

Microwave sources over the active region and during a flare

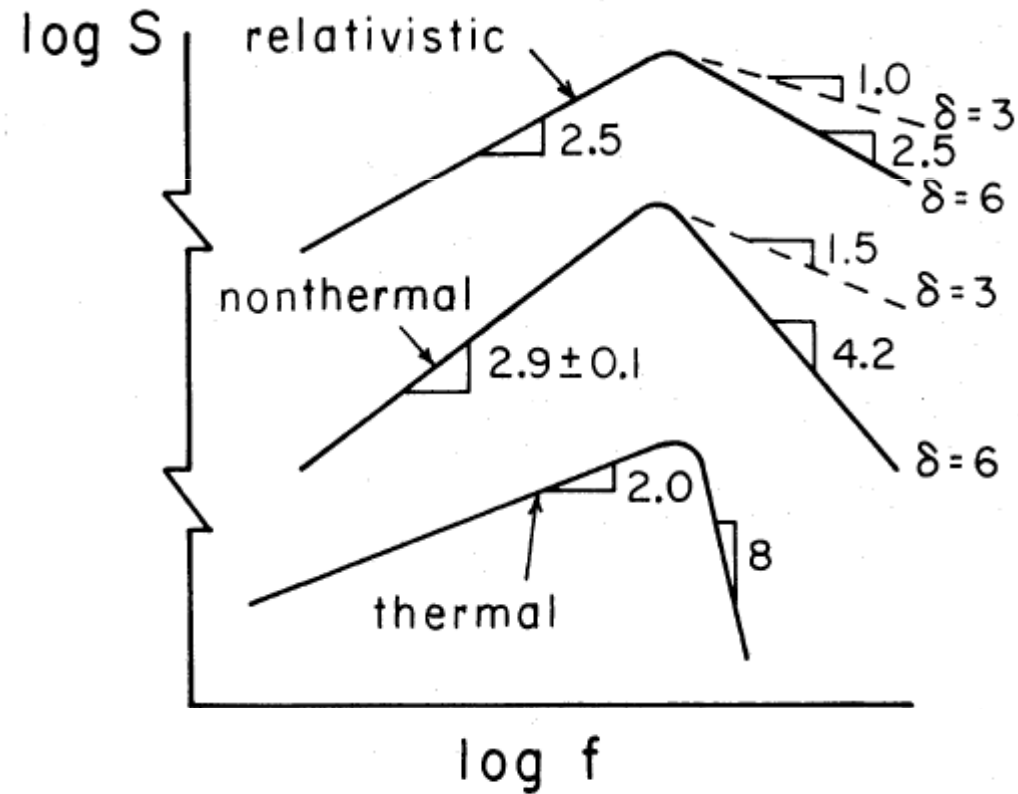
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EOVSA specifications

- 2.5 to 18 GHz
- 8 antennae, total power mode, 1 s integration, 332 frequency channels in 2.5 to 18 GHz range
- $57'' / \nu \text{ GHz} \times 51'' / \nu \text{ GHz}$
- 1.08 km EW x 1.22 km NS

