XVIth Hvar Astrophysical Colloquium
International Study of Earth-affecting Solar Transients
ISEST 2018 Workshop
24 - 28 September 2018, Hvar, Croatia

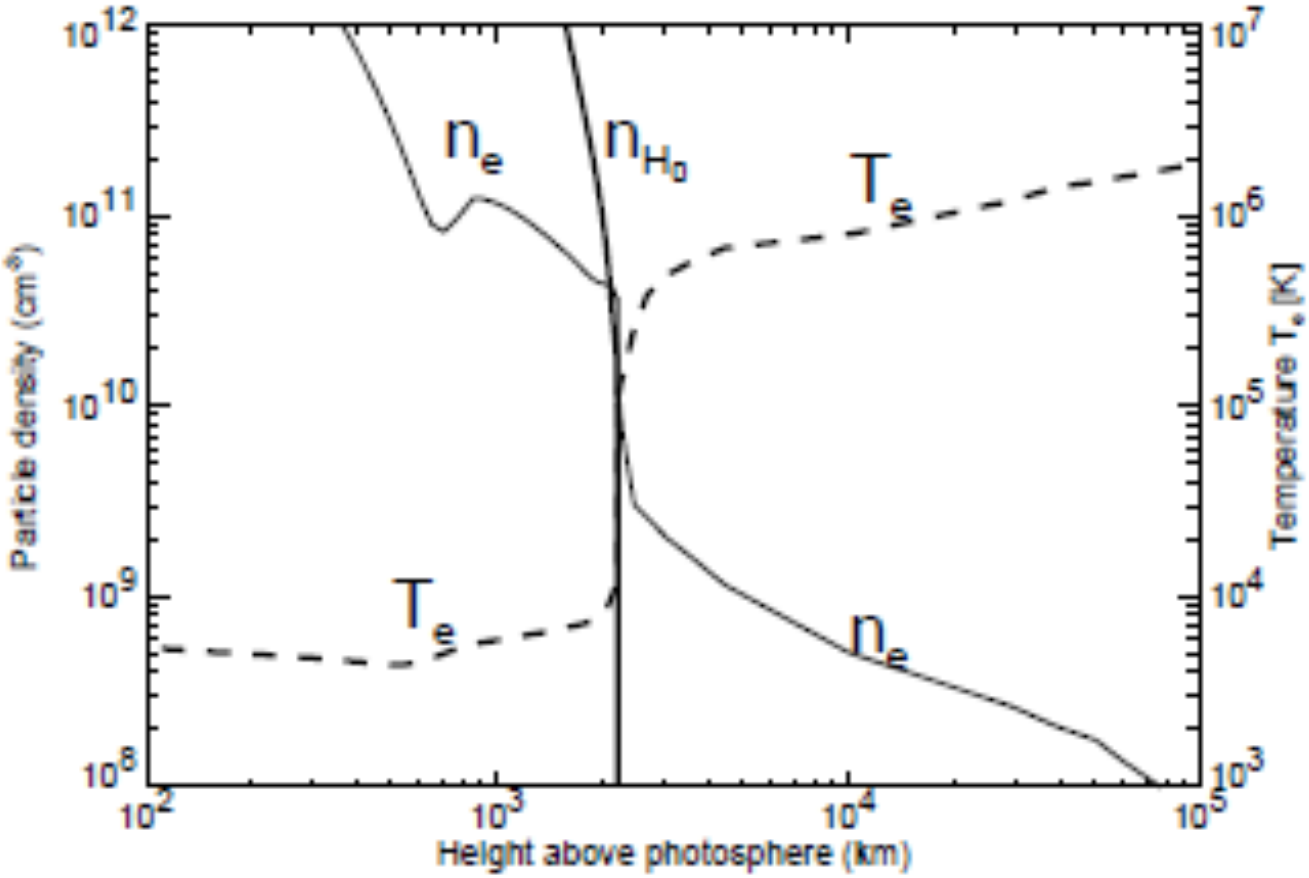
Features of spectral-polarization dynamics of flare active regions by microwave observations

Tatiana Kaltman, Vladimir Bogod, Anton Storozhenko

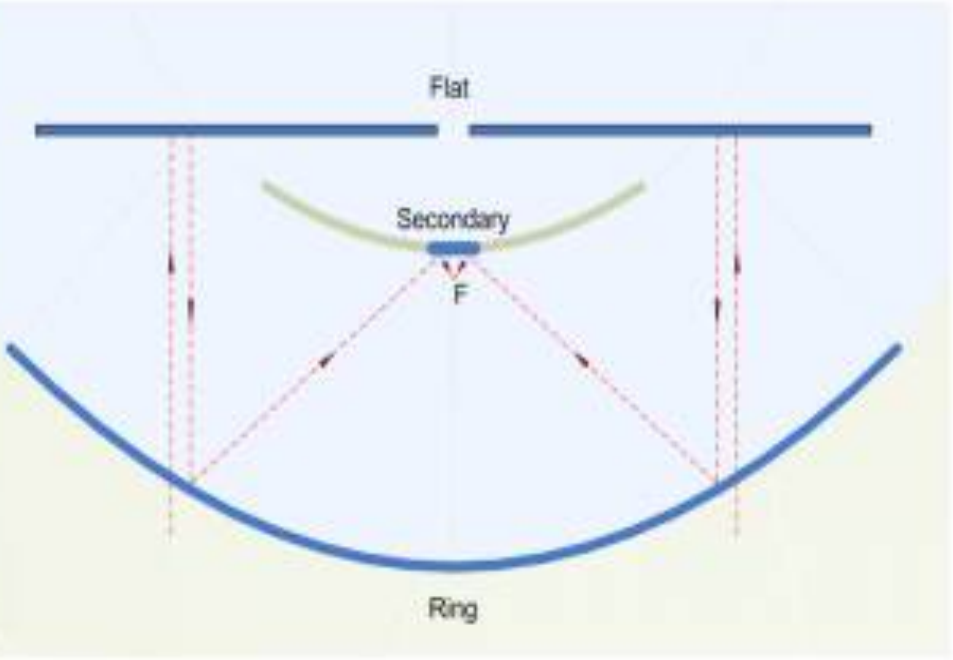
Russian Academy of Sciences
Special
Astrophysical Observatory

Radio astronomical methods are important tools for the study of the solar atmosphere because they provide the data about the parameters of active plasma over a wide range of heights that are difficult to probe using other methods.

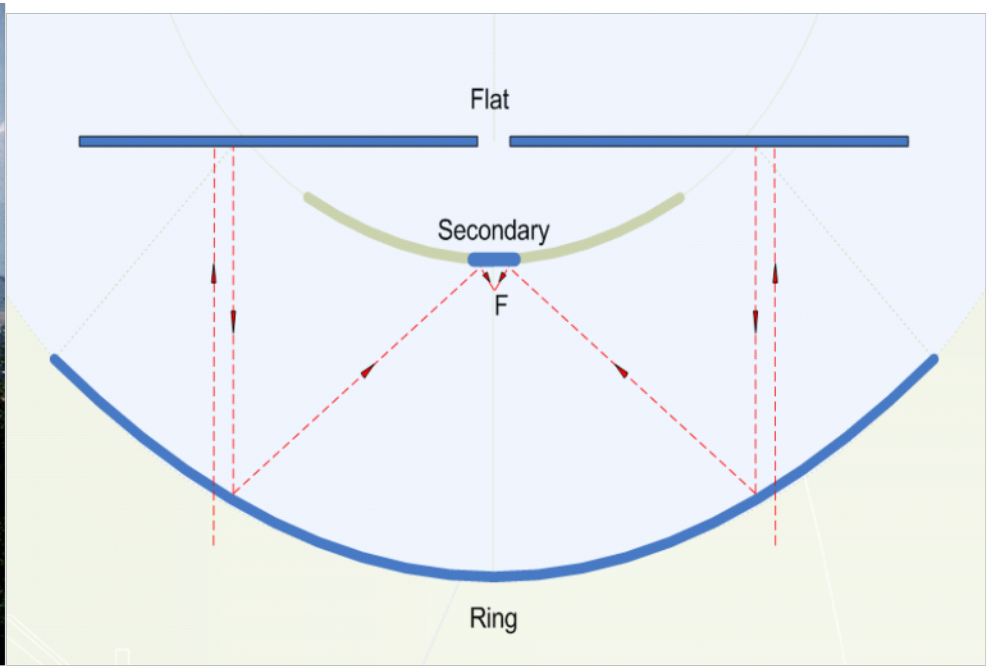
The radio emission of the chromosphere can be observed at mm-wave frequencies, whereas the transition region between the chromosphere and the corona and the lower corona radiate efficiently at centimeter- and decimeter-wave frequencies.



. Electron density and temperature model of the chromosphere (Fontenla et al. 1990; Model FAL-C) and lower corona (Gabriel, 1976).



PARAMETERS	range	resolution
Spectral	0.76-18 GHz	1%
Spatial		~15 arcsec x 17 arcmin at 18GHz
Temporal	7-11 UT	4 min cadence, 61 scans
Other parameters:		
Circular polarization accuracy of measurement		0.1%
Flux sensitivity		0.01 s.f.u.



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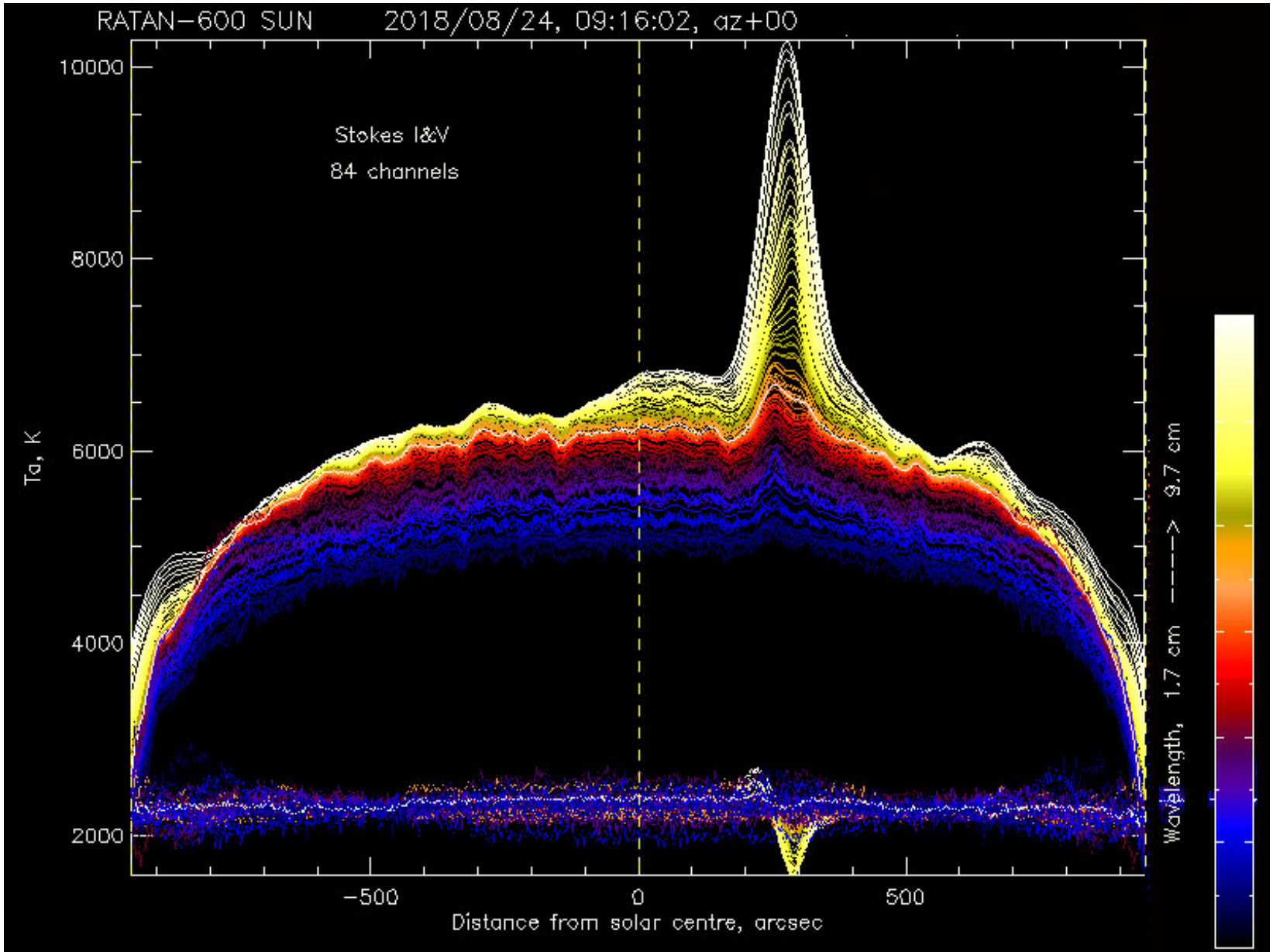
The RATAN-600 archive containing solar data starting from 1997

is available on site http://www.spbf.sao.ru

9-13 UT in the range from 1.67 cm up to 32 cm with left and right circular polarization

