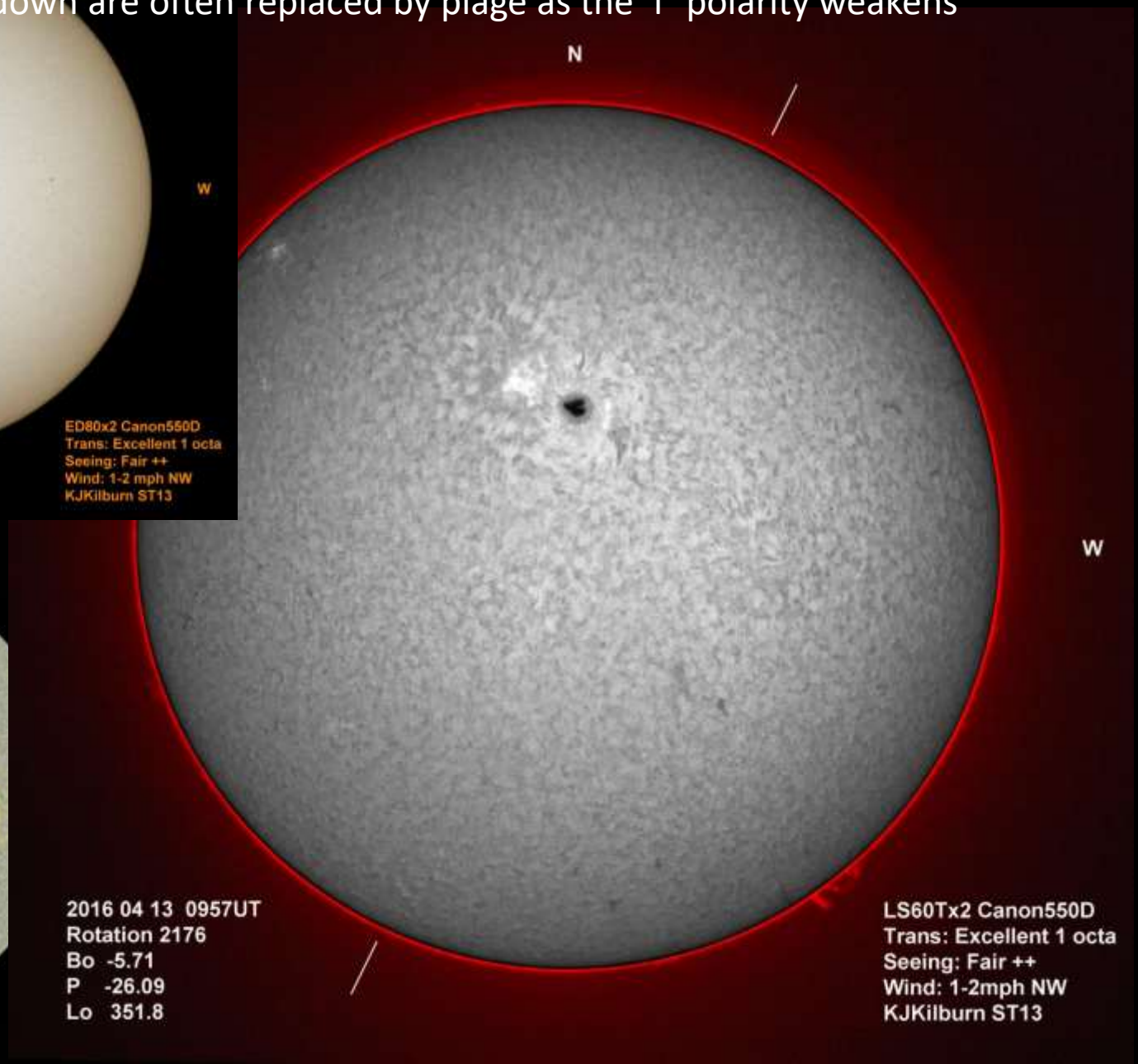




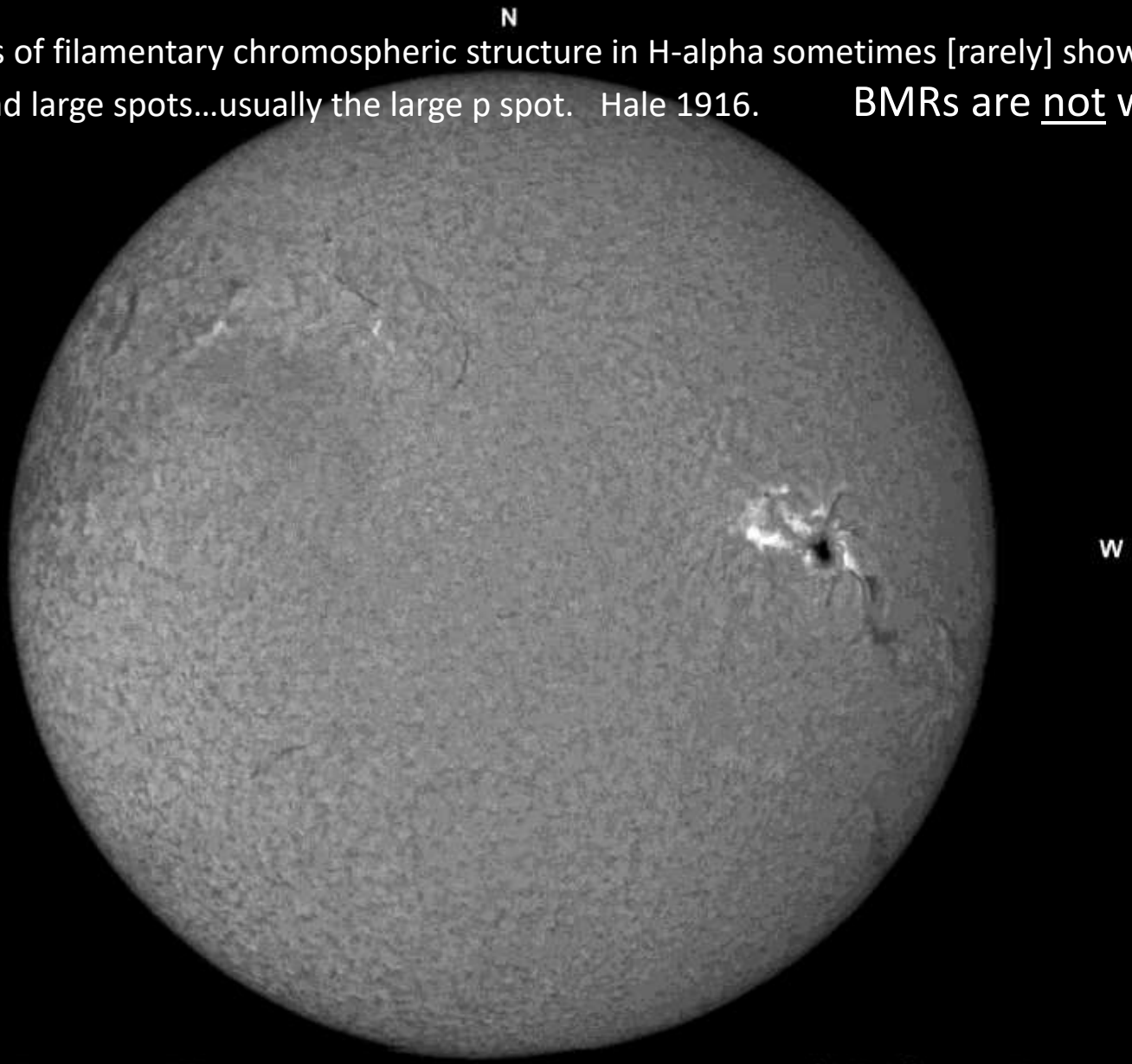
Preceding spots of a group tend to be larger and have a longer lifetime than ‘f’ spots which as the cycle winds down are often replaced by plage as the ‘f’ polarity weakens