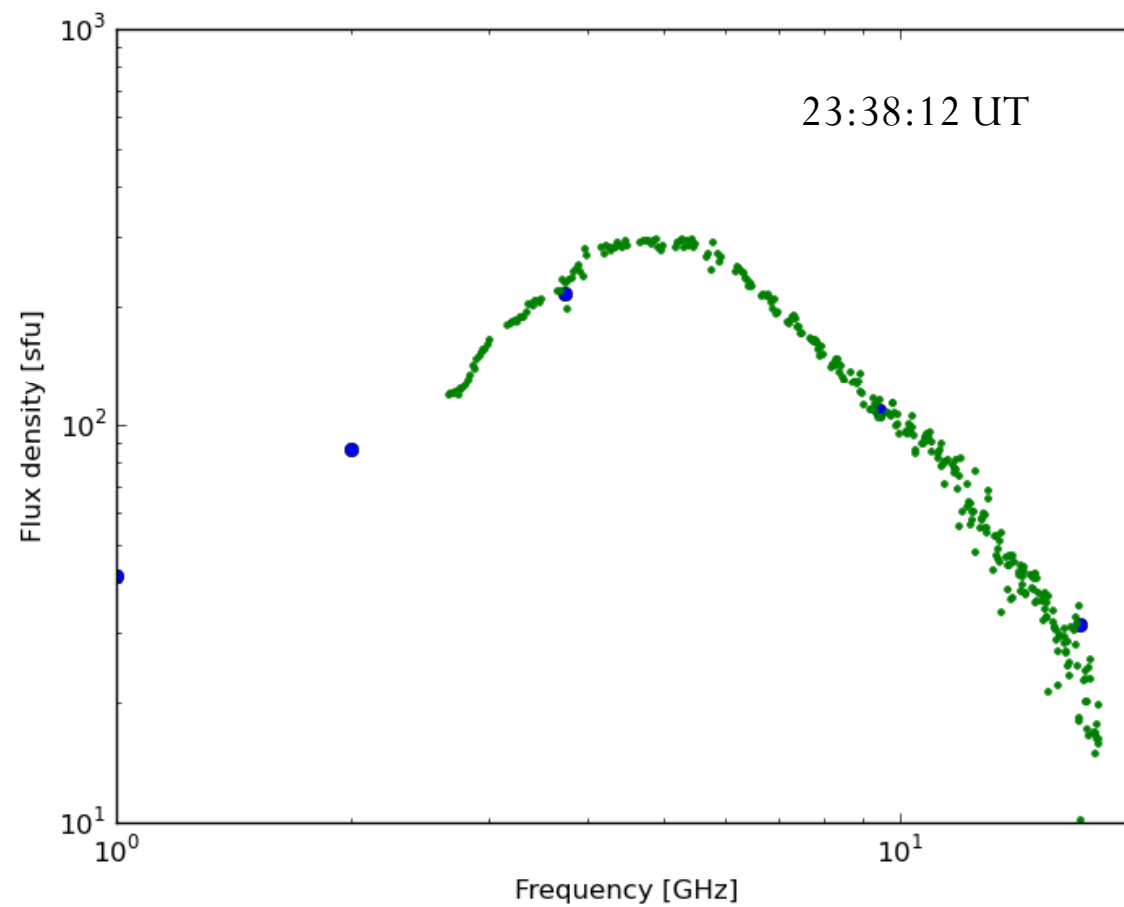
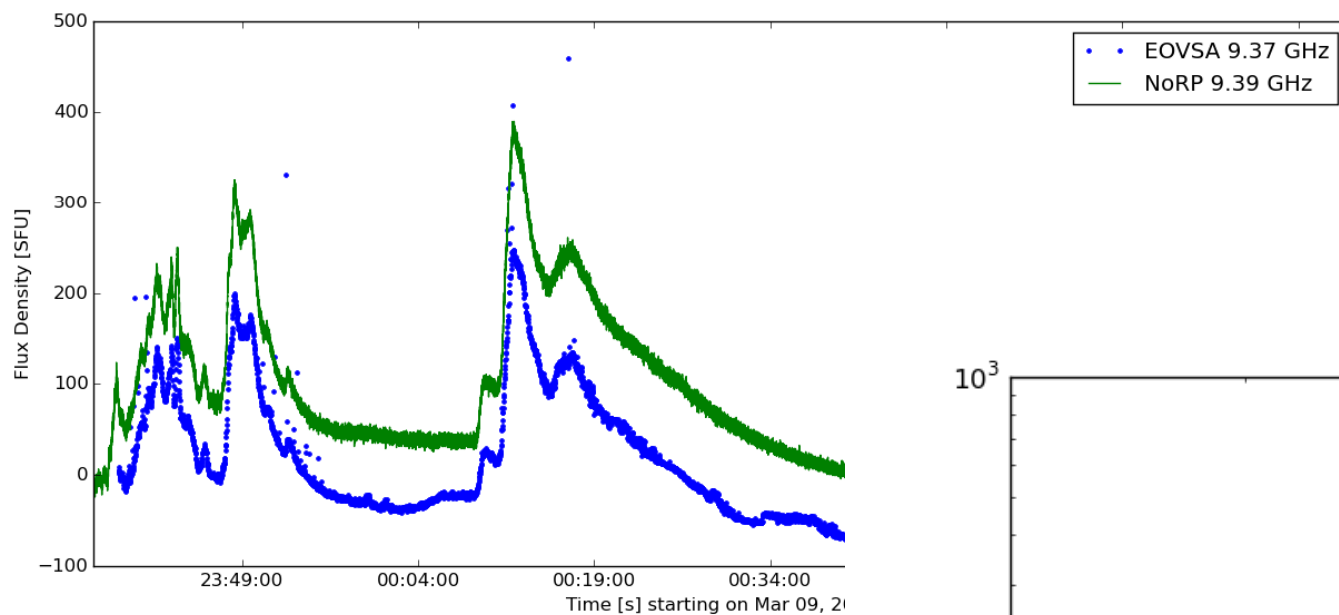
Microwave Density Spectrum