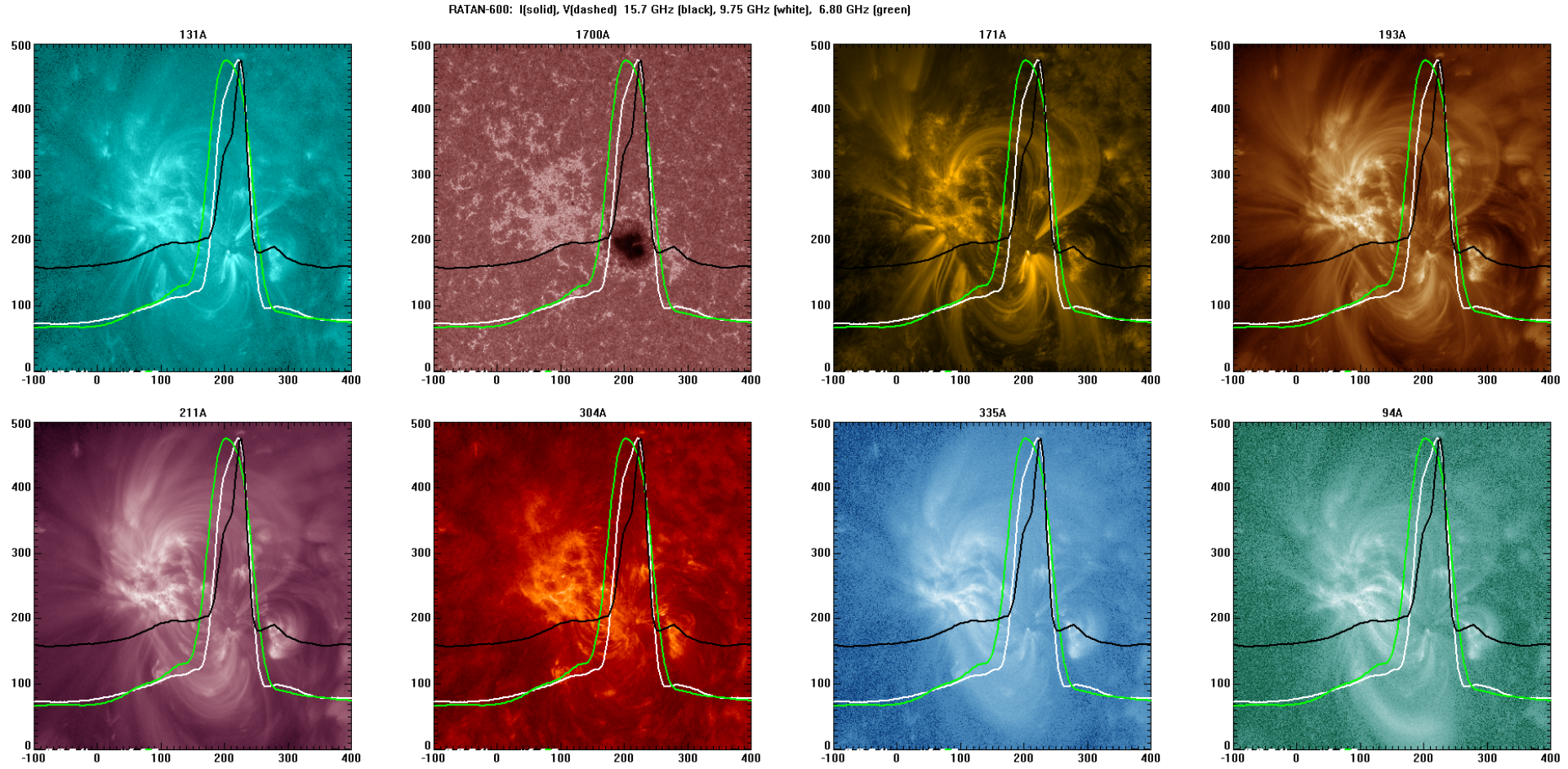


The composition of the active regions magnetosphere:

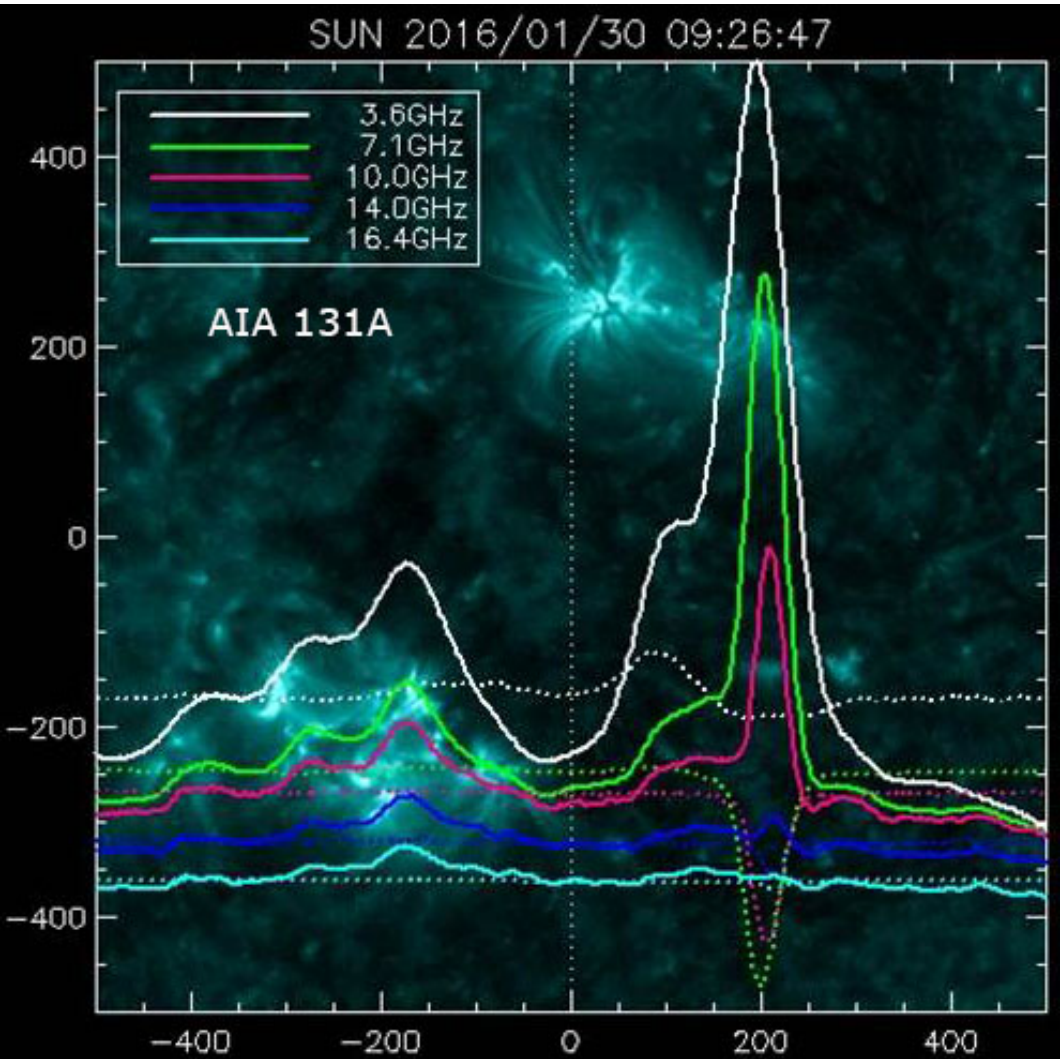
Plage - increased brightness over the chromospheric flocculus

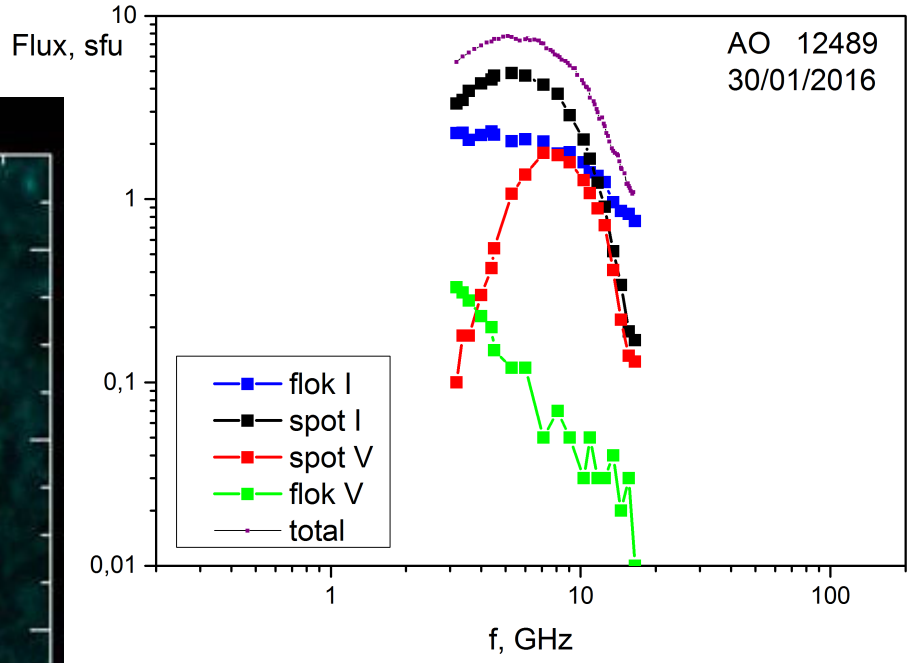
Spot component - over local areas of strong magnetic fields. which in visible light is darker than the surrounding photosphere (spots) , and in radio emission - bright polarized sources

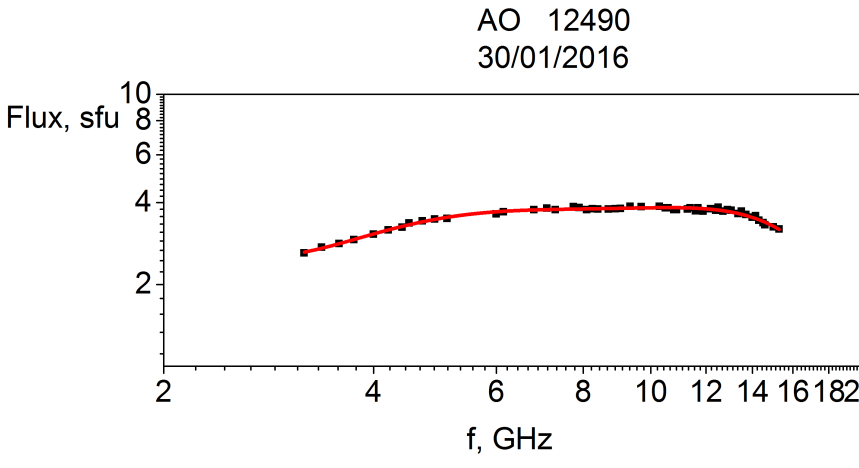
Halo - arcade of coronal loops



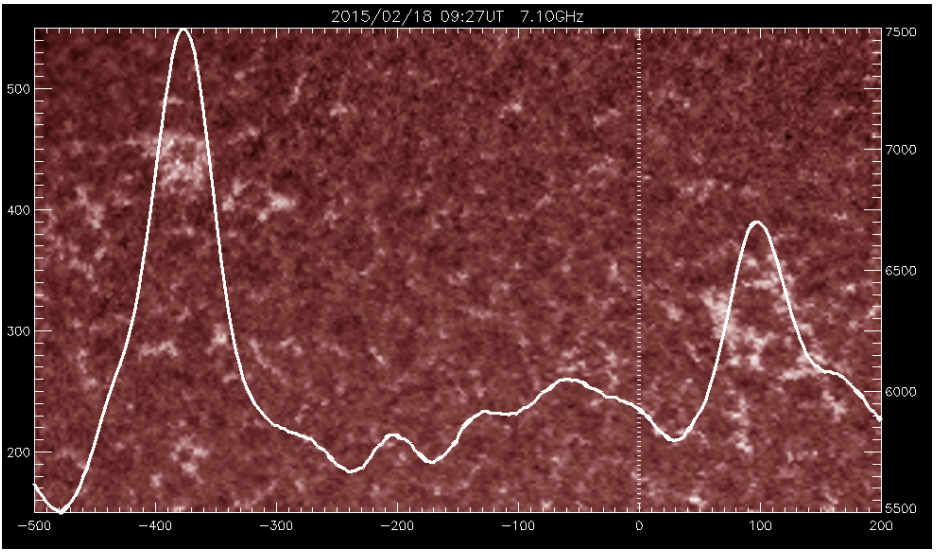
The study of the physical nature of solar active region magnetospheres by the spectrum of microwave emission