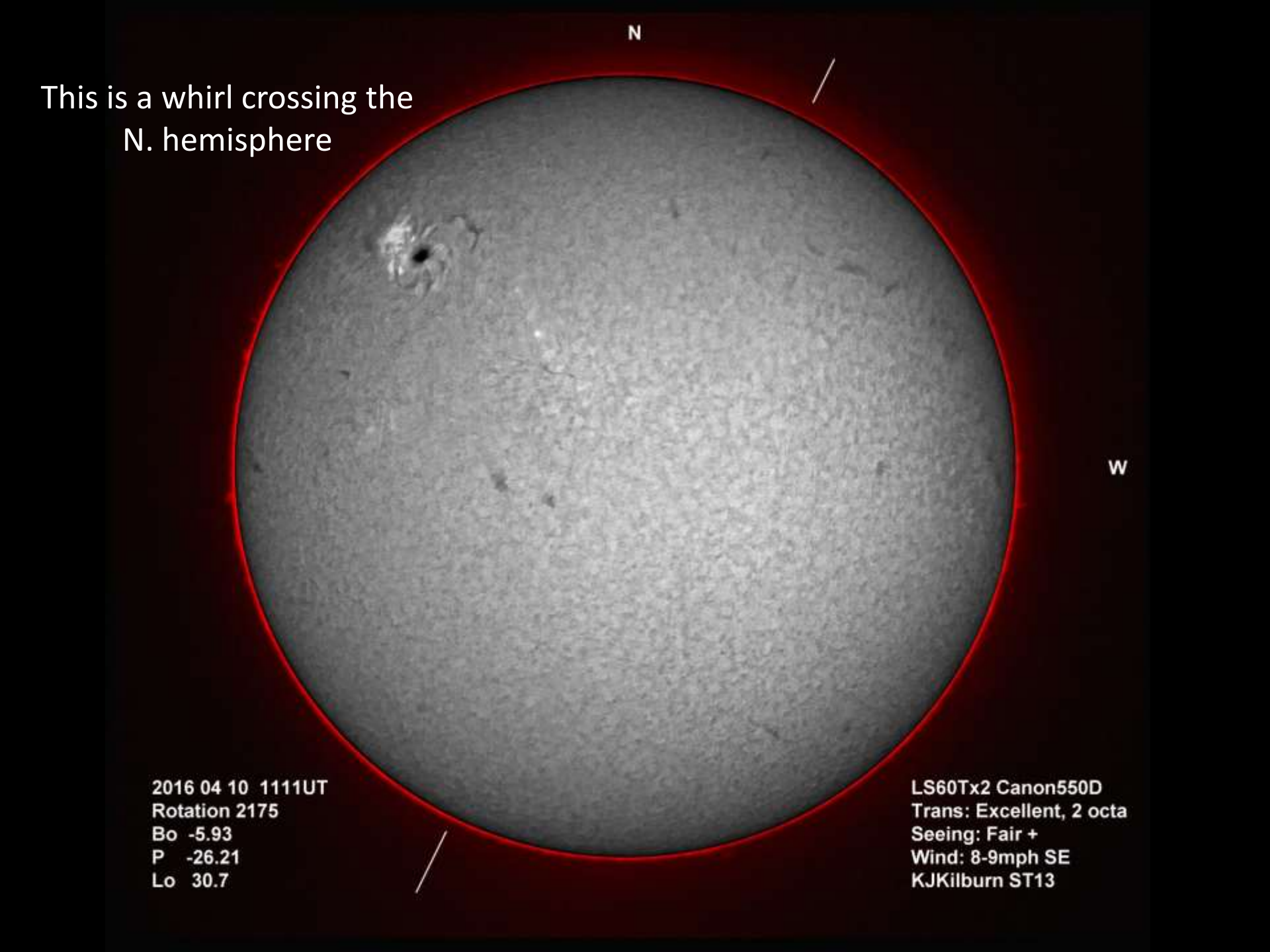


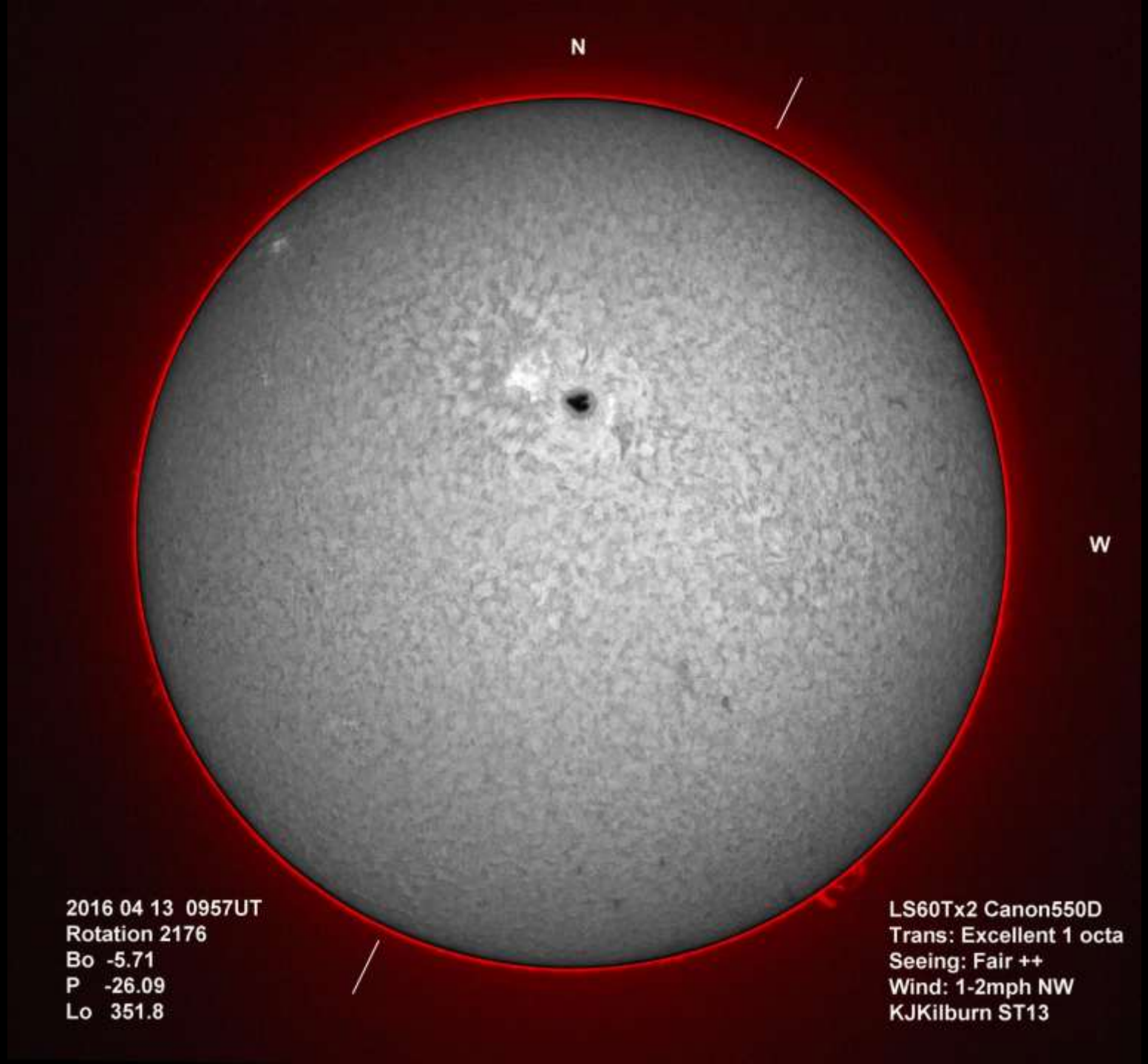


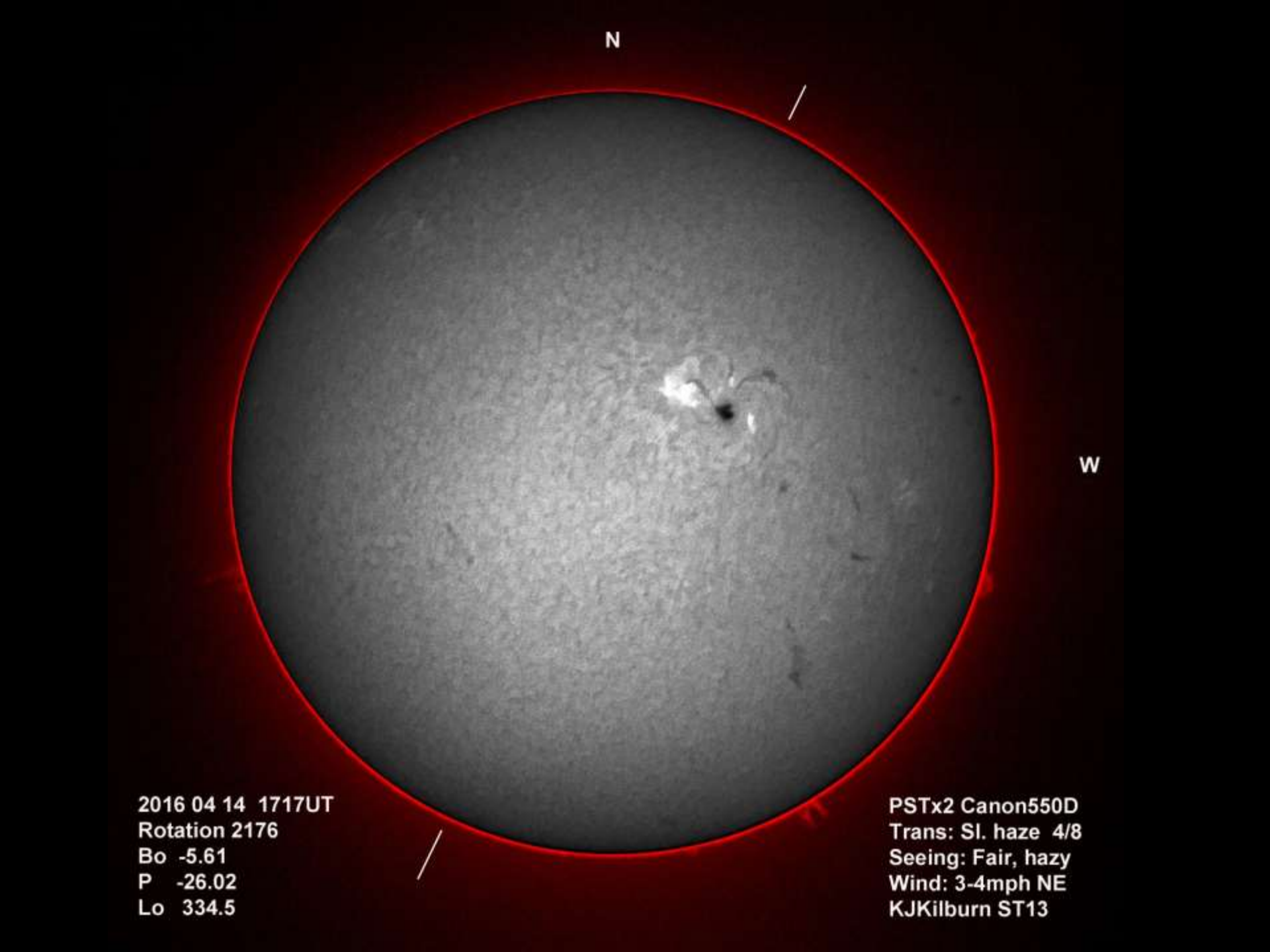
Observations of filamentary chromospheric structure in H-alpha sometimes [rarely] show spiral 'whirls' around large spots…usually the large p spot. Hale 1916. BMRs are <u>not</u> whirls.