- Temporal evolution
- Peak flux variation

Dulk 1985

EOVSA and NoRP Spectrum

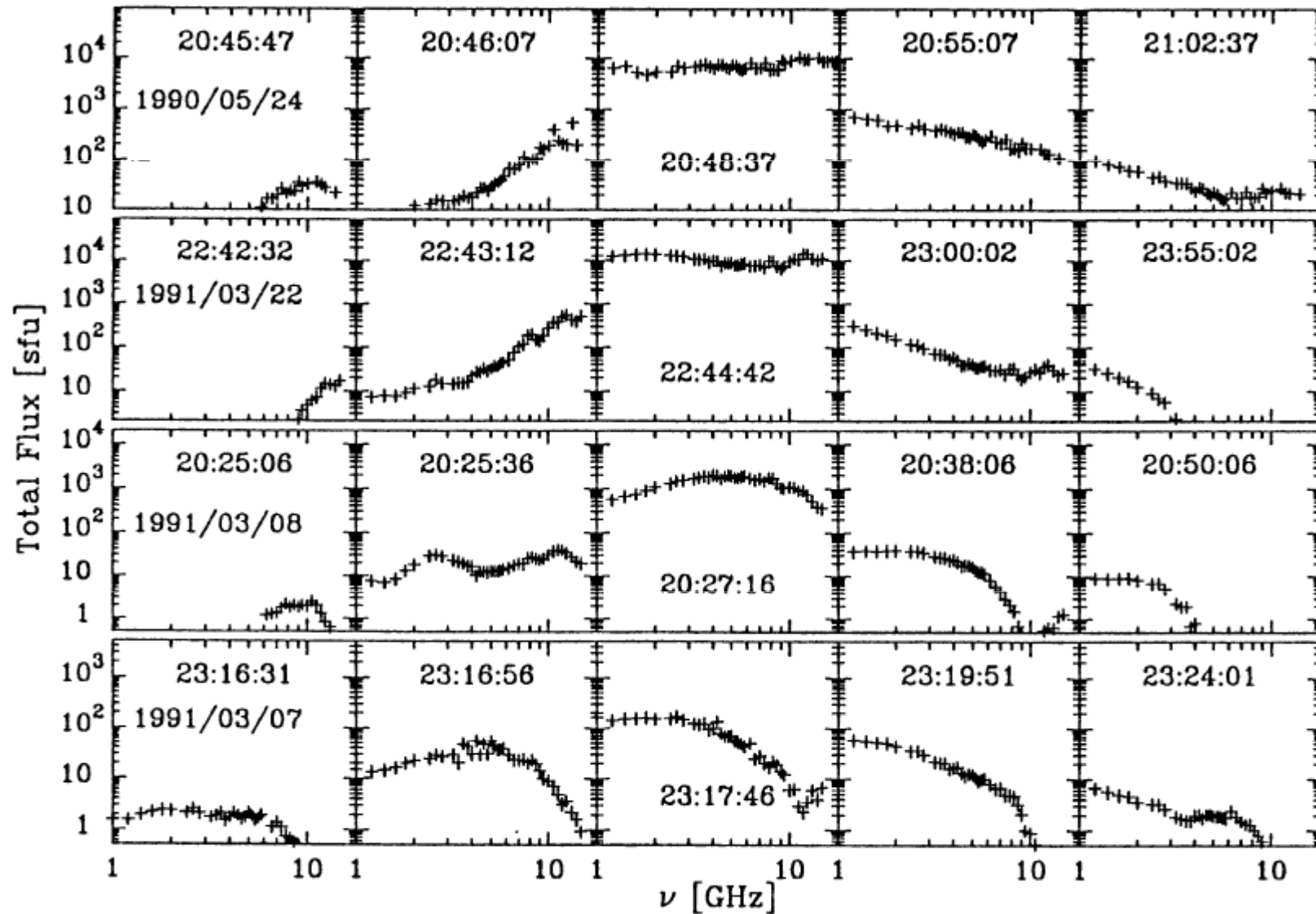


Microwave Source Size and Spectrum

- Magnetic field
- Density
- Flat spectrum
 - Uniform source / Homogeneous source
 - Ununiform / Inhomogeneous source