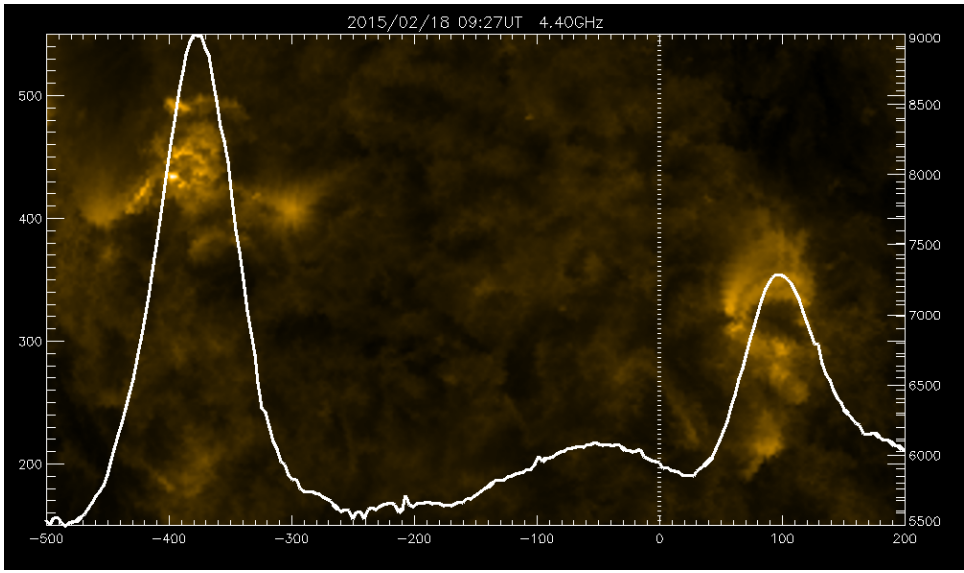






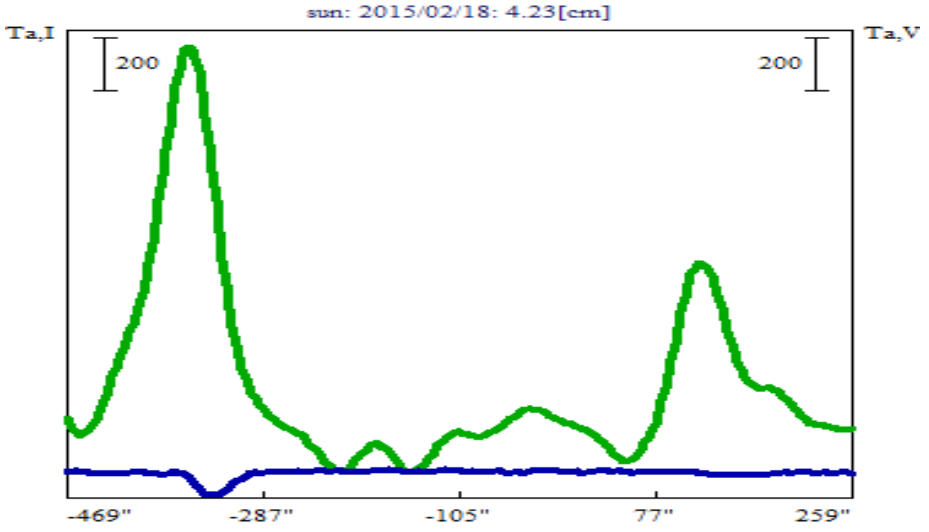
Magnetosphere with the Plage component only