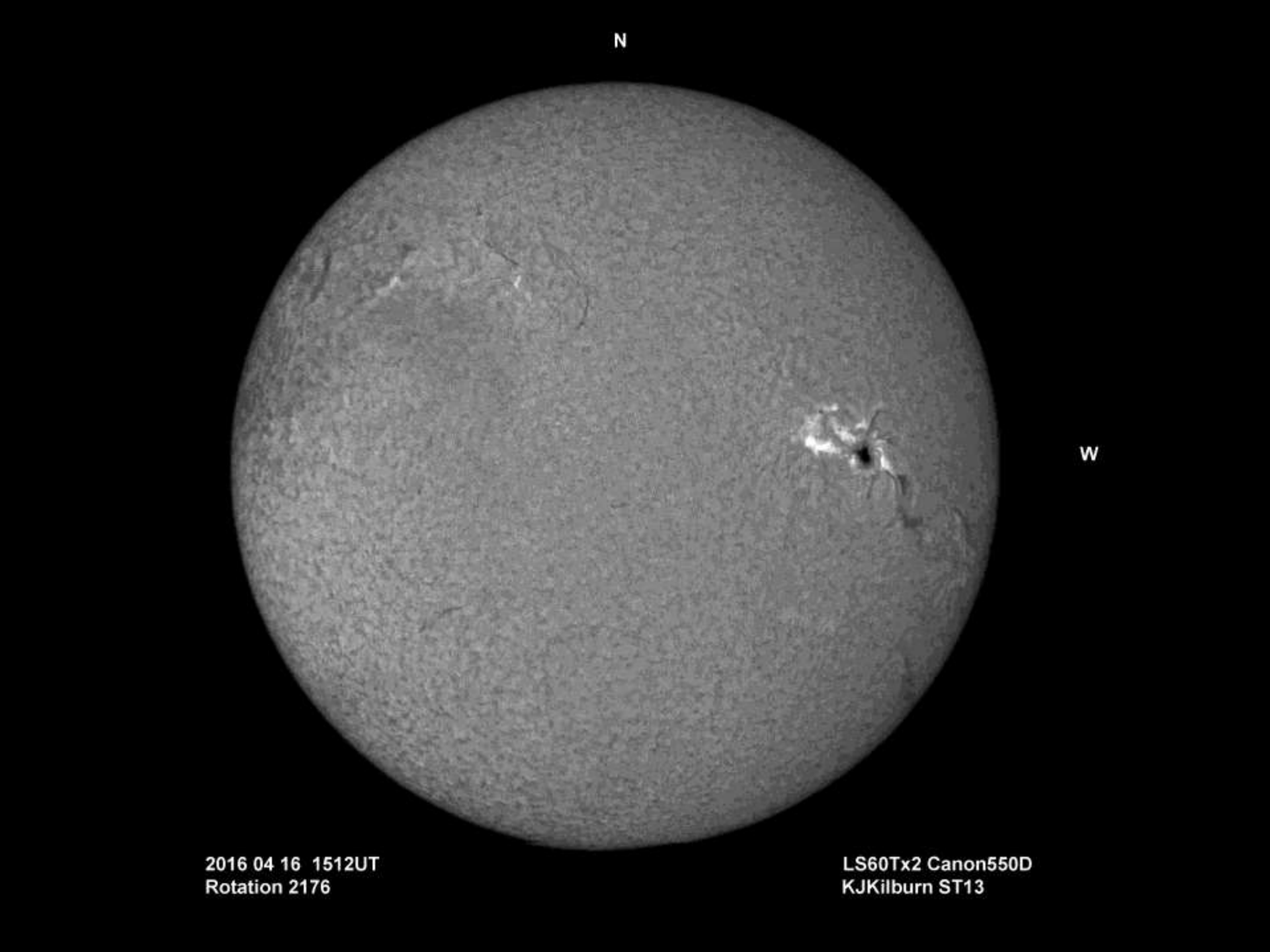


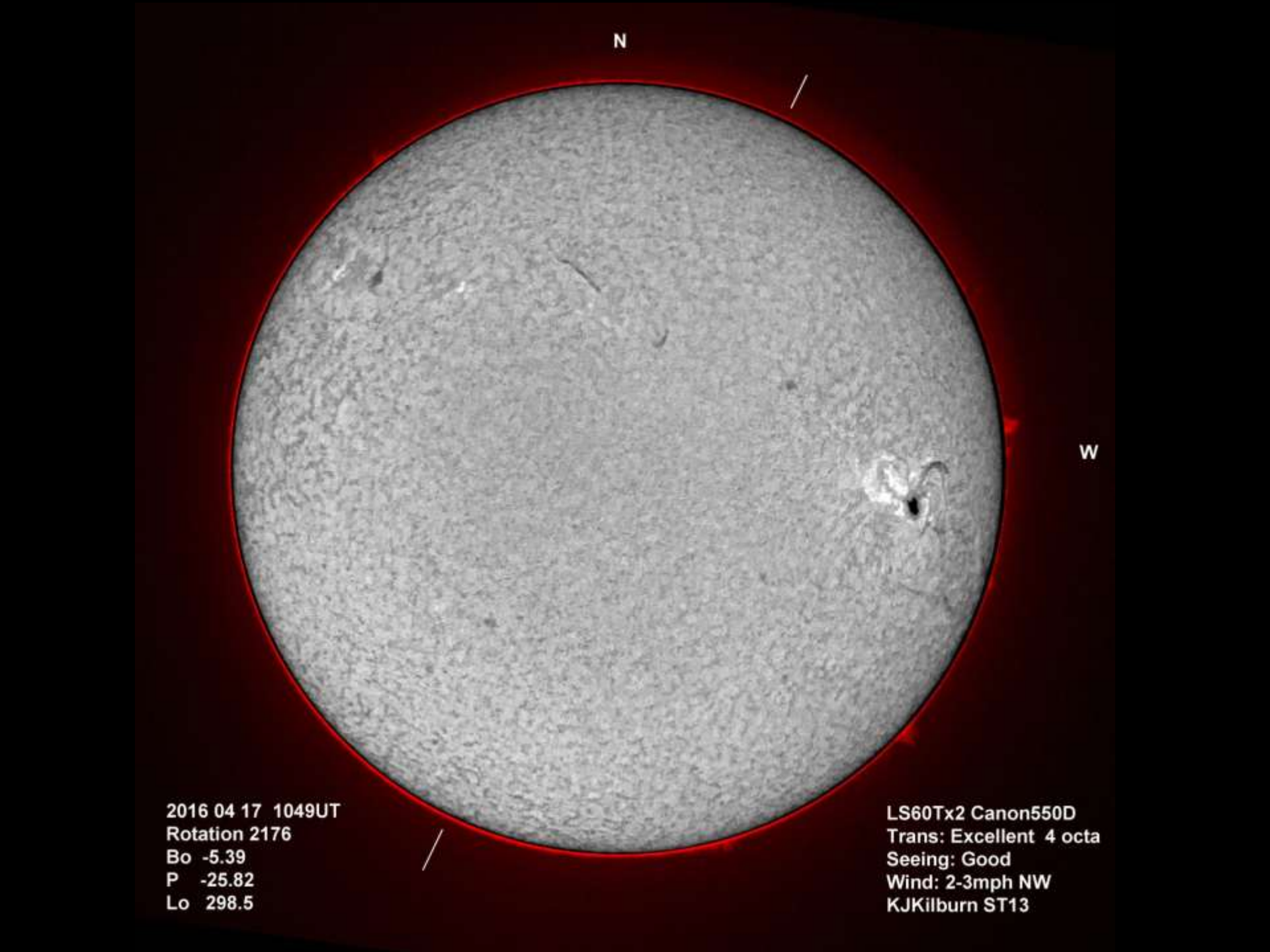
This is a whirl crossing the N. hemisphere



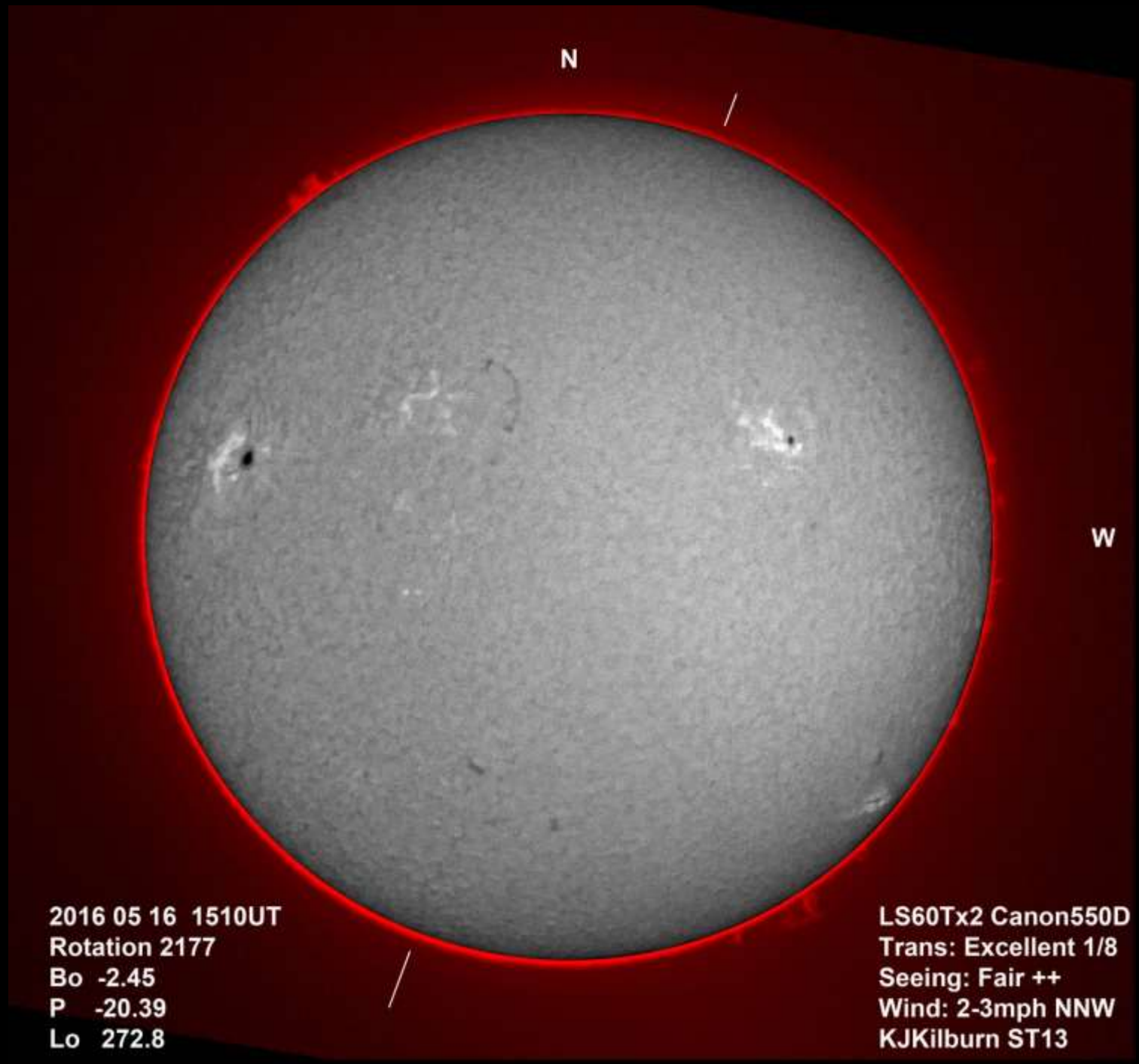

N
W
2016 04 13 0957UT
Rotation 2176
Bo -5.71
P -26.09
Lo 351.8
LS60Tx2 Canon550D
Trans: Excellent 1 octa
Seeing: Fair ++
Wind: 1-2mph NW
KJKilburn ST13

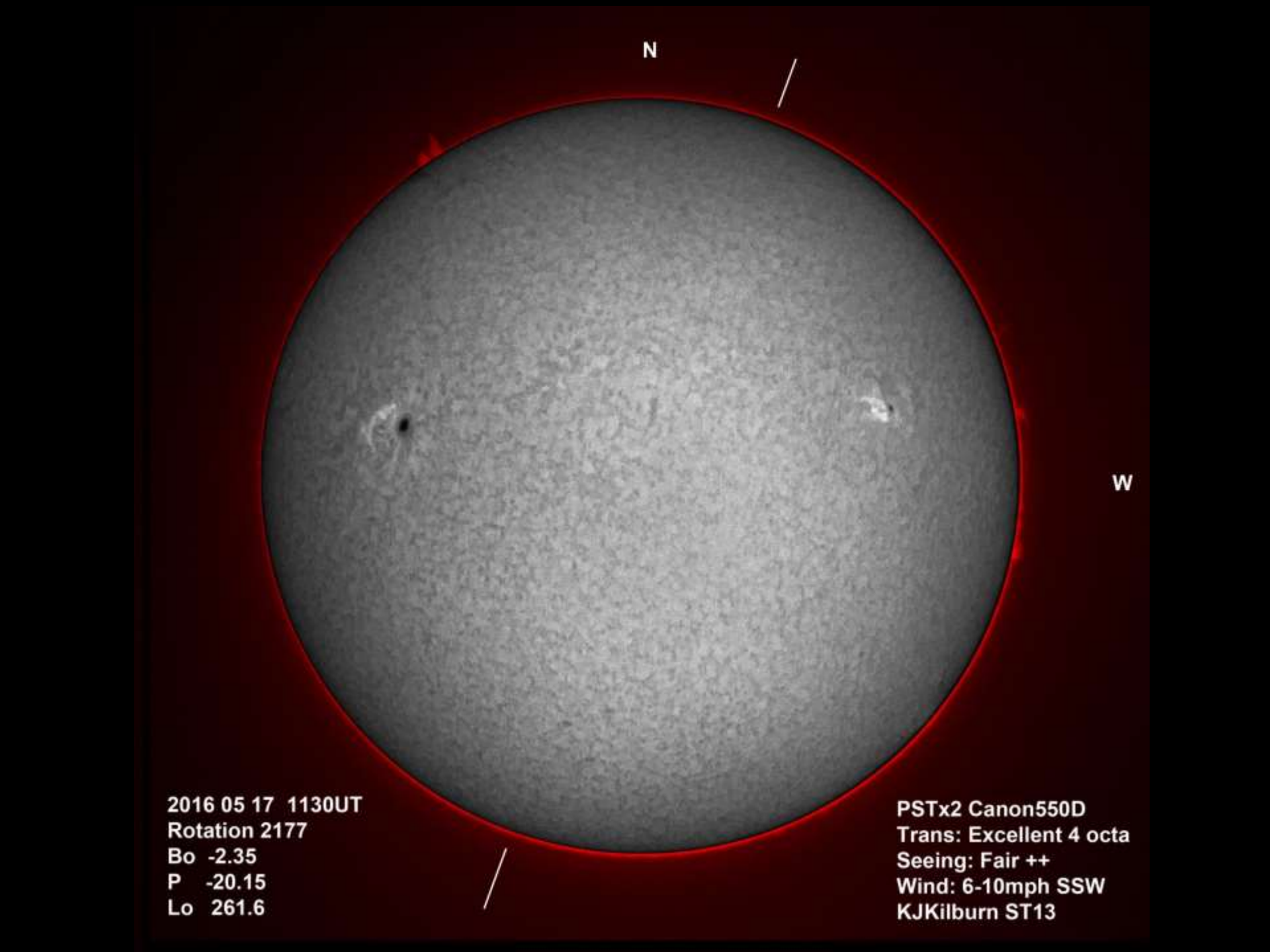

N
W
2016 04 14 1717UT
Rotation 2176
Bo -5.61
P -26.02
Lo 334.5
PSTx2 Canon550D
Trans: Sl. haze 4/8
Seeing: Fair, hazy
Wind: 3-4mph NE
KJKilburn ST13