Gary and Hurford 1989, Lee et al. 1994, Melnikov et al. 2008

Microwave Source Size and Spectrum



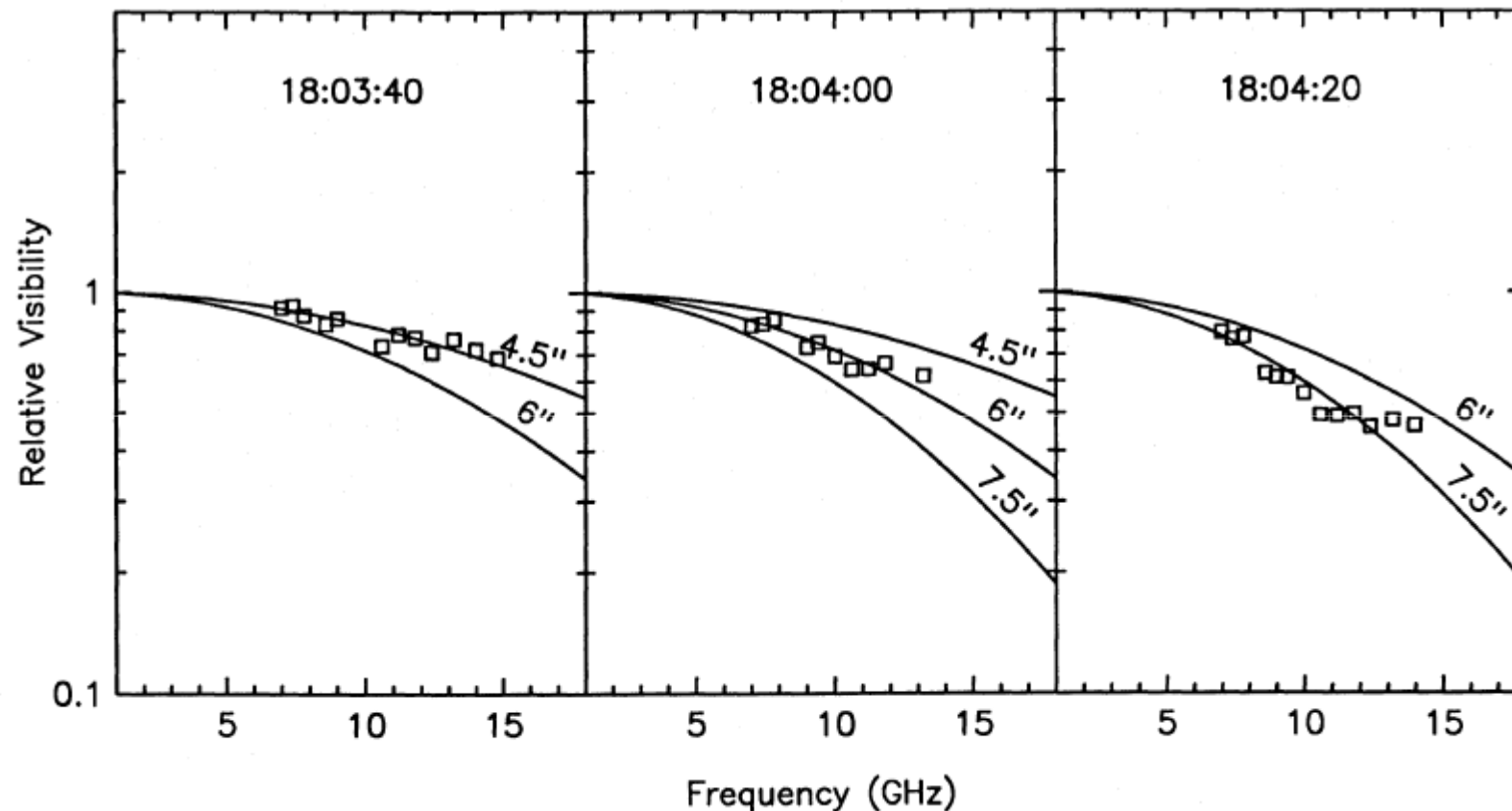
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Relative visibility Spectrum

- Ratio of the fringe amplitudes to the total power as a function of frequency
- Higher frequency – Higher resolution



Gary and Hurford 1989, Kucera et al, 1994

Halo – Microwave Sources

- “Halo type sources from microwave observations with high angular resolution”, N. G. Peterova, L. V. Opeikina and N. A. Topchilo, Geomagnetism and Aeronomy, 2014
- “The self-Inversion of the sign of circular polarisation in Halo microwave sources”, T. I. Kaltman, A. N. Korzhavin and N. G. Peterova, Solar Physics, 2007