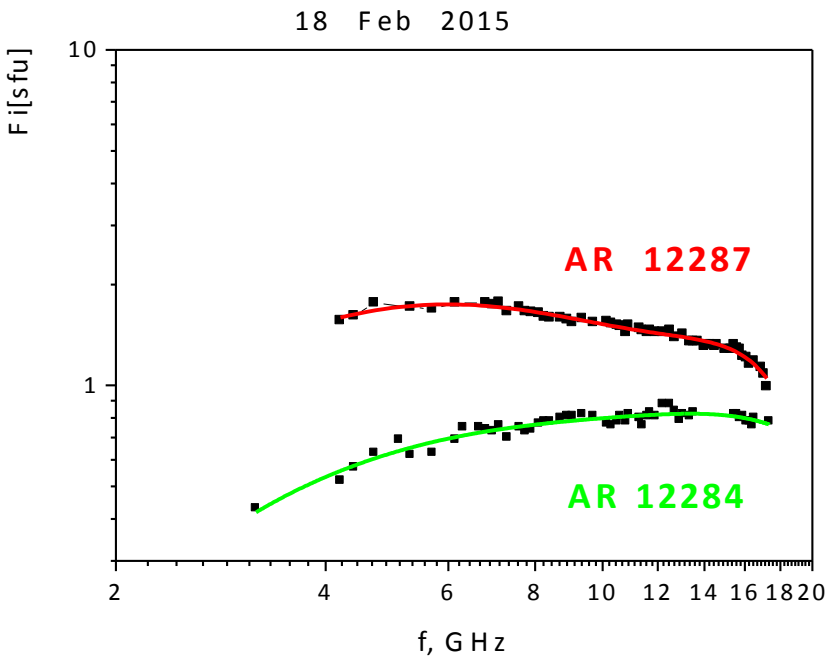


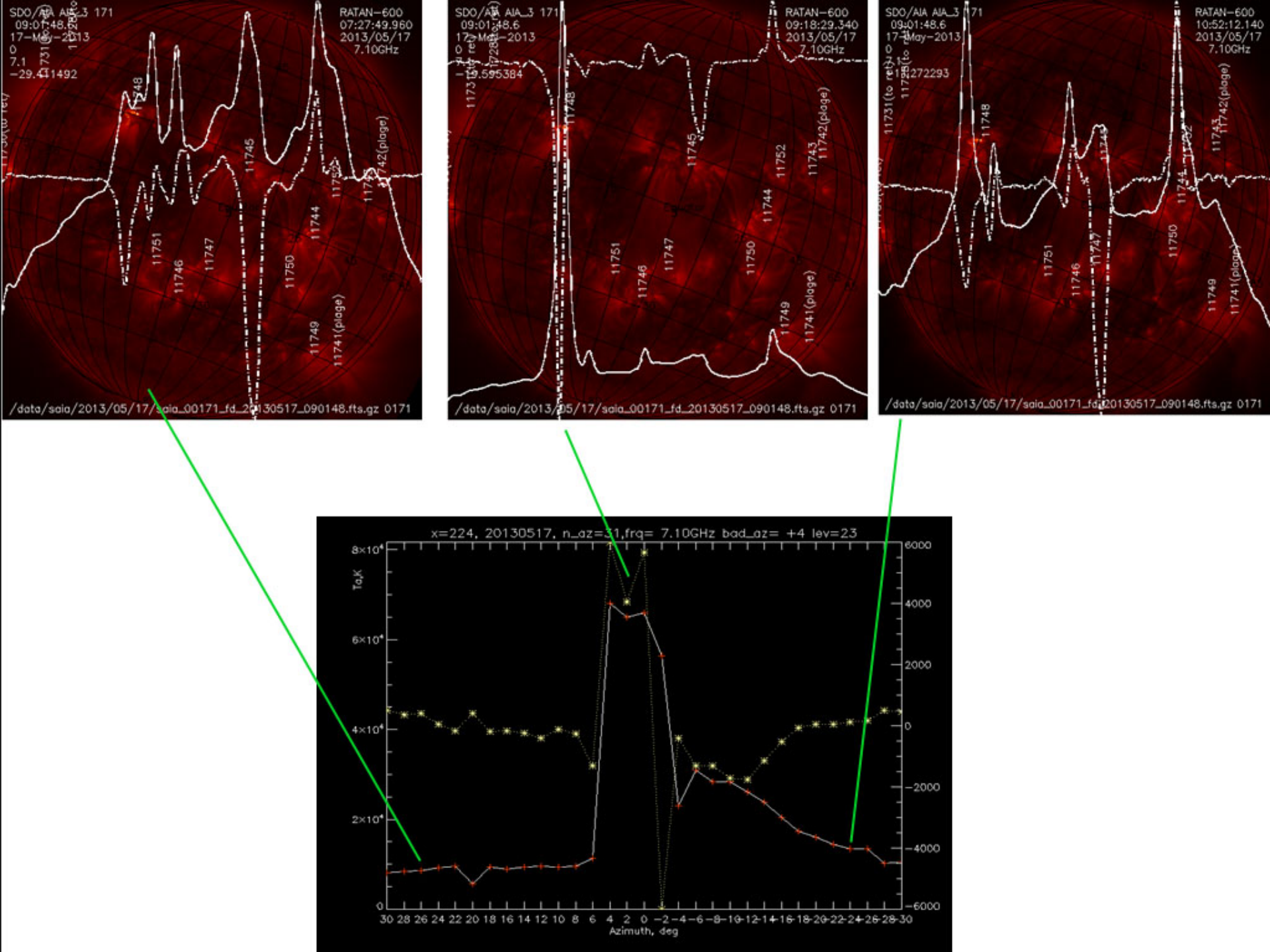


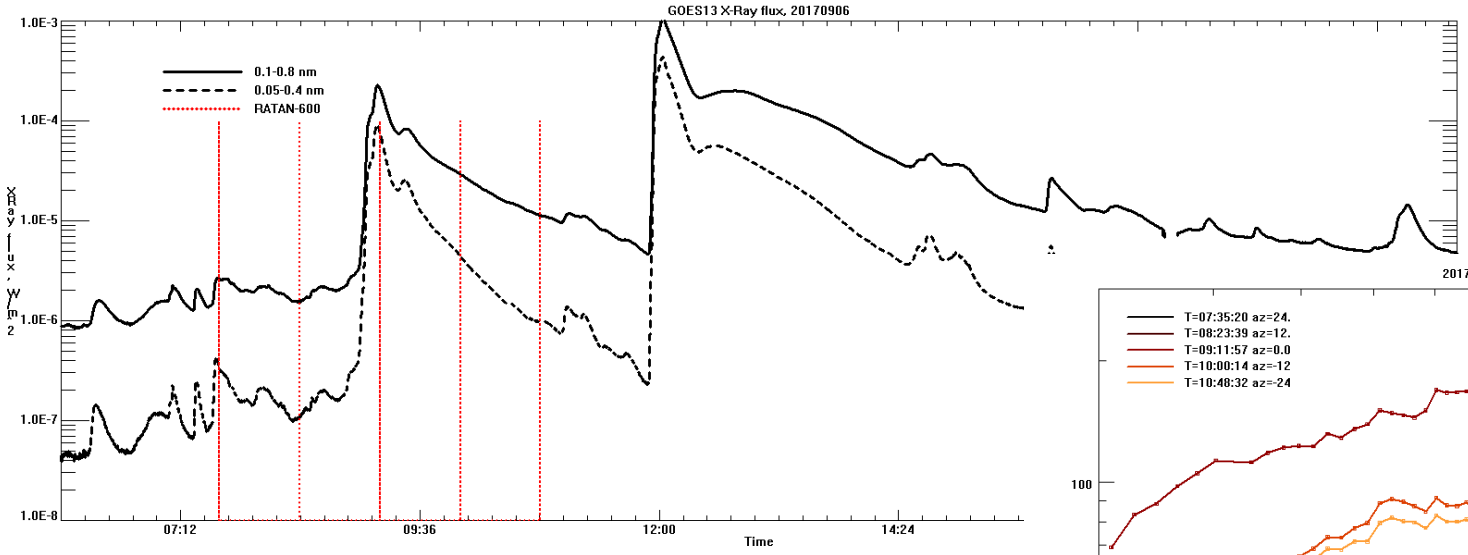
171 A, 4.4 GHz

SDO 1700 A, RATAN-600 7.1 GHz



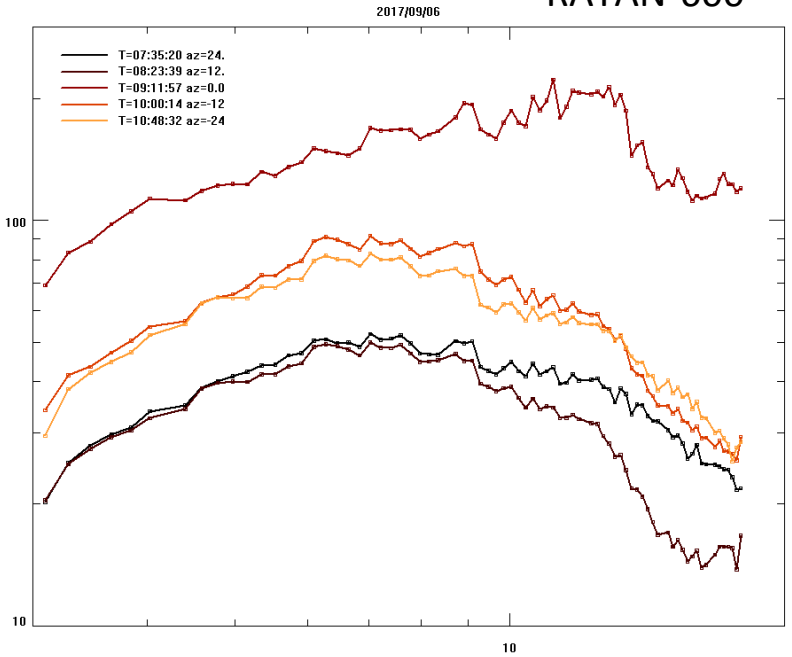


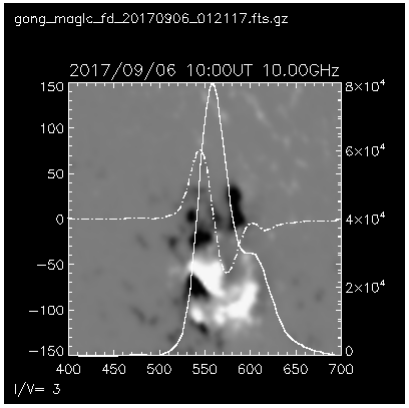

SDO/AIA AIA_3 171
09:01:48.6
17-May-2013
RATAN-600
07:27:49.960
2013/05/17
7.10GHz
RATAN-600
09:18:29.340
2013/05/17
7.10GHz
RATAN-600
10:52:12.140
2013/05/17
7.10GHz
11748
11745
11751
11746
11747
11750
11744
11752
11743
11742(plage)
11749
11741(plage)
/data/saia/2013/05/17/saia_00171_fd_20130517_090148.fts.gz 0171
x=224, 20130517, n_az=31,frq= 7.10GHz bad_az= +4 lev=23
Ta,K
Azimuth, deg

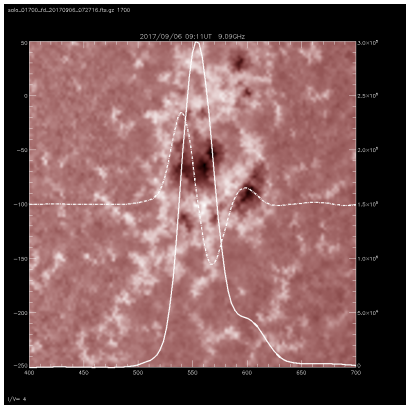


06 Sep 2017
X2.2(08:57)

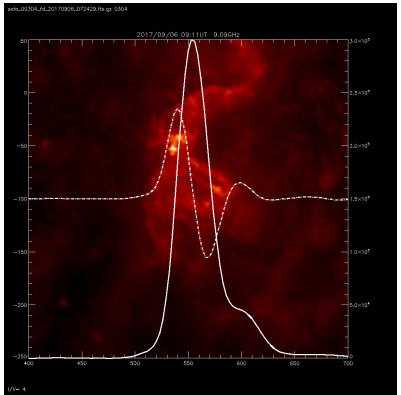
RATAN-600

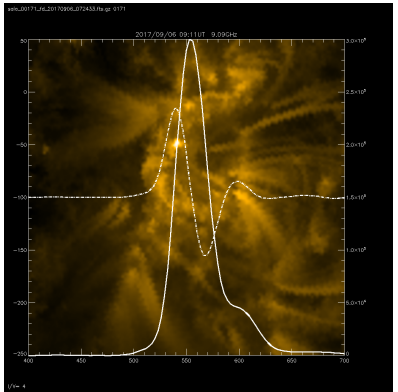




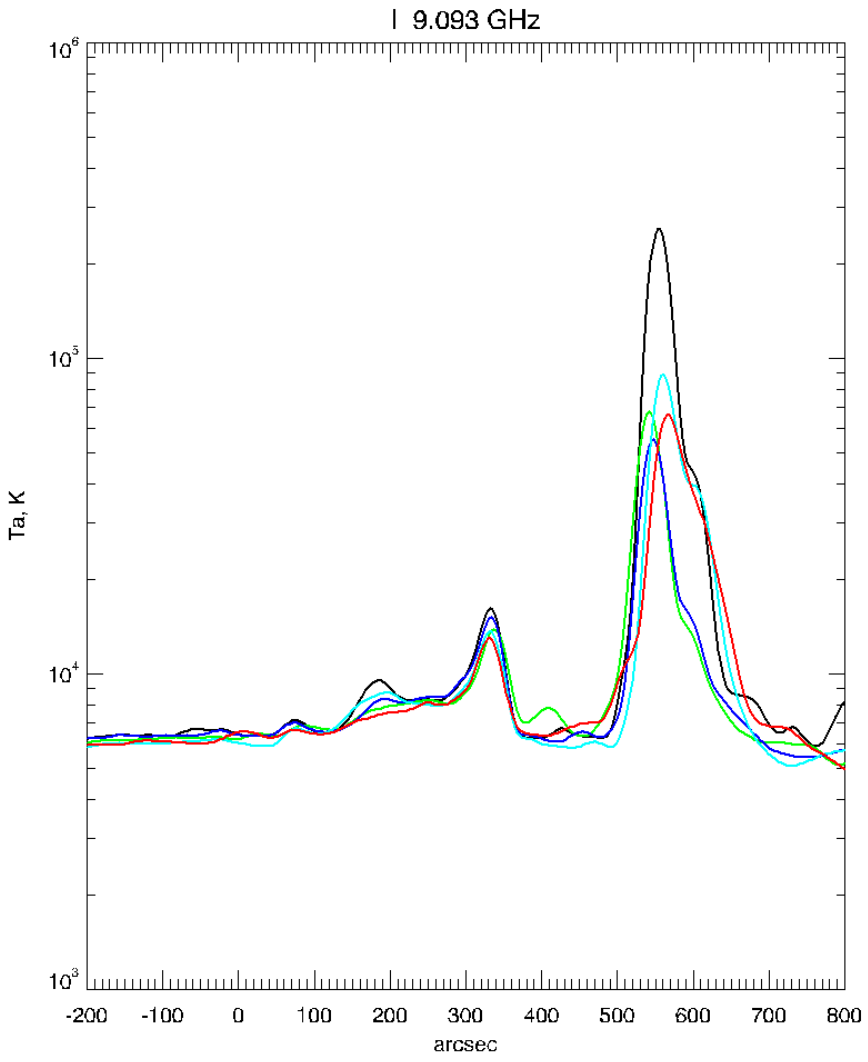


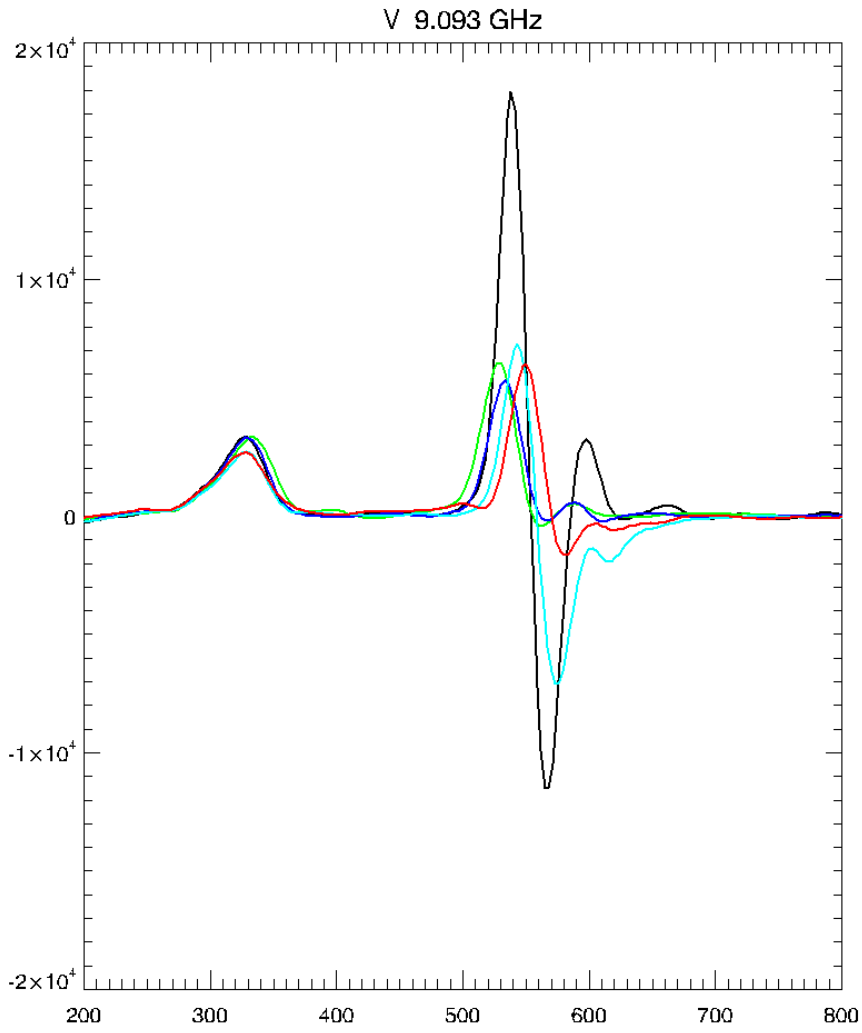
HMI
AIA 1700





AIA 304
AIA 171


I 9.093 GHz
Ta, K
arcsec


V 9.093 GHz

Changes in microwave emission of AR 12497 before and after flare M1.0 (12.02. 2016)

Event#	EName	Start	Stop	Peak	GOES Class	Derived Position
1	gev_20160212_1036	2016/02/12 10:36:00	10:53:00	10:47:00	M1.0	N11W14 (2497)