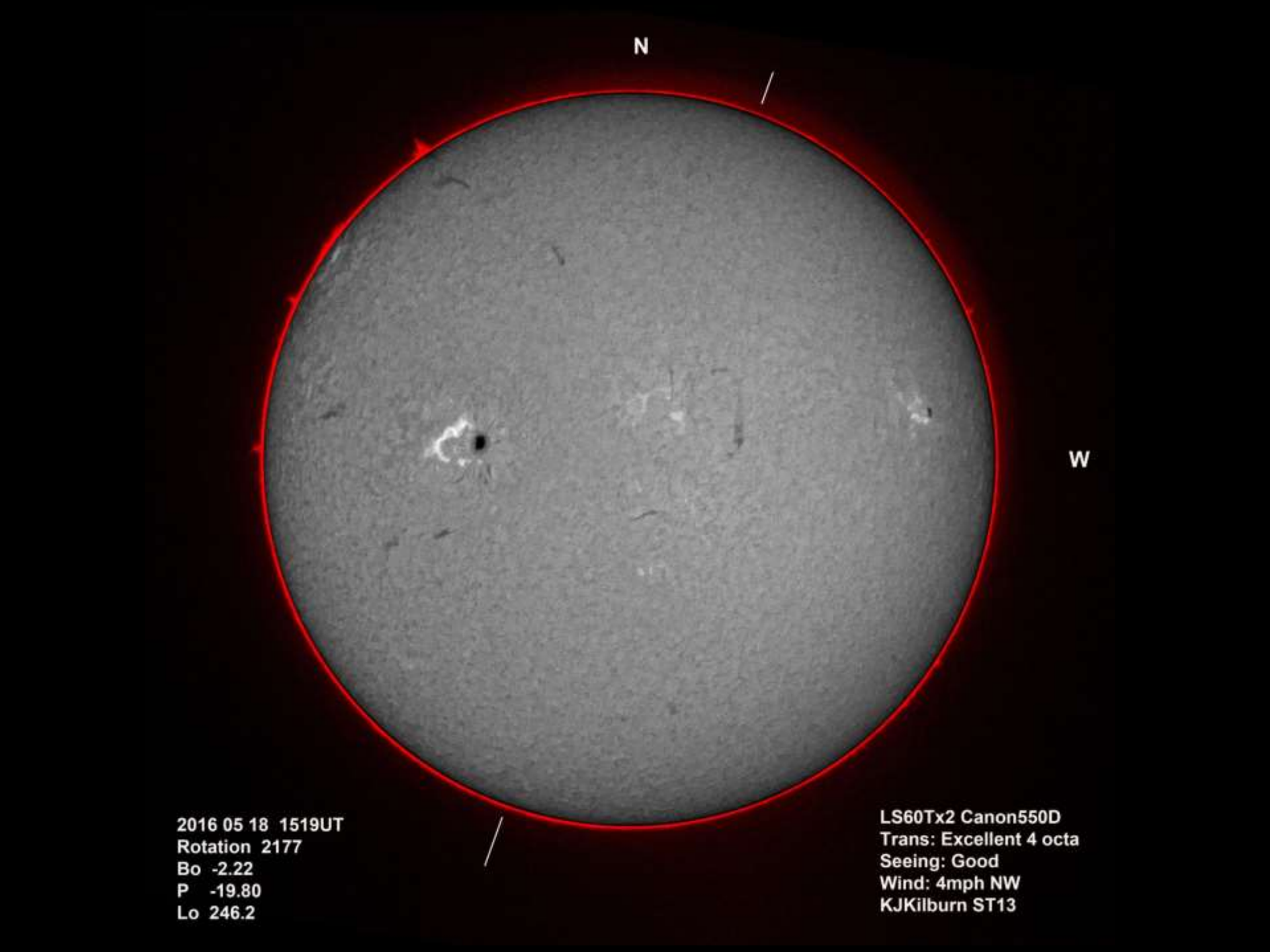

N
W
2016 04 16 1512UT
Rotation 2176
LS60Tx2 Canon550D
KJKilburn ST13


N
W
2016 04 17 1049UT
Rotation 2176
Bo -5.39
P -25.82
Lo 298.5
LS60Tx2 Canon550D
Trans: Excellent 4 octa
Seeing: Good
Wind: 2-3mph NW
KJKilburn ST13

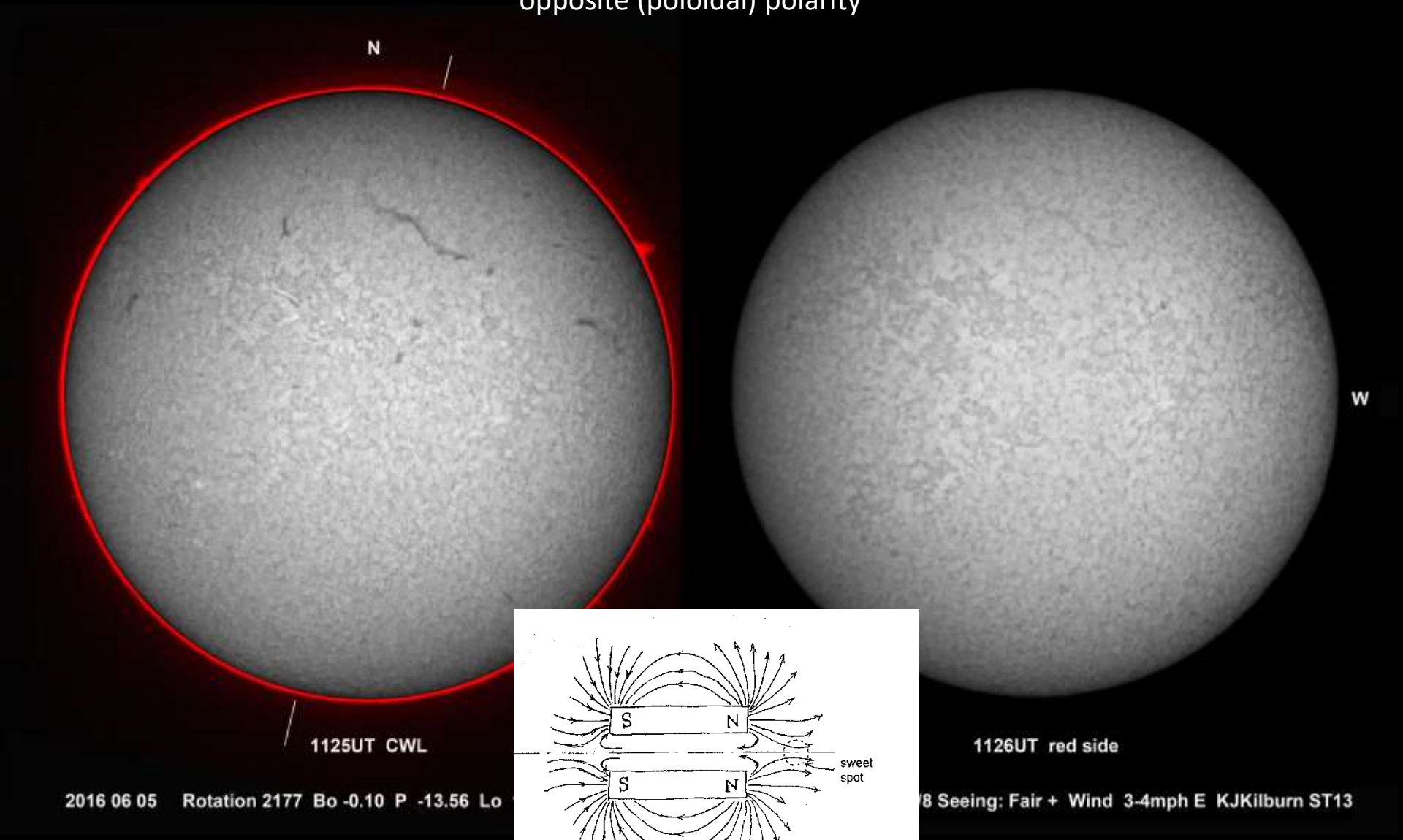
…and another in the S. hemisphere a month later


N
W
2016 05 16 1510UT
Rotation 2177
Bo -2.45
P -20.39
Lo 272.8
LS60Tx2 Canon550D
Trans: Excellent 1/8
Seeing: Fair ++
Wind: 2-3mph NNW
KJKilburn ST13

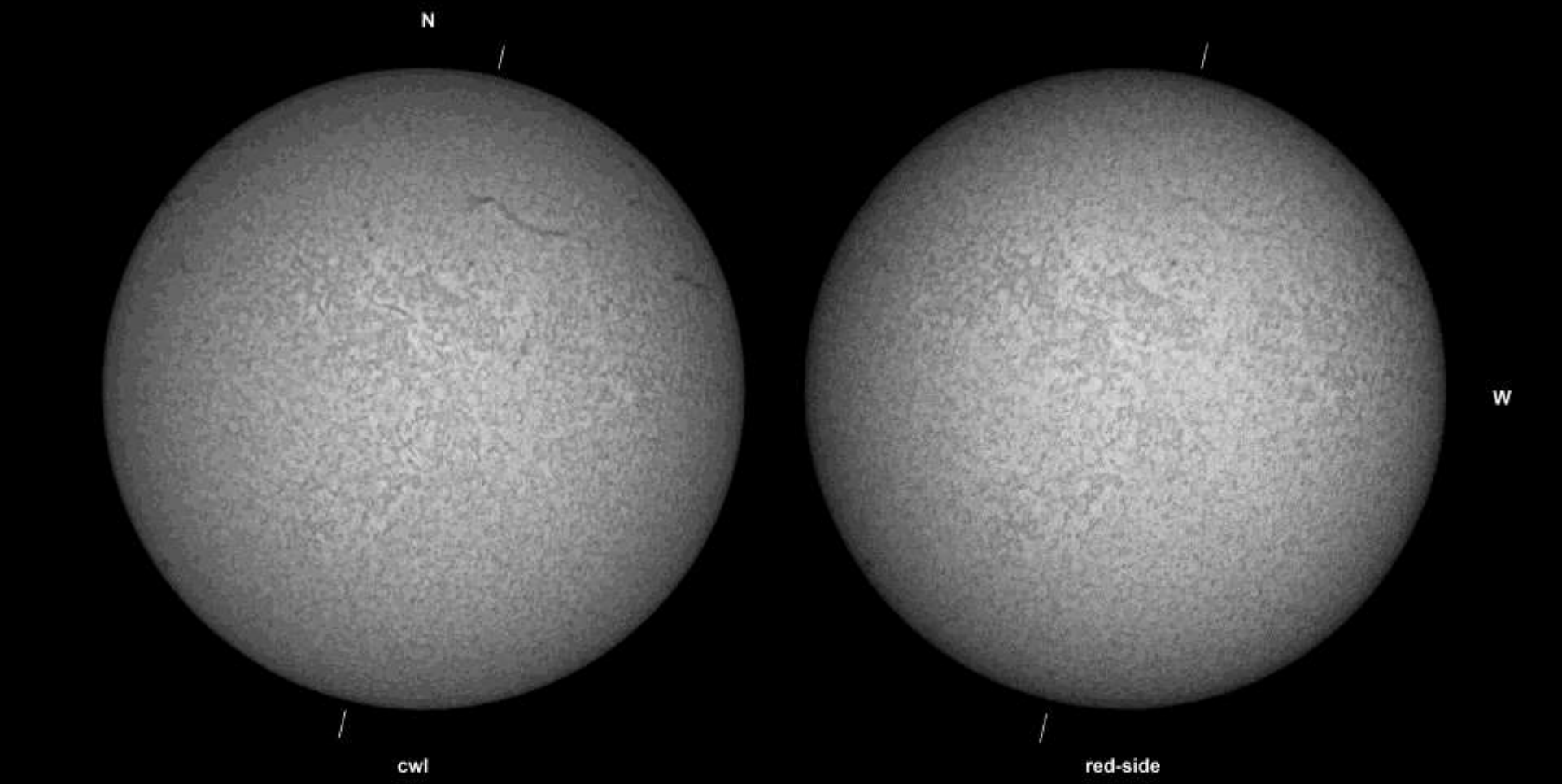

N
W
2016 05 17 1130UT
Rotation 2177
Bo -2.35
P -20.15
Lo 261.6
PSTx2 Canon550D
Trans: Excellent 4 octa
Seeing: Fair ++
Wind: 6-10mph SSW
KJKilburn ST13


N
W
2016 05 18 1519UT
Rotation 2177
Bo -2.22
P -19.80
Lo 246.2
LS60Tx2 Canon550D
Trans: Excellent 4 octa
Seeing: Good
Wind: 4mph NW
KJKilburn ST13