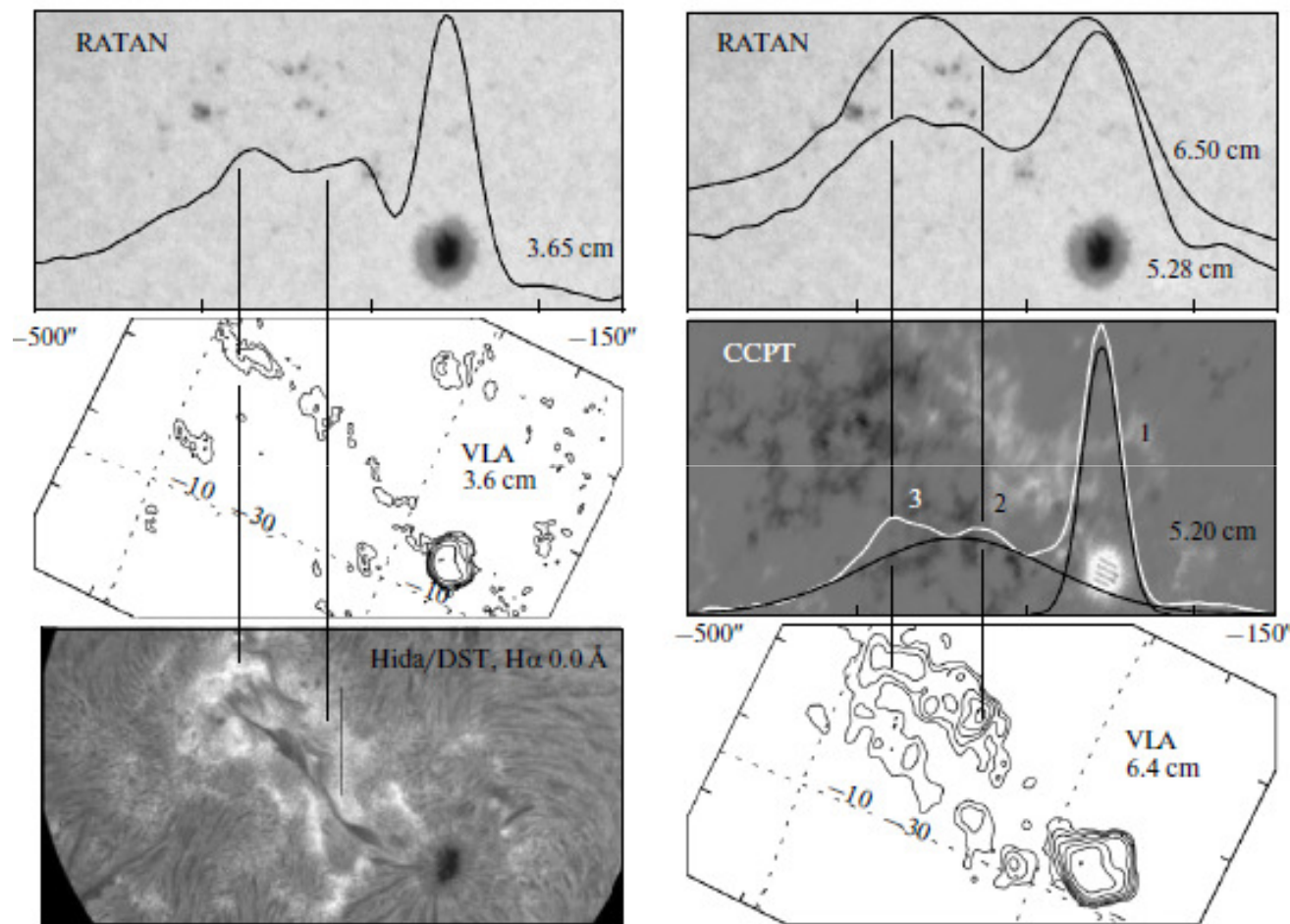
Halo Microwave Source

- Located in the solar atmosphere above the active regions
- Wide emission source with a size of about the whole active region
- Multi-component structure
 - Bright, highly polarized, compact to the size of spots ($\sim 20\text{-}30''$)
 - Less bright, weakly polarized, extended to the size of the whole AR ($\sim 2\text{-}4'$)
- Also called as 'interspot' above the sunspots
- Inhomogeneity of the interspot region

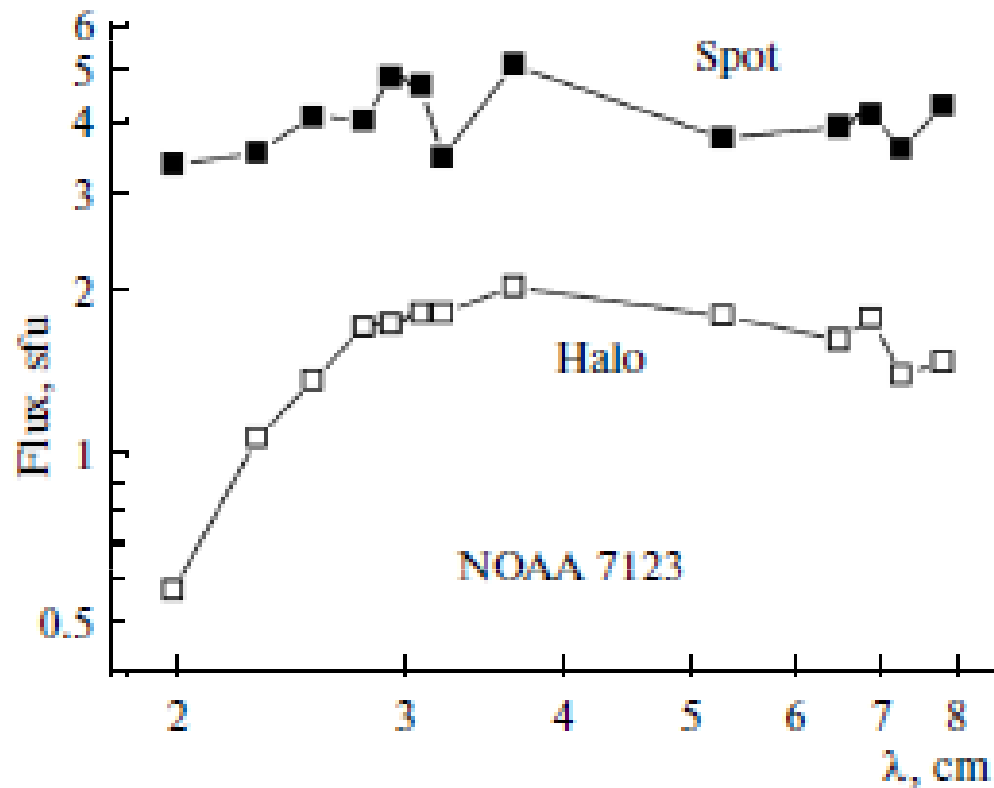
Peterova et al. 2014, Akhmedov et al. 1987

Halo Microwave Source, Peterova et al.