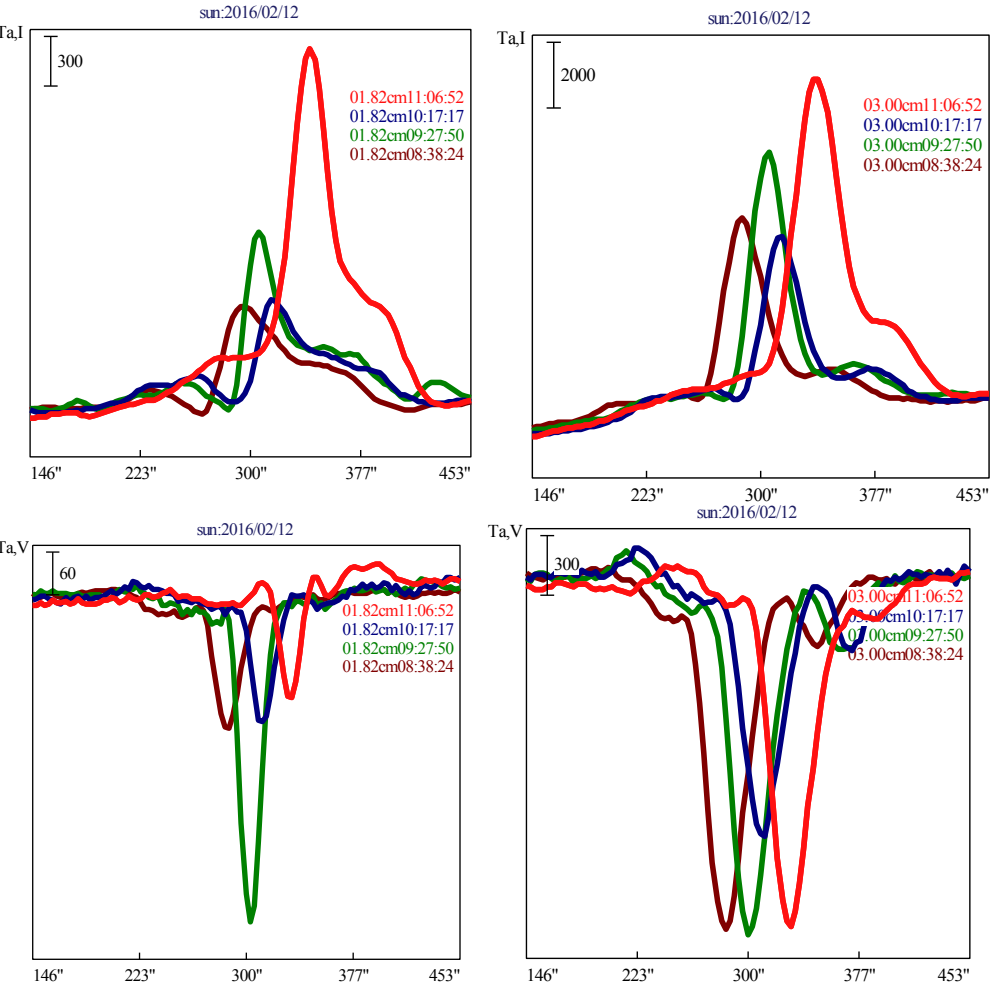


Рис. 1

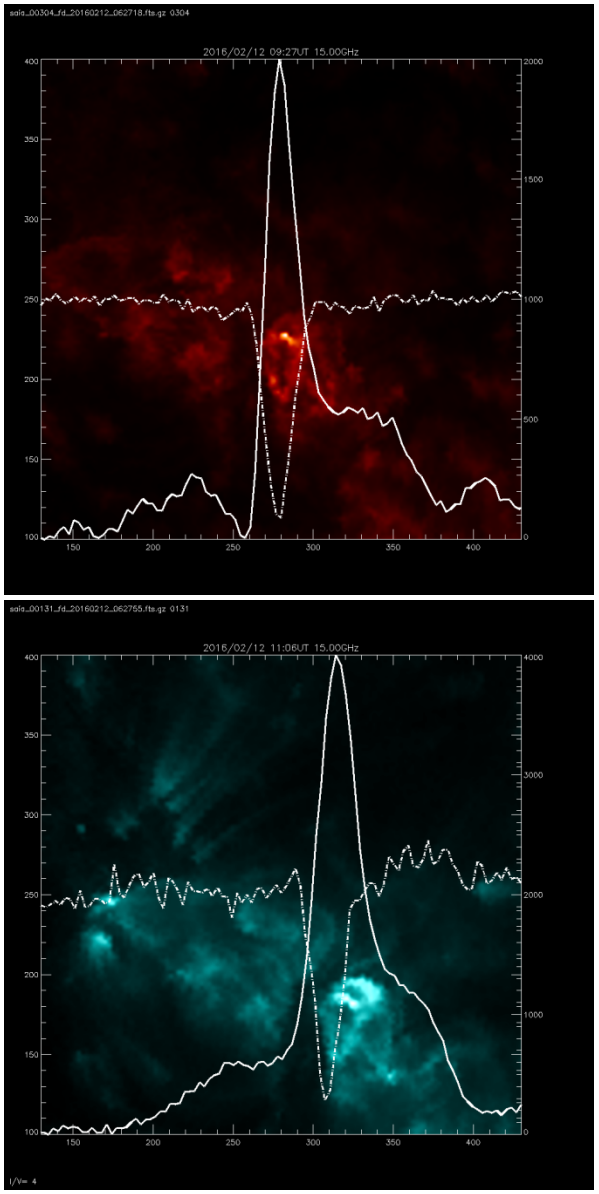


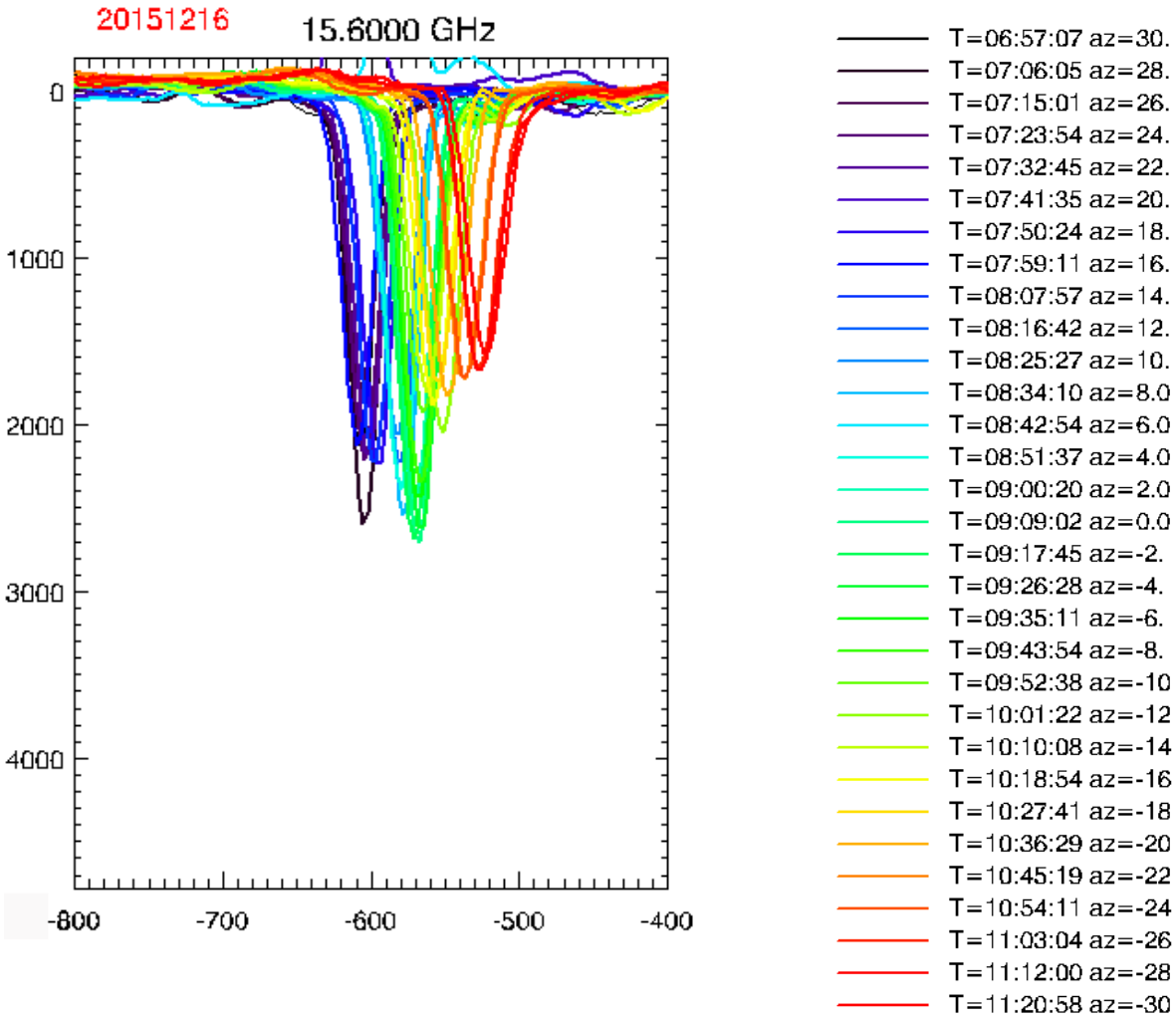
Рис. 2

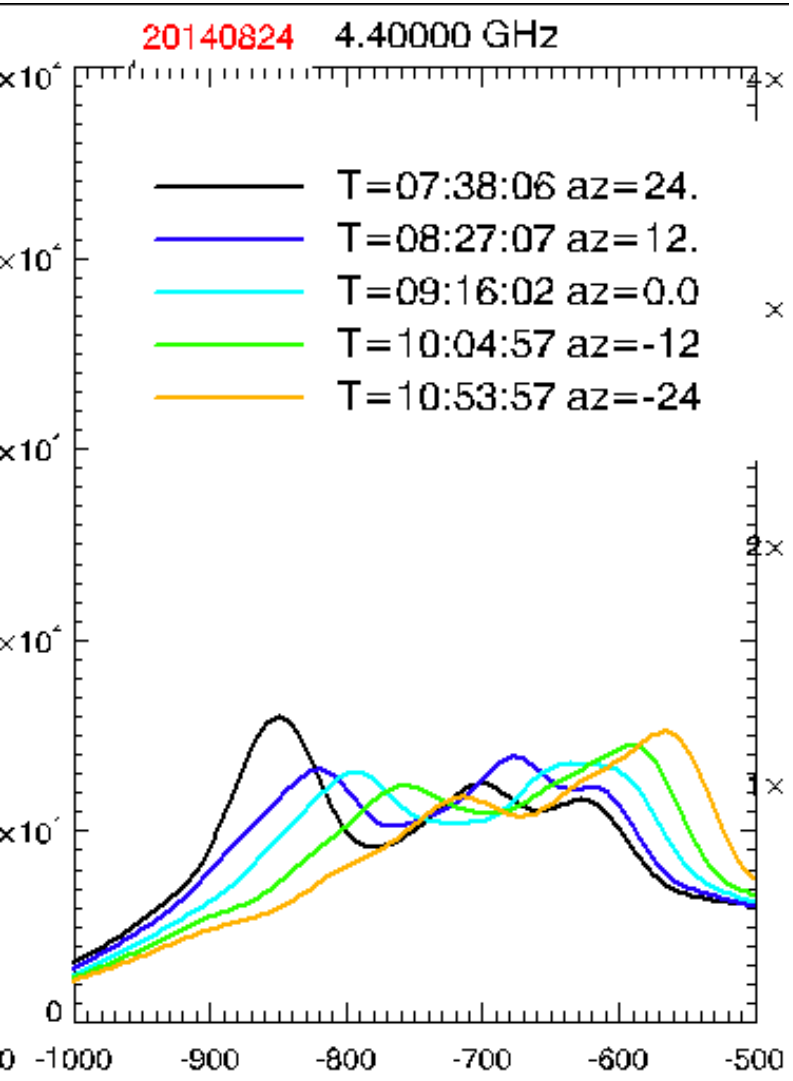
SOHO/LASCO HALO CME CATALOG

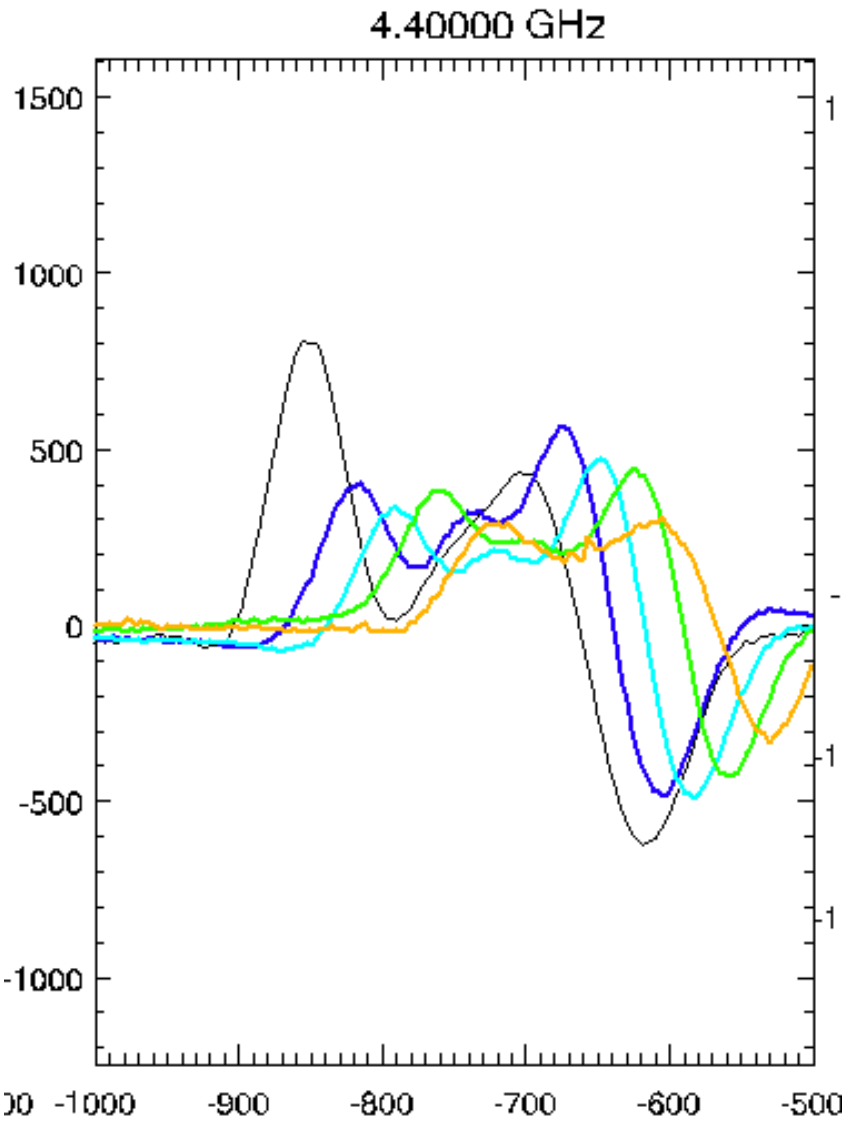
RATAN-600 CATALOG

https://cdaw.gsfc.nasa.gov/CME_list/HALO/

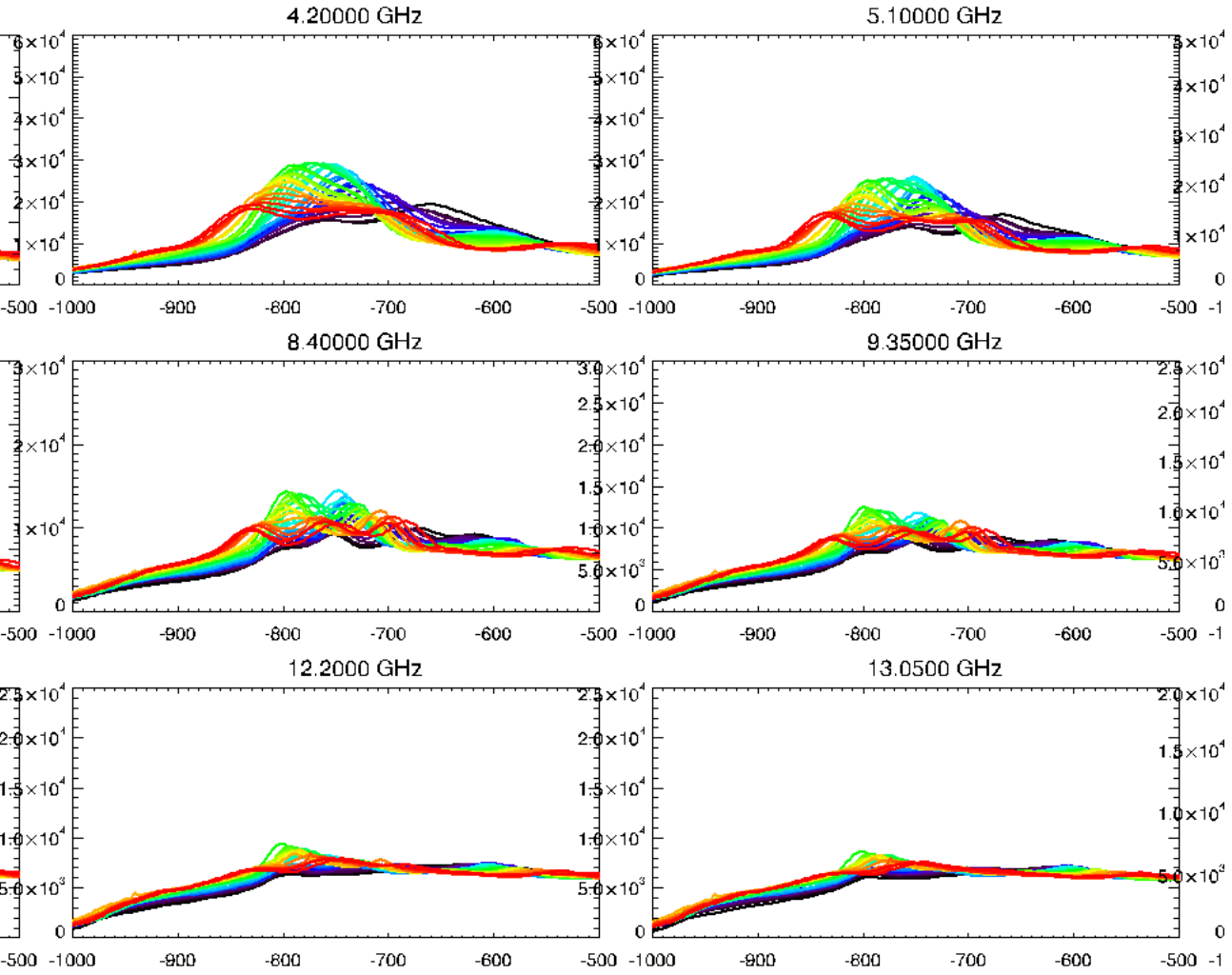
First C2 Appearance Date Time [UT]		Apparent Speed [km.s]	MPA [deg]	Source Locationd	X-ray Importance	Flare onset [UT]	number of records	period between records [min]	presence of changes	frequency range of changes [GHz]	period before flare [hour]	gr limit
17.05.2013	9:12:10	1345	50	N12E57	M3.2	8:43	31	7:30	yes	4.2-11.7	0:30	11.7 GHz
22.05.2013	13:25:50	1466	287	N15W70	M5.0	13:08	31	8:50	yes	4.2-15.3	5:30	15.5 GHz
16.02.2014	10:00:05	634	227	S11E01	M1.1	9:20	31	8:10	yes	9.2-12.4	1:30	13.7 GHz
02.04.2014	13:36:20	1471	60	N11E53	M6.5	13:18	27	9:00	No	-	-	17.5 GHz
18.04.2014	13:25:51	1203	238	S20W34	M7.3	12:31	31	8:10	yes	4.0-12.0	1:00	17.5 GHz
04.06.2014	12:48:05	467	160	S29E40	---	9:12	5	52:30	yes	4.9-10.6	1:20-1:50	16.4 GHz
10.06.2014	13:30:23	1469	156	S17E82	X1.5	12:36	3	9:00	yes	10.0-14.0	1:00	17.2 GHz
22.08.2014	11:12:05	600	359	N12E01	C2.2	10:13	5	49:10	yes	10.0-16.0	0:10-3:00	16.0 GHz
24.08.2014	12:36:05	551	100	S07E75	M5.9	12:00	5	49:00	yes	4.0-10.0	1:00-4:00	15.6 GHz
21.12.2014	12:12:05	669	189	S14W25	M1.0	12:12	28	8:30	yes	10.8-16.5	4:00	17.5 GHz
25.06.2015	8:36:05	1627	330	N09W42	M7.9	8:02	31	8:00	No	-	-	17.5 GHz