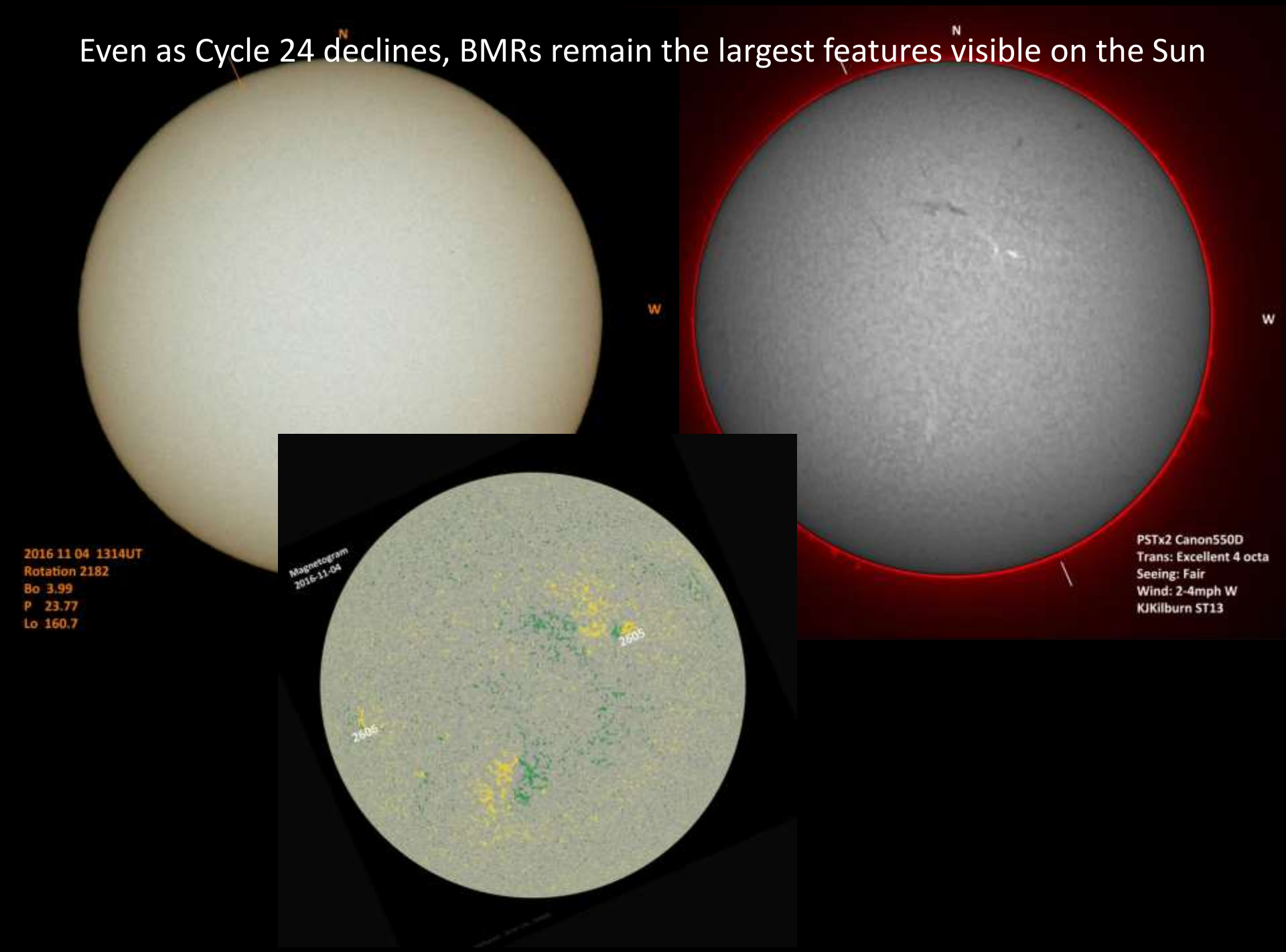
Weakening BMRs migrate poleward until they squash against polar magnetic fields thus giving rise to filament polar crowns. Tightening toroidal field lines, cancel each other and a new cycle begins; with opposite (poloidal) polarity



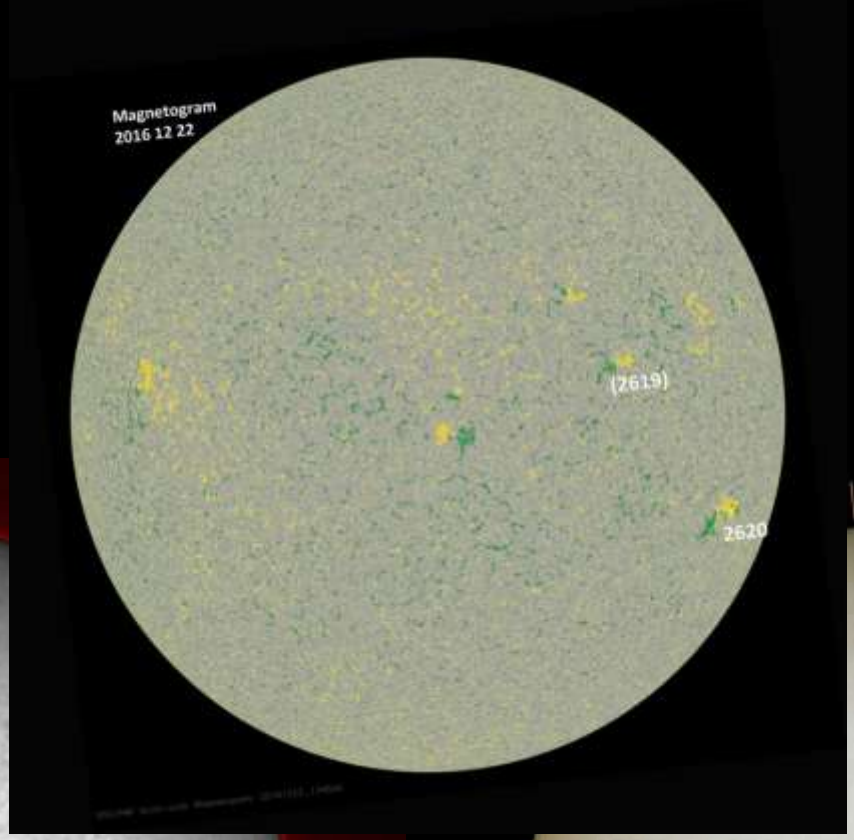
All the main H-a features described by Babcock have been observed since 2015; but it was necessary to observe in H-alpha both on-CWL and in the red-side CWL wing to get a fuller picture and appreciation of different features caused by BMRs