- 3.6 and 6.4 cm (8.3 and 4.68 GHz) VLA (2-4")
- 5.2 and 3.65, 5.28cm SSRT and RATAN (>20")

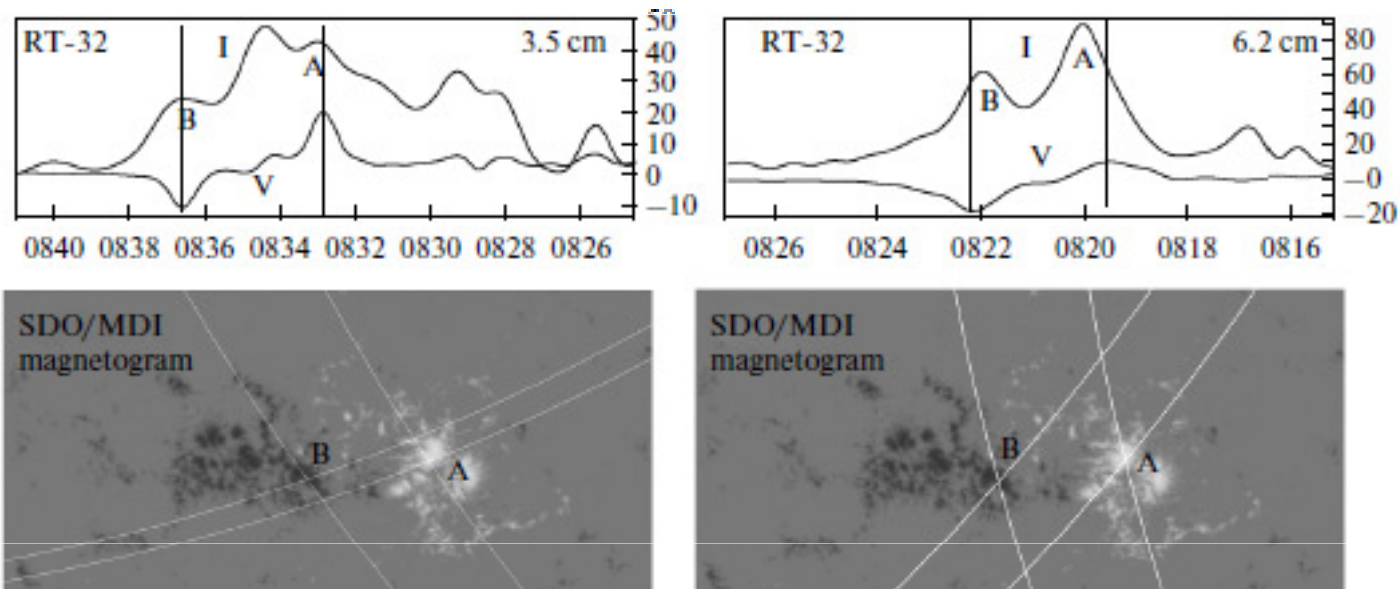


Halo Microwave Source, Peterova et al.



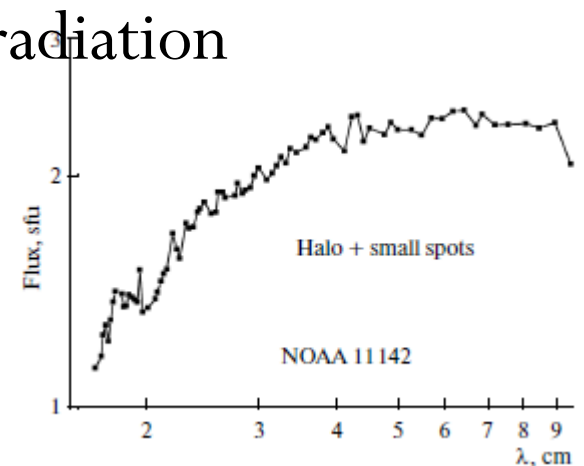
Wavelength/Source	Maximum temperature, MK		
	3	2	1
6.4 cm	0.35	1.0	3
3.6 cm	0.13	0.1	2

Halo Microwave Source, Peterova et al.



Halo Microwave Source, Peterova et al.