16.12.2015	9:36:04	579	334	S13W04	C6.6	8:34	31	8:15	yes	4.7-15.6	2:00	17.5 GHz


20151216
15.6000 GHz
0
1000
2000
3000
4000
-800
-700
-600
-500
-400
T=06:57:07 az=30.
T=07:06:05 az=28.
T=07:15:01 az=26.
T=07:23:54 az=24.
T=07:32:45 az=22.
T=07:41:35 az=20.
T=07:50:24 az=18.
T=07:59:11 az=16.
T=08:07:57 az=14.
T=08:16:42 az=12.
T=08:25:27 az=10.
T=08:34:10 az=8.0
T=08:42:54 az=6.0
T=08:51:37 az=4.0
T=09:00:20 az=2.0
T=09:09:02 az=0.0
T=09:17:45 az=-2.
T=09:26:28 az=-4.
T=09:35:11 az=-6.
T=09:43:54 az=-8.
T=09:52:38 az=-10
T=10:01:22 az=-12
T=10:10:08 az=-14
T=10:18:54 az=-16
T=10:27:41 az=-18
T=10:36:29 az=-20
T=10:45:19 az=-22
T=10:54:11 az=-24
T=11:03:04 az=-26
T=11:12:00 az=-28
T=11:20:58 az=-30


20140824 4.40000 GHz
T=07:38:06 az=24.
T=08:27:07 az=12.
T=09:16:02 az=0.0
T=10:04:57 az=-12
T=10:53:57 az=-24
0
-1000
-900
-800
-700
-600
-500


4.40000 GHz
1500
1000
500
0
-500
-1000
-1000
-900
-800
-700
-600
-500

20130522



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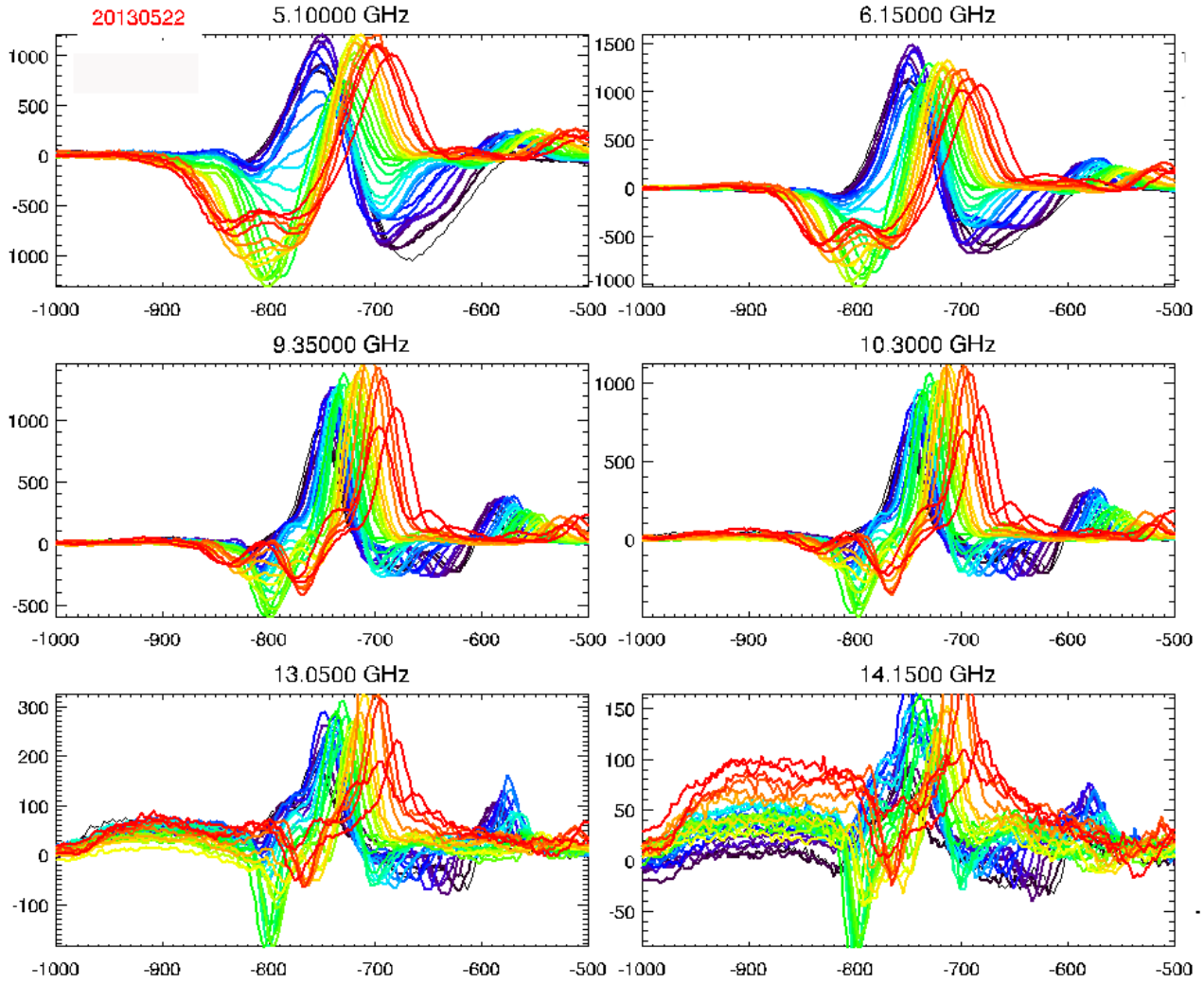
T=07:10:00 az=28.
T=07:18:42 az=26.
T=07:27:22 az=24.
T=07:36:01 az=22.
T=07:44:38 az=20.
T=07:53:15 az=18.
T=08:01:50 az=16.
T=08:10:25 az=14.
T=08:19:00 az=12.
T=08:27:33 az=10.
T=08:36:06 az=8.0
T=08:44:39 az=6.0
T=08:53:11 az=4.0
T=09:01:44 az=2.0
T=09:10:16 az=0.0
T=09:18:49 az=-2.
T=09:27:21 az=-4.
T=09:35:54 az=-6.
T=09:44:26 az=-8.
T=09:53:00 az=-10
T=10:01:33 az=-12
T=10:10:08 az=-14
T=10:18:43 az=-16
T=10:27:18 az=-18
T=10:35:55 az=-20
T=10:44:33 az=-22
T=10:53:12 az=-24
T=11:01:52 az=-26
T=11:10:34 az=-28
T=11:19:18 az=-30