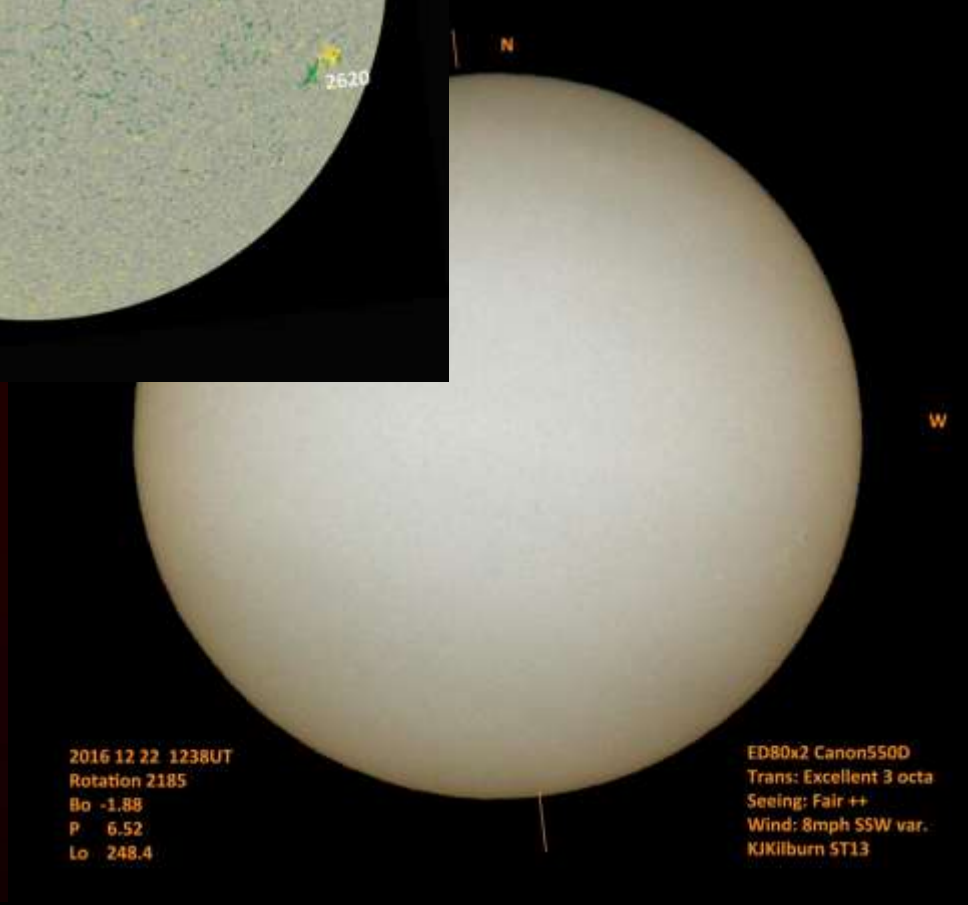


Even as Cycle 24 declines, BMRs remain the largest features visible on the Sun

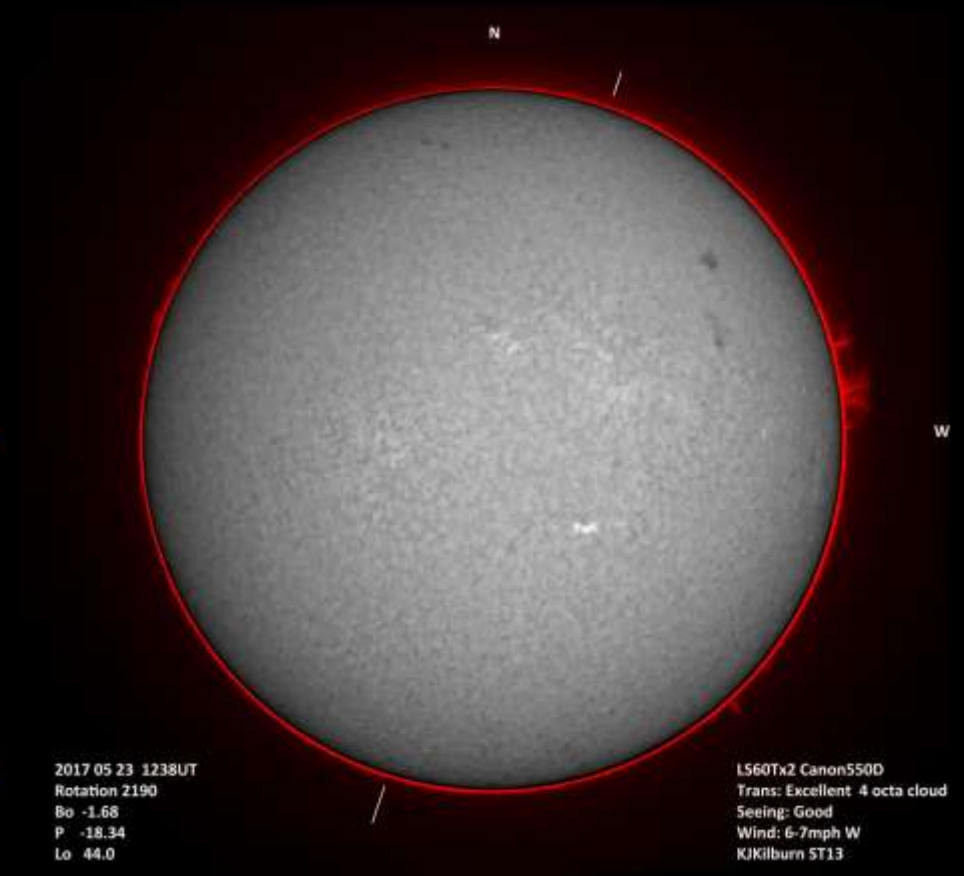


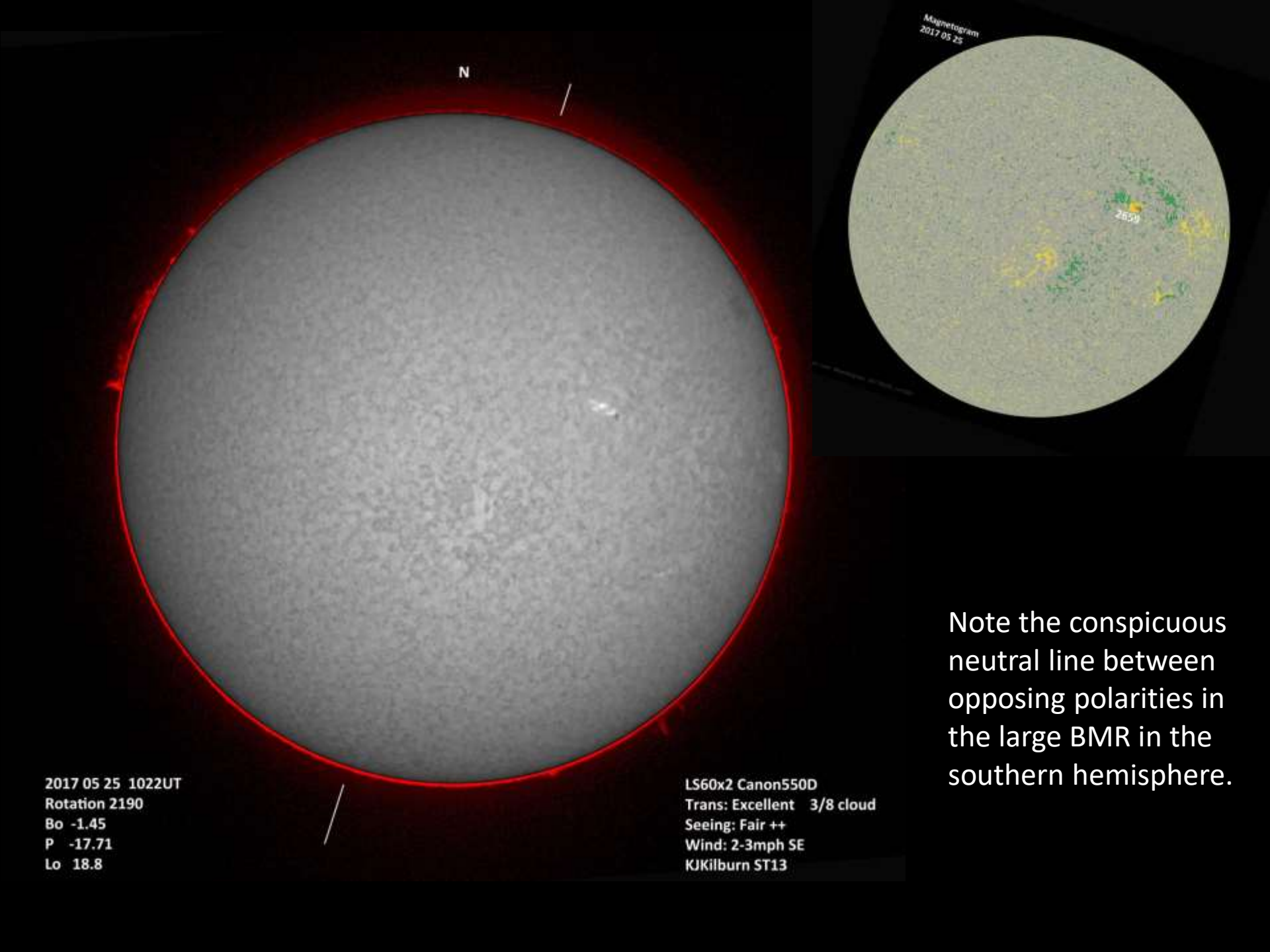
Observing BMRs shows us new things about our quirky star. Note AR2620's reversed polarity



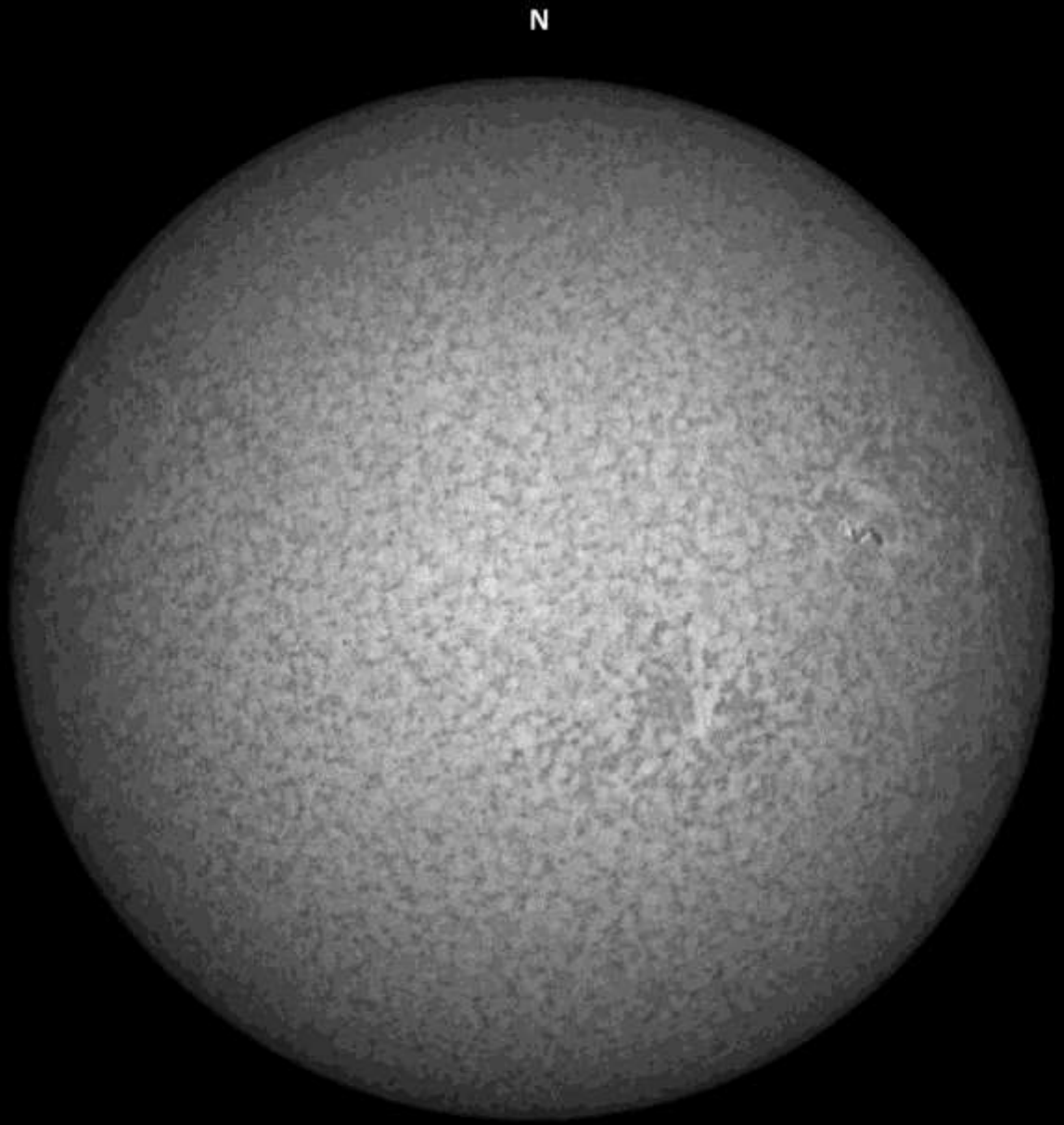


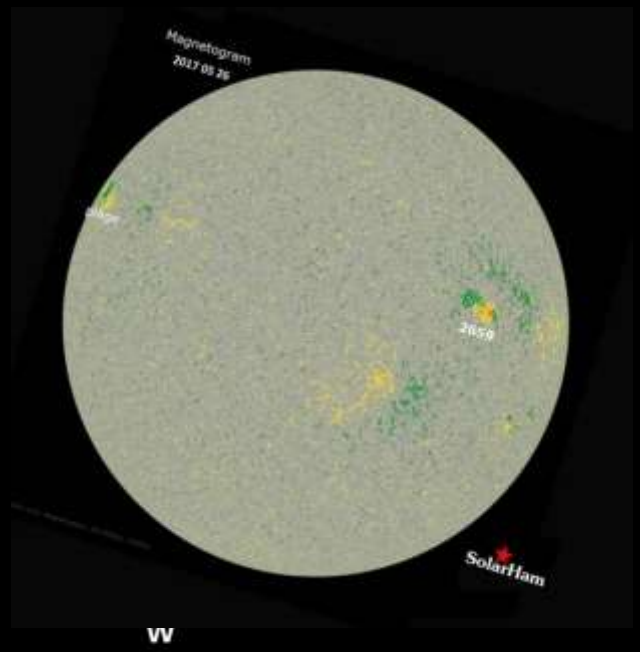
Recent images





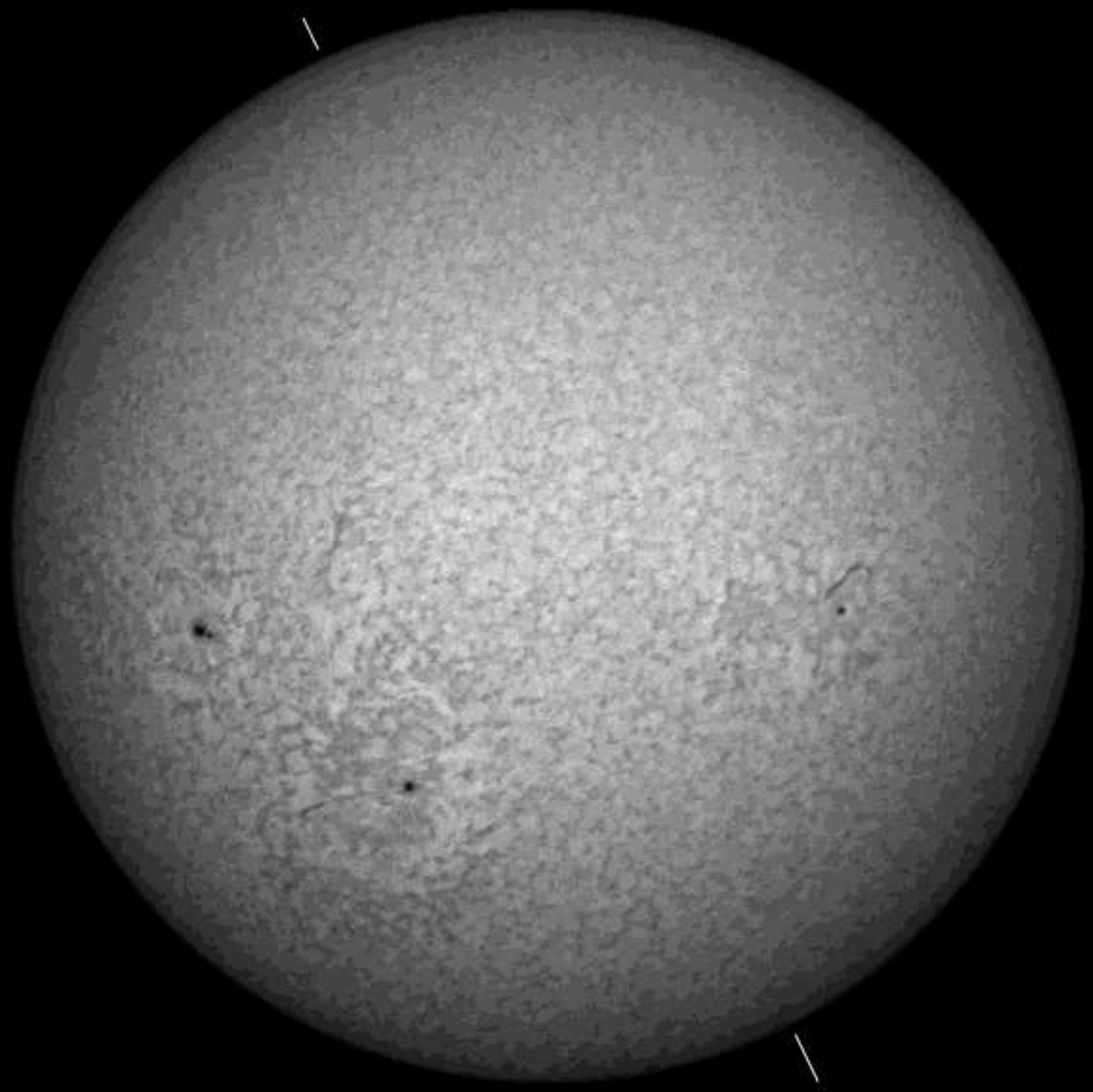
Note the conspicuous neutral line between opposing polarities in the large BMR in the southern hemisphere.