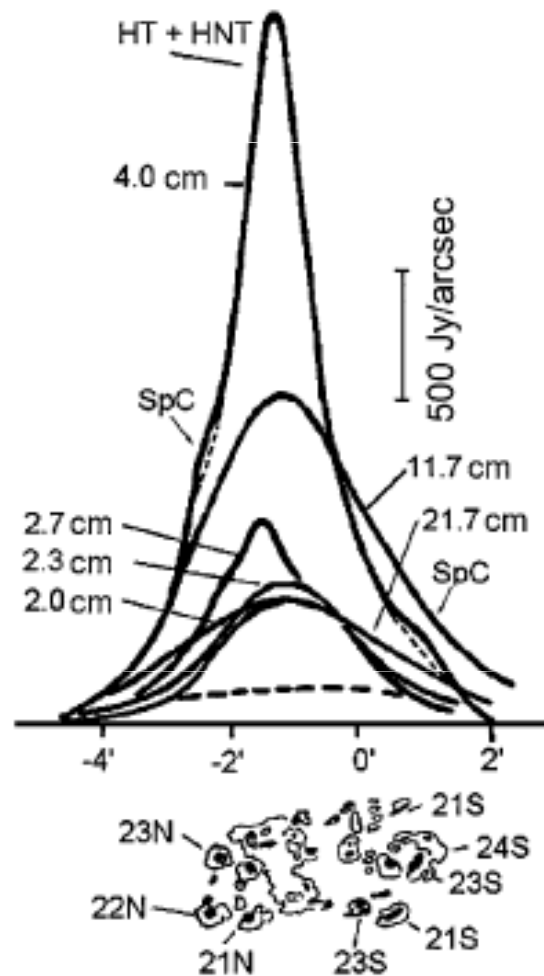
- With high angular resolution of 2-5''
- Halo is an extended component in microwave image equal to the size of active region 2-3', has fine structure
- **Structures:** as regions of small sunspots, pores and neutral line of the large scale magnetic field
- **Height:** low above the photospheric level at 100,000 km, shining through the upper optically transparent diffuse halo
- Thermal electrons generating cyclotron radiation



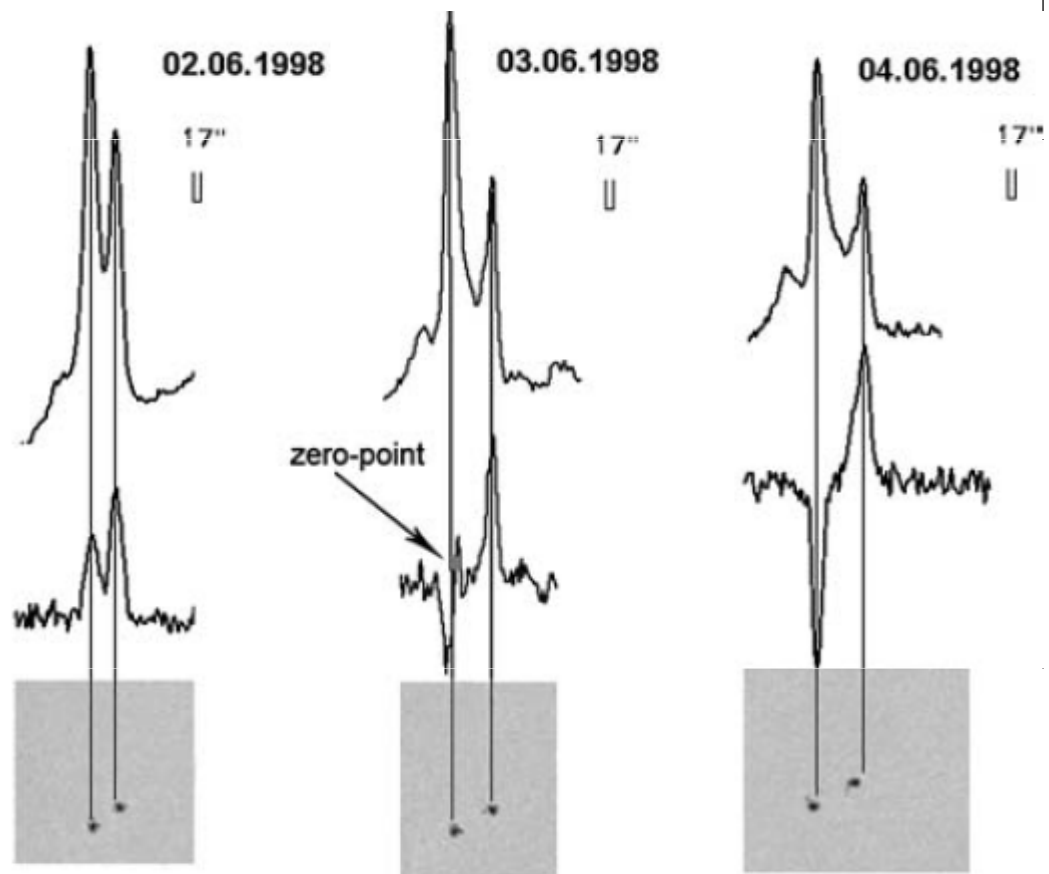
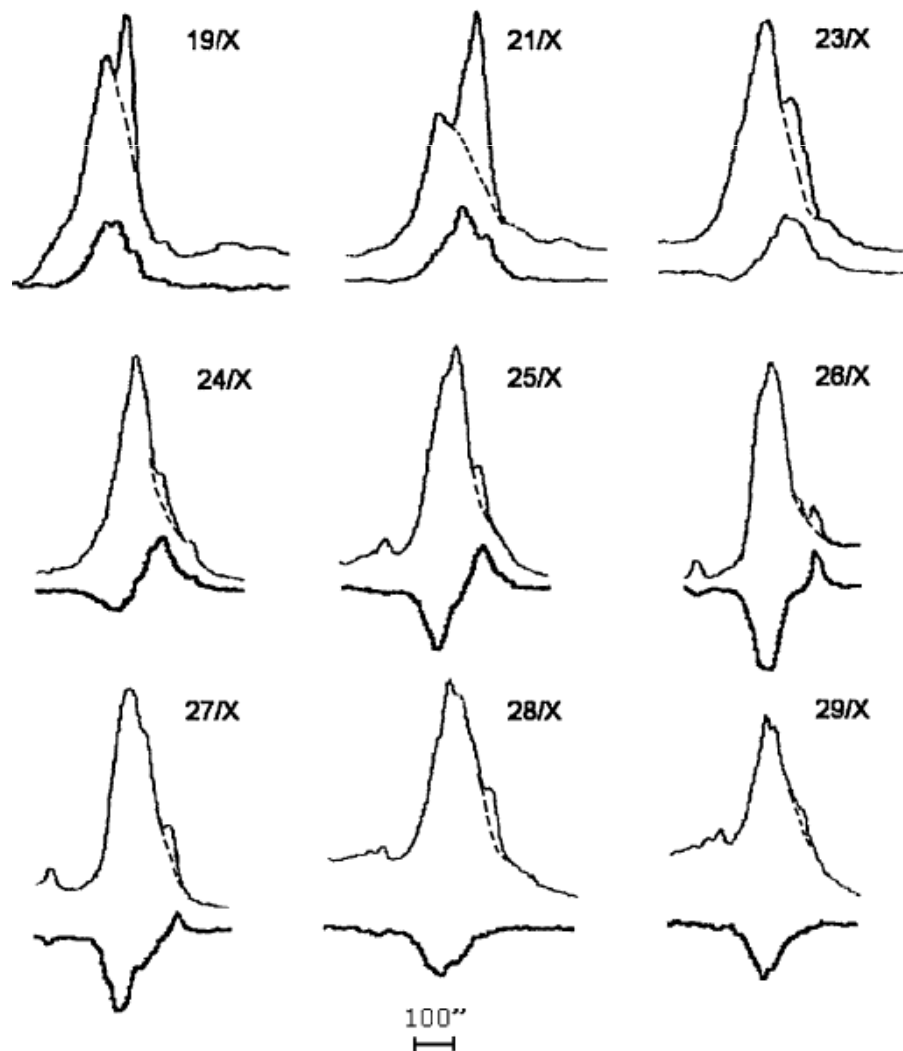
Halo Microwave Source, Kaltman et al.