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T=07:10:00 az=28.
T=07:18:42 az=26.
T=07:27:22 az=24.
T=07:36:01 az=22.
T=07:44:38 az=20.
T=07:53:15 az=18.
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T=08:27:33 az=10.
T=08:36:06 az=8.0
T=08:44:39 az=6.0
T=08:53:11 az=4.0
T=09:01:44 az=2.0
T=09:10:16 az=0.0
T=09:18:49 az=-2.
T=09:27:21 az=-4.
T=09:35:54 az=-6.
T=09:44:26 az=-8.
T=09:53:00 az=-10
T=10:01:33 az=-12
T=10:10:08 az=-14
T=10:18:43 az=-16
T=10:27:18 az=-18
T=10:35:55 az=-20
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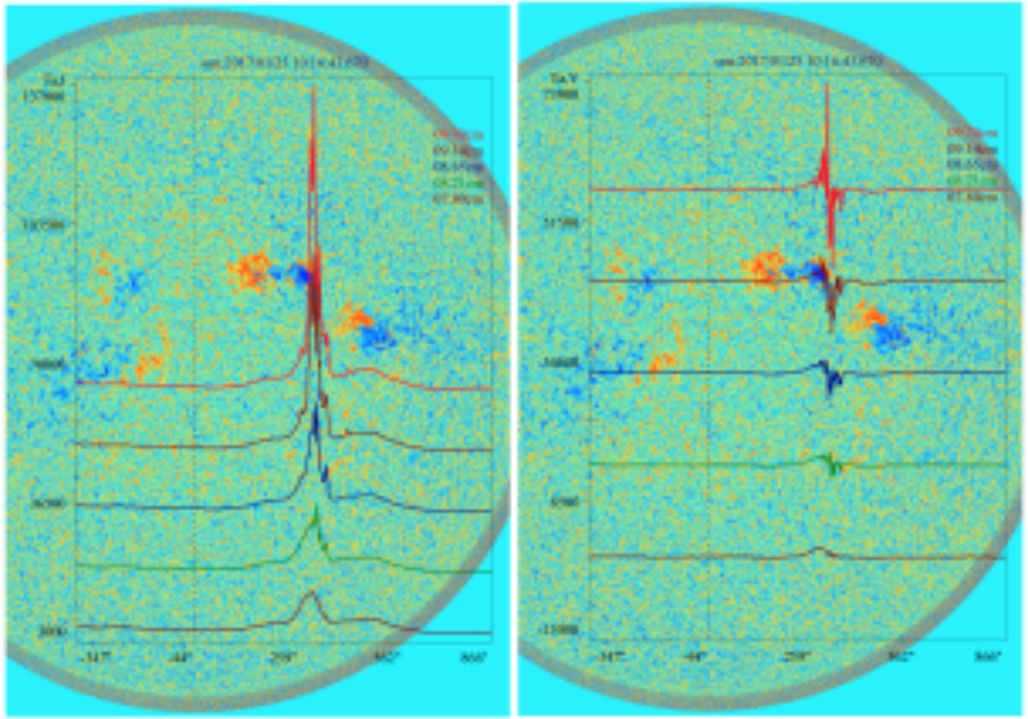
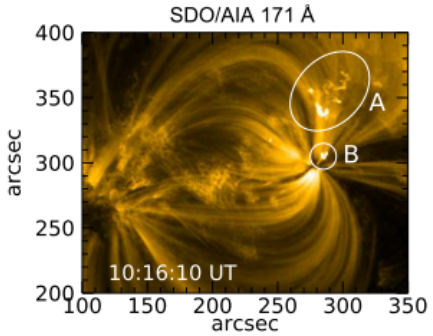
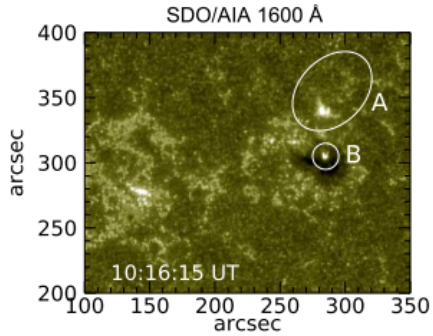
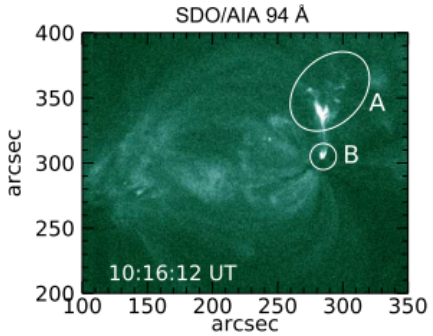
T=10:53:12 az=-24
T=11:01:52 az=-26
T=11:10:34 az=-28
T=11:19:18 az=-30

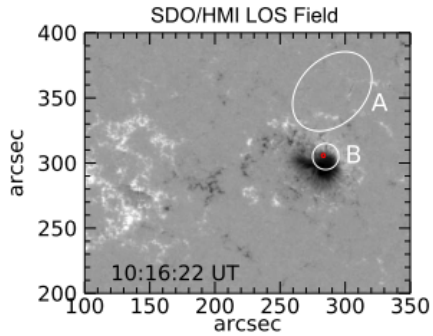
Quasi-periodic Pulsations in a Solar Microflare
Nakariakov et al.
Astroph. J., V. 859, I. 2, article id. 154, 8 pp.
2018

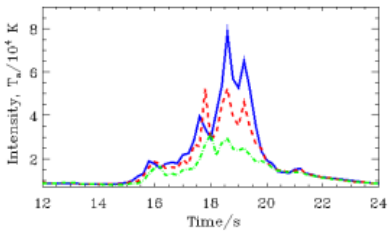


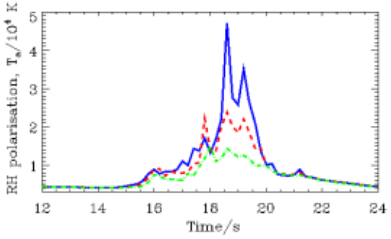


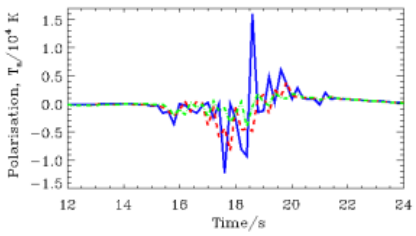


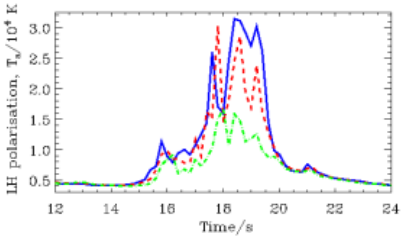


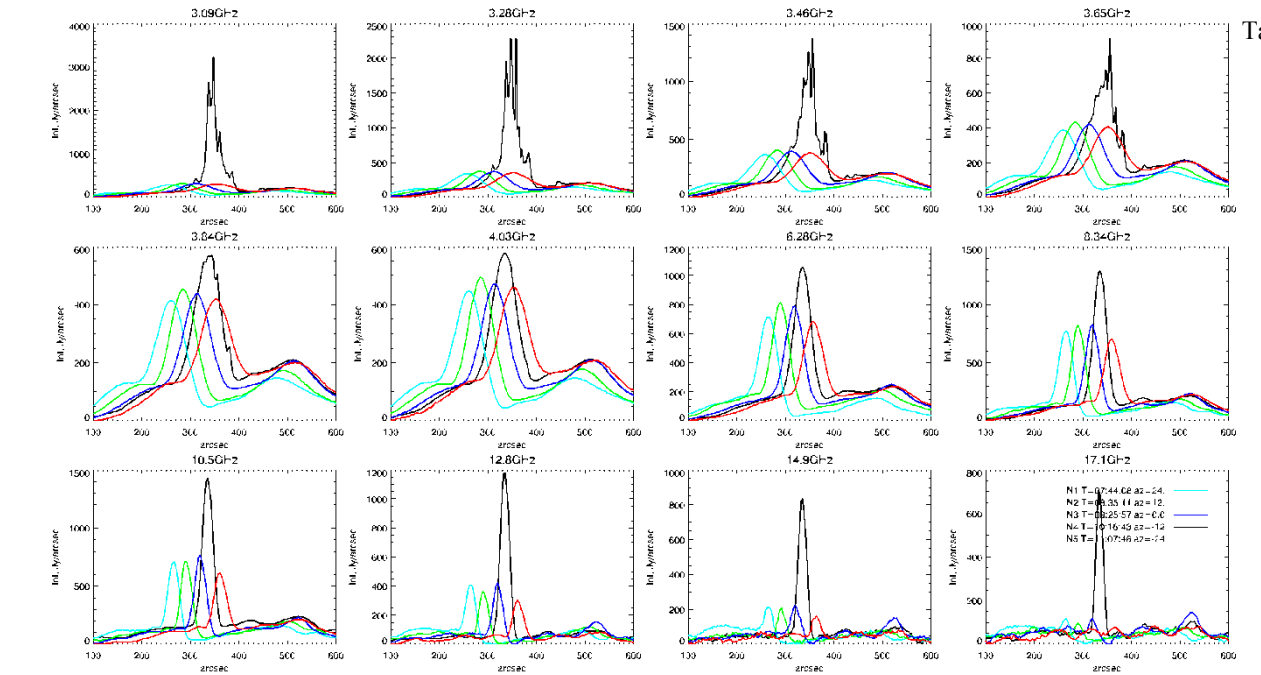


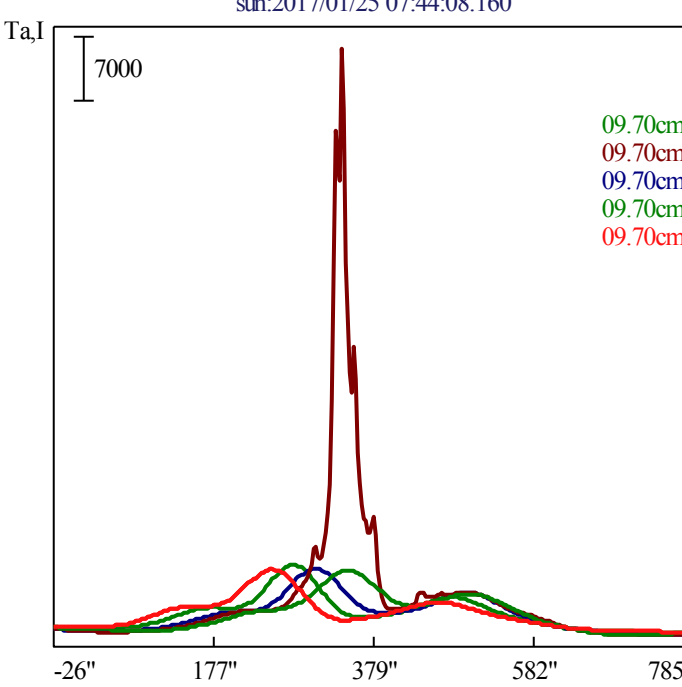


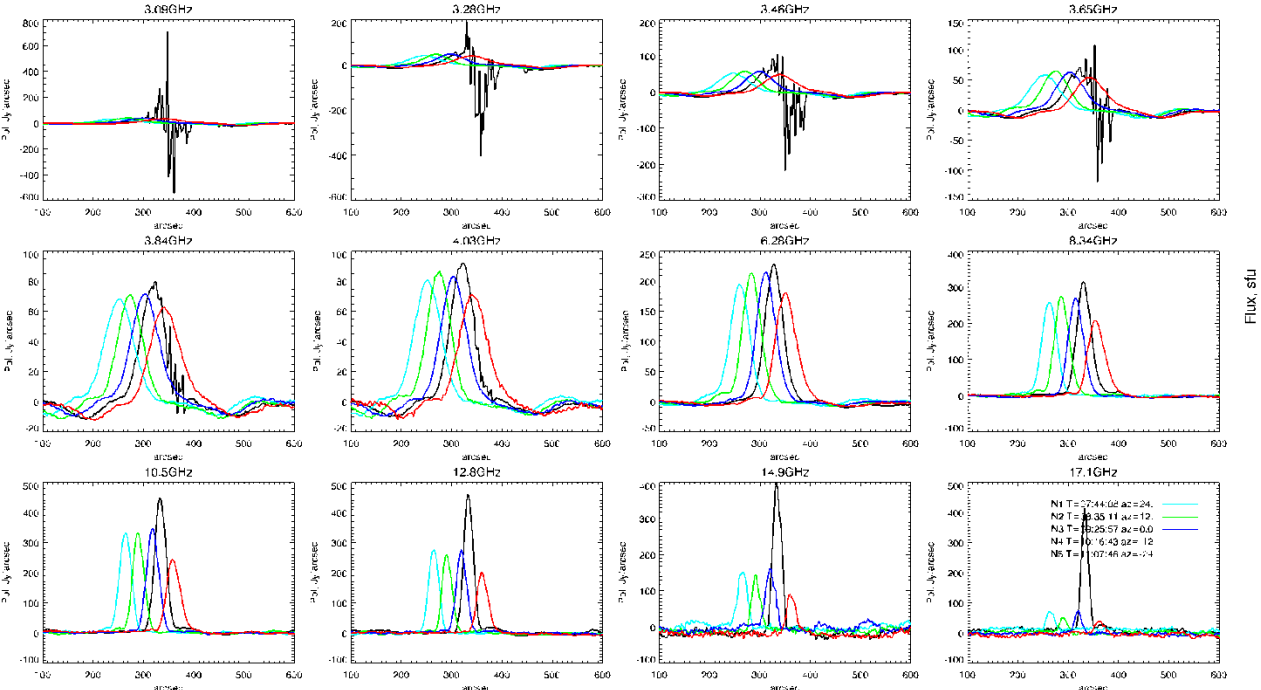


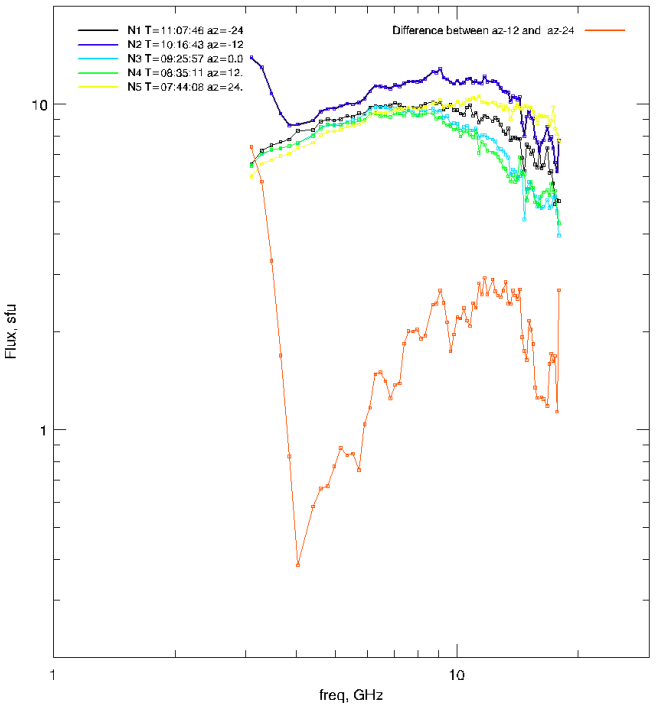





3.09GHz
3.28GHz
3.46GHz
3.65GHz
3.84GHz
4.03GHz
6.28GHz
8.34GHz
10.5GHz
12.8GHz
14.9GHz
17.1GHz
arcsec