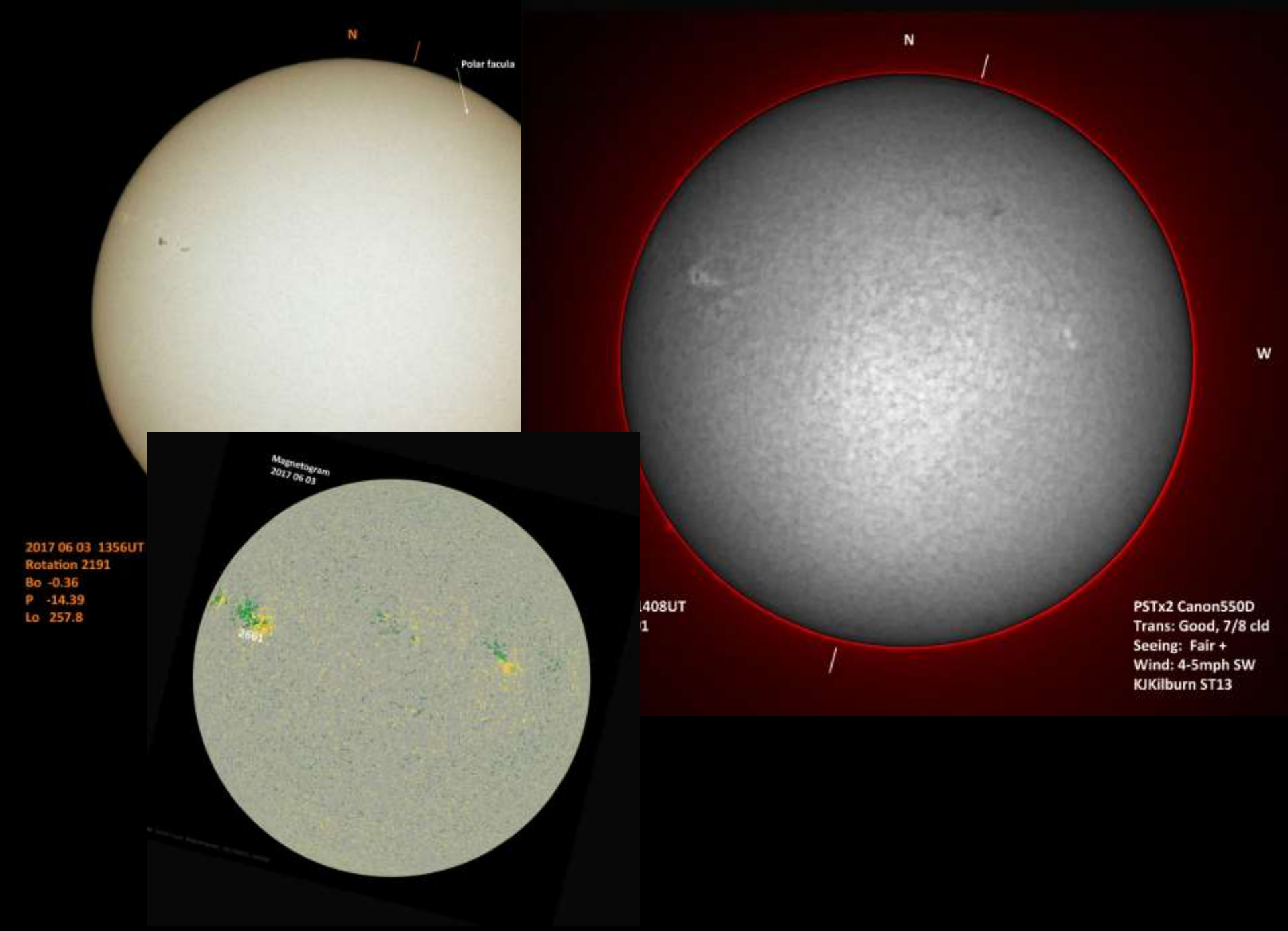


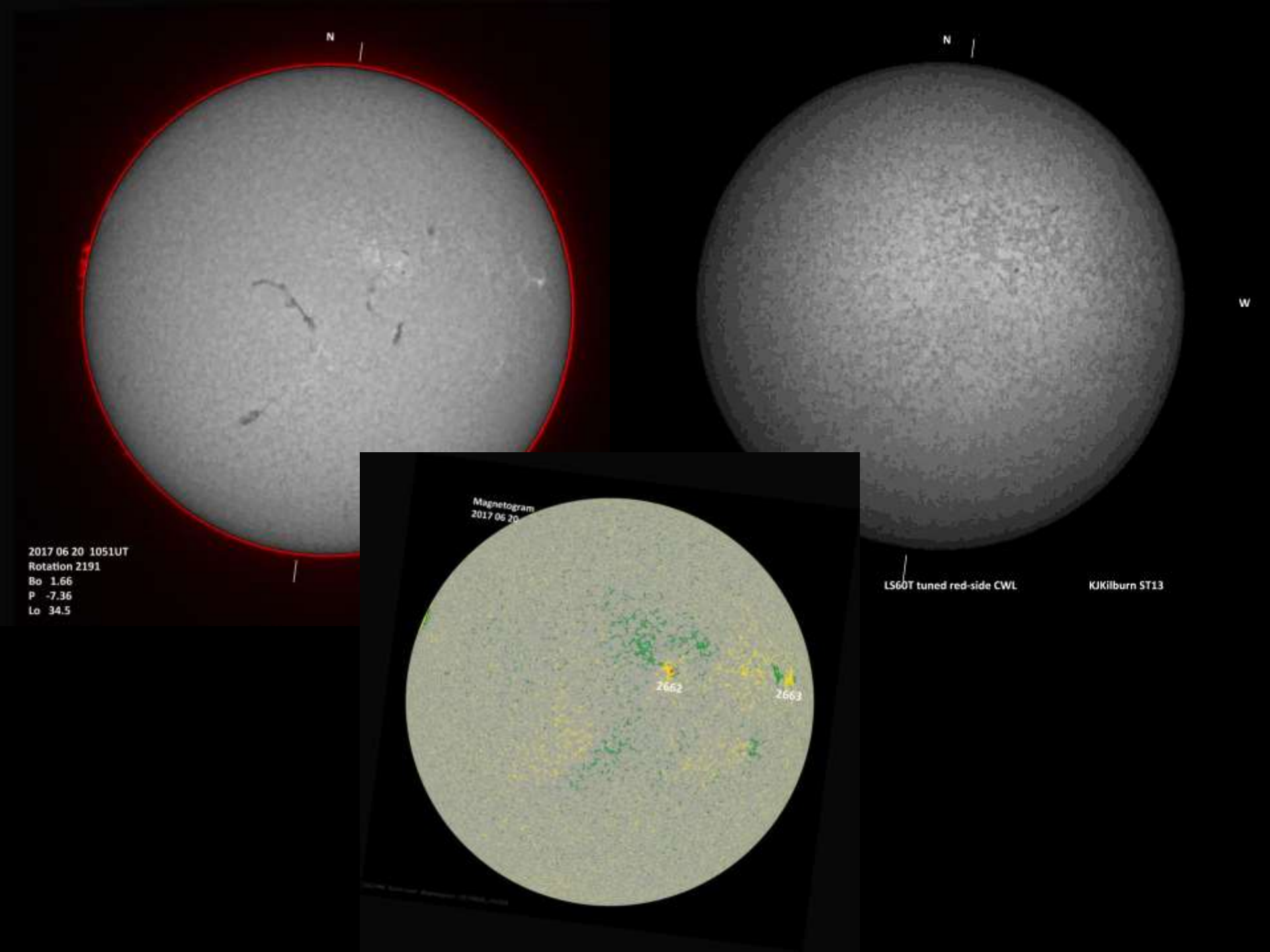
2017 05 26 1044UT LS60T tuned red-side CWL KJKIlburn ST13

Even as Cycle 24 declines, BMRs remain the largest features visible on the Sun…with or without white light sunspots.



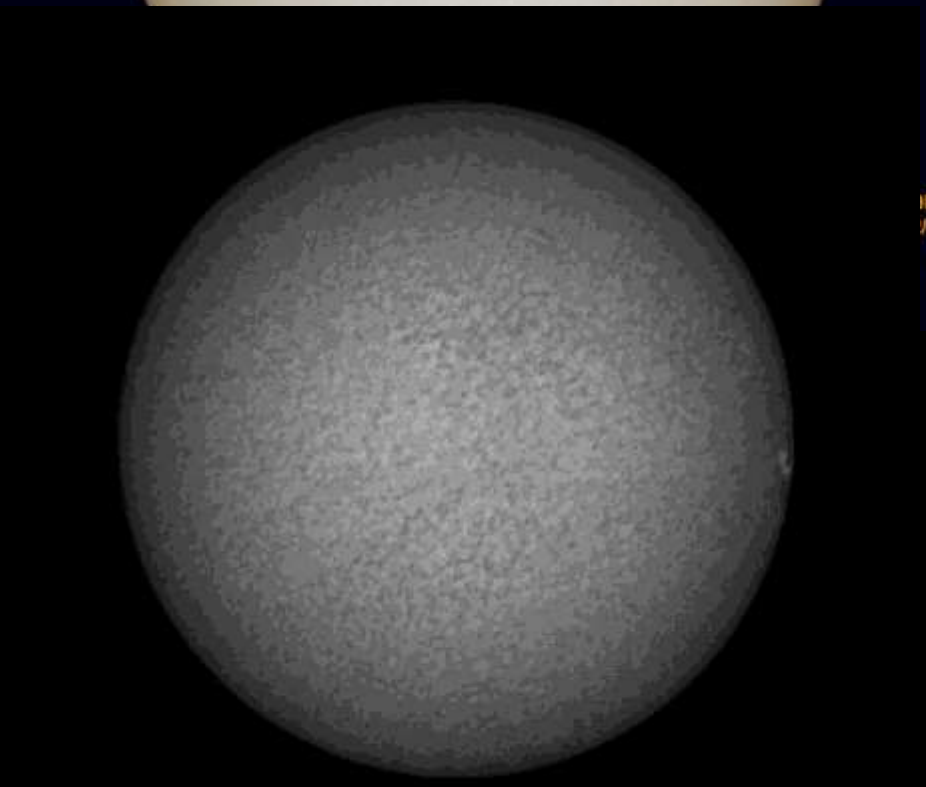
2017 09 28 1121UT LS60T tuned red-side CWL KJKilburn ST13

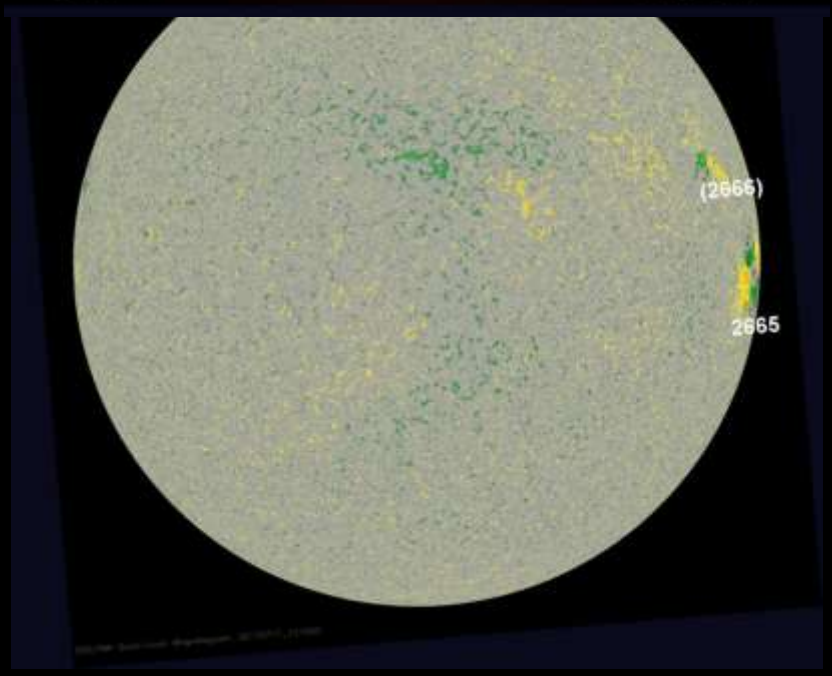

N
Polar facula
N
W
Magnetogram
2017 06 03
2661
2017 06 03 1356UT
Rotation 2191
Bo -0.36
P -14.39
Lo 257.8
1408UT
PSTx2 Canon550D
Trans: Good, 7/8 cld
Seeing: Fair +
Wind: 4-5mph SW
KJKilburn ST13

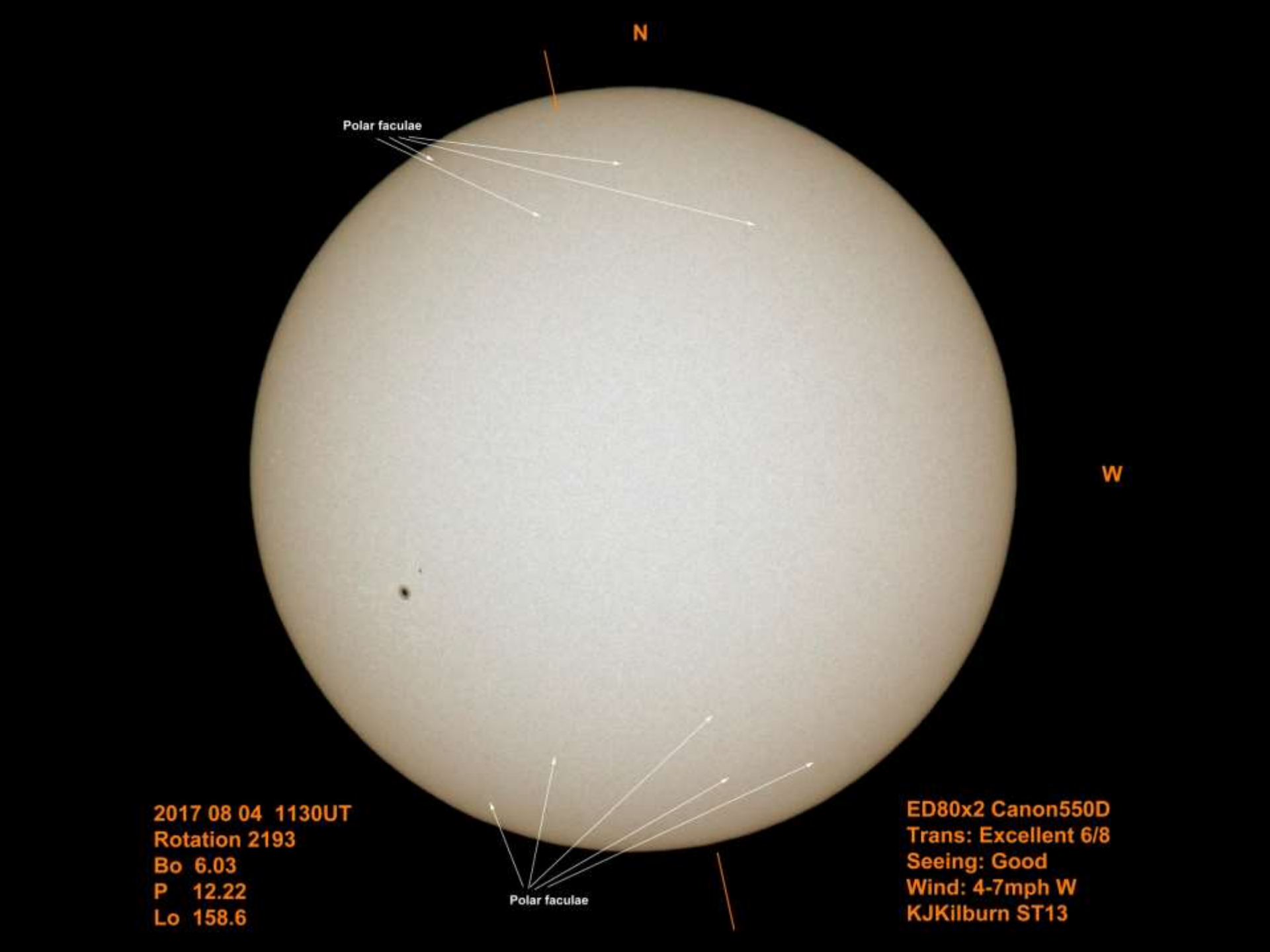

N
N
W
2017 06 20 1051UT
Rotation 2191
Bo 1.66
P -7.36
Lo 34.5
Magnetogram
2017 06 20
2662
2663
LS60T tuned red-side CWL
KJKilburn ST13


N
W


N
W
2017 07 17 1103UT
Rotation 2192
Bo 4.56
P 4.77
Lo 37.0
LS60Tx2 Canon550D
Thrans: Excellent 2/8
Seeing: Good
Wind: 5mph WSW
KJKIlburn ST13

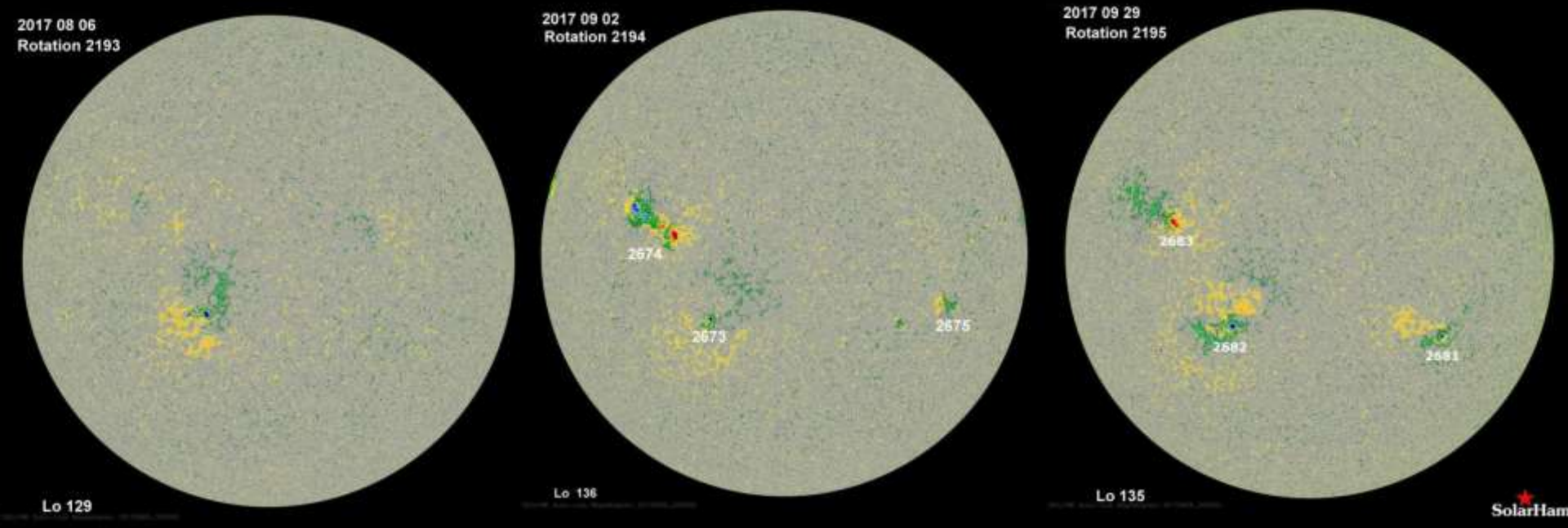

2017 07 17 1104UT
LS60T tuned red-side CWL
KJKIlburn ST13


(2666)
2665


N
W
Polar faculae
Polar faculae
2017 08 04 1130UT
Rotation 2193
Bo 6.03
P 12.22
Lo 158.6
ED80x2 Canon550D
Trans: Excellent 6/8
Seeing: Good
Wind: 4-7mph W
KJKilburn ST13


N
W
2017 08 04 1408UT
Rotation 2193
Bo 6.03
P 12.26
Lo 157.2
2017 08 04 1410UT
LS60T tuned red-side
Magnetogram
2017 08 04
2670

BMRs can persist for more than one solar rotation

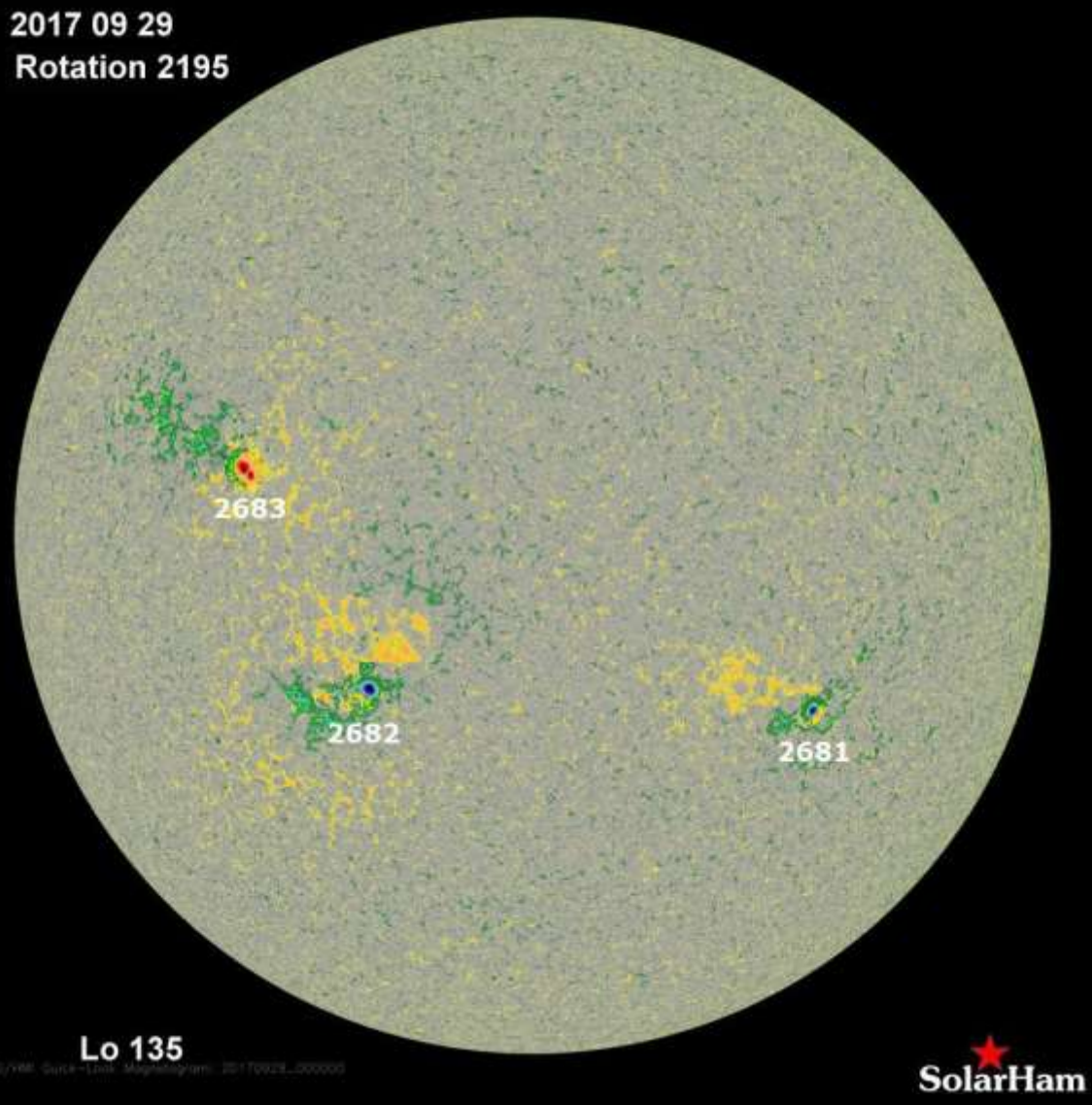


During the lifetime of a typical amateur solar observer (I'm 67) the 11yr solar cycle is quite a long time; a 22yr cycle may not be survivable but I'm on the case!

My to do list

- Take higher-resolution, stacked video, images of spicules in BMRs
- Monitor short term (hourly) changes to supergranulation structures in BMRs via hi-res monochrome video imaging
- Watch and record how BMRs change as Cycle 24 winds down towards 2019-2020 and Cycle 25 commences
- Monitor exactly when sunspots start to form in Cycle 25
- Watch how Cycle 25 evolves
- Learn, for my own interest and BAA , a fuller understanding of how BMRs affect the development of sunspots and associated features.

…and next week monitor ongoing activity in the BMR associated with AR2682 !



References:

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- Mt Wilson and Palomar Observatories, 1955 SAO/NASA Astrophysical Data System http://adswww.harvard.edu/

- *The Topology of the Sun's Magnetic Field and the 22-year Cycle*. Horace W Babcock
- Mt Wilson and Palomar Observatories, 1961. Available from SAO/NASA Astrophysical Data System

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THANK YOU

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