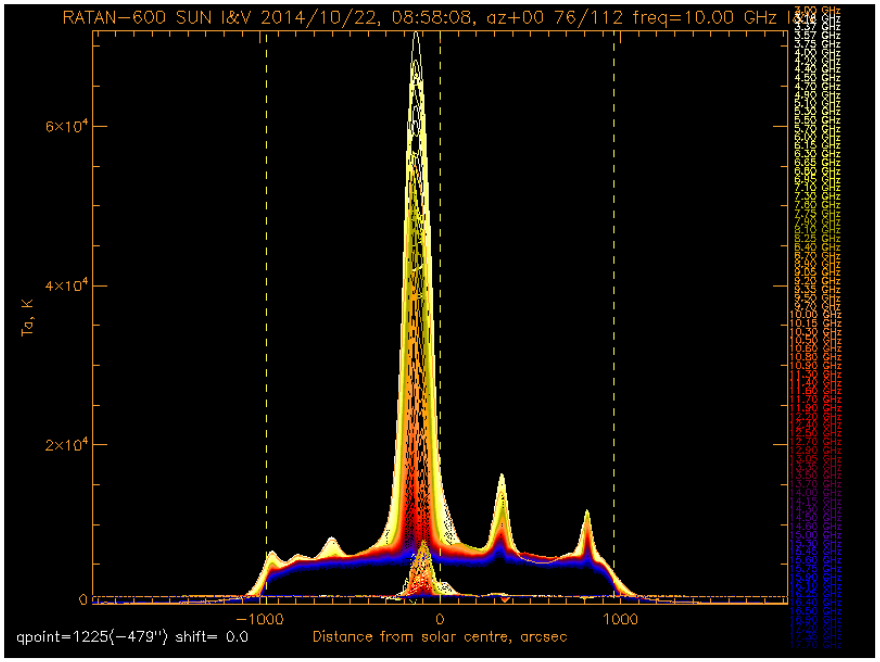

sun:2017/01/25 07:44:08.160
Ta,I
7000
09.70cm
09.70cm
09.70cm
09.70cm
09.70cm
-26"
177"
379"
582"
785


3.09GHz
3.28GHz
3.46GHz
3.65GHz
3.84GHz
4.03GHz
6.28GHz
8.34GHz
10.5GHz
12.8GHz
14.9GHz
17.1GHz
arcsec


2017/01/25
N1 T=11:07:46 az=-24
N2 T=10:16:43 az=-12
N3 T=09:25:57 az=0.0
N4 T=08:35:11 az=12.
N5 T=07:44:08 az=24.
Difference between az-12 and az-24
Flux, sfu
freq, GHz
10
1
1
10

WEB-SITE OF THE FORECAST OF SOLAR ACTIVITY USING RATAN DATA

Spectra fFlux xs 300 xu GHz subtr auto yscale auto xscale auto Label freq All sources (More)



The Sun centre has been shifted=21.64 arcsec (7pix, or 1.5sec).

Download the data in FITS format:

Level1 file (authorization required)	Level2 (auto treatment from the archive)	Level 2 (current work file)
20141022_125808_sun0.fits	20141022_125808_sun0_out.fits	/data/tmp/20141022sun0_113-

Tanaka-Enome big flares prediction criterion (Flux 3 cm >10 sfu, Flux 3c

Latest big flare prognosis for the next 3 days from the last observations day 20141022

today NOAA ARs: 2187 2192 2193 2194

Time	az	NOAA AR	x pos	y pos	flux 3cm	flux 3cm corr	flux 10cm	flux 10cm corr	Pol	location	area	prognosis	sps	x1	x2
08:58:08	0	2187_2191	819	3.3	5.20	5.54	3.50	3.50	S	S08W53	170	negative	0.00	699	934
08:58:08	0	2193_2190	340	2.6	3.60	3.75	3.50	3.50	E	N04W18	80	negative	0.00	272	405
08:58:08	0	2192	-150	-6.3	47.10	59.17	41.60	41.60	S	S14E19	2410	positive	0.00	-315	99

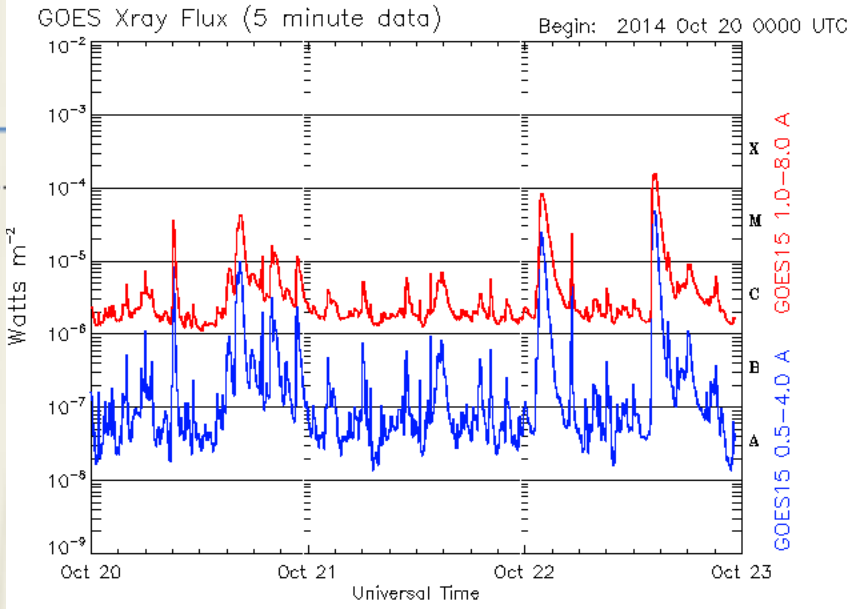
WARNING! Big flare is probable within the next 3 days

Check also the polarization configuration.

X-ray flares within 2014-10-22 and 2014-10-25

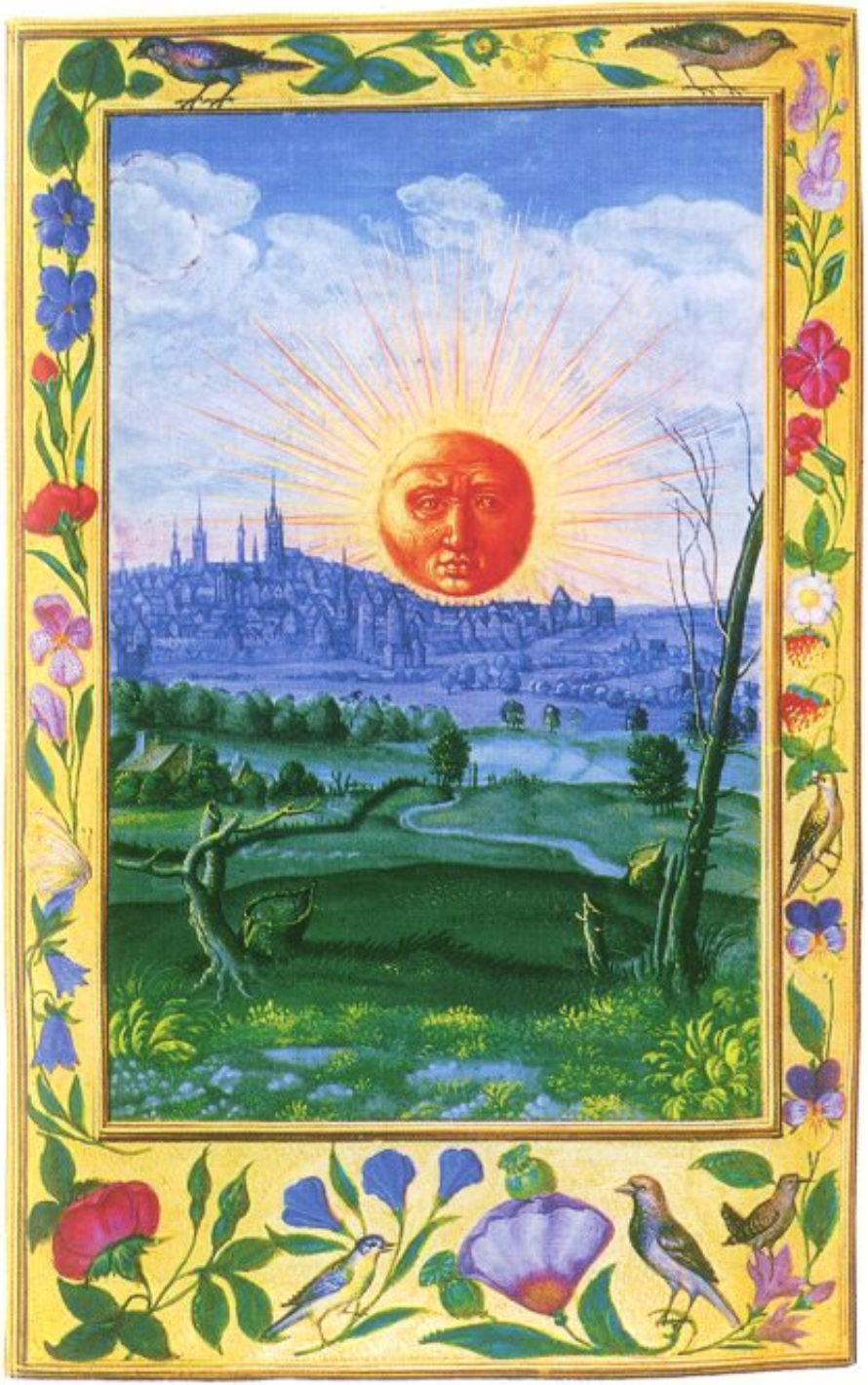
X-ray flares within 2014-10-22 and 2014-10-25

Date	Begin	Max	End	Loc	Xray class	Op	NOAA AR
2014.10.22	0116	0159	0228		M8.7		2192
2014.10.22	0511	0517	0521		M2.7		2192
2014.10.22	1402	1428	1450	S14E13	X1.6	2b	2192
2014.10.22	1551	1557	1603		M1.4		0
2014.10.22	1652	1659	1703		C5.7		0
2014.10.23	0944	0950	0956	S16E03	M1.1	1f	2192
2014.10.24	0235	0243	0248	S20W02	C4.2	Sf	2192
2014.10.24	0356	0400	0402	S22W00	C3.6	Sf	2192
2014.10.24	0737	0748	0753		M4.0		2192
2014.10.24	2107	2141	2213	S16W21	X3.1	3b	2192



Summary

- The RATAN-600 archive of daily solar observations starting from 1997 (9-13 UT in the range from 1.67 cm up to 32 cm with left and right circular polarization) is open for investigations.
- Several solar events based on regular observations with RATAN-600 radio telescope are presented.
- The spectral-polarization observations over a wide wavelength range reveal numerous intensity and polarization effects reflecting the characteristics of active regions at the pre-flare, flare and post-flare stages.
- The frequency range covers the gyroresonance emission from all the active regions, corresponding to the magnetic field strengths found in the corona (up to 2500 G), and other emission mechanisms, being able to indicate the preflare state and monitor the solar flare activity.



THANK YOU FOR ATTENTION!

Salomon Trismosinus
“Splendor Solis”
around 1535