- Halo accounted $>50\%$ of the total AR emission
- Halo is large, non structured, size of AR emission centered at the neutral line
- Thermal and non thermal components
- Self-inversion
- Maximum in halo flux density spectrum at 5-10 cm
- Non thermal character is interpreted as gyrosynchrotron radiation of the subrelativistic electrons

Halo Microwave Source, Kaltman et al.

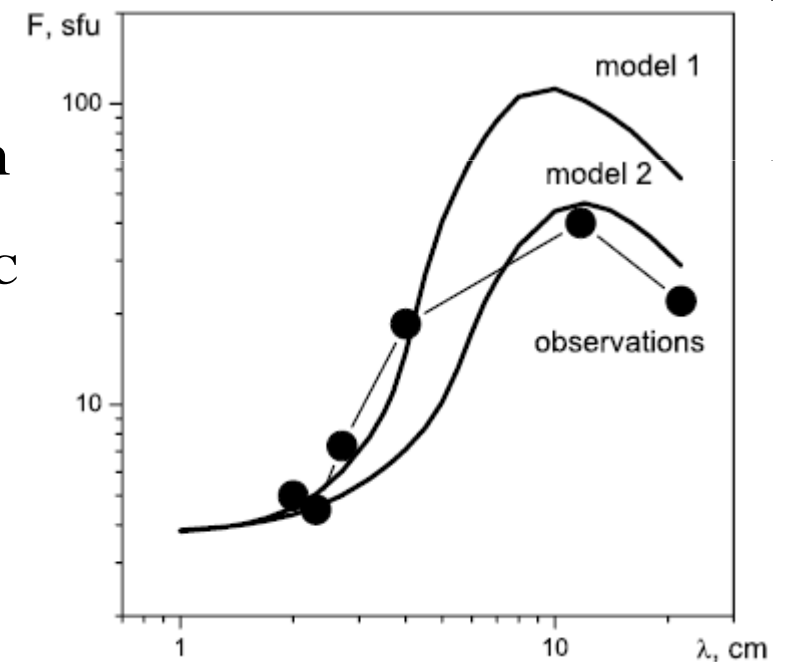


Halo Microwave Source, Kaltman et al.



Halo Microwave Source, Kaltman et al.

- The halo source can strongly affect the observational features of the underlying sunspot associated sources
- Thermal and non thermal components in the halo emission spectrum
 - Thermal emission with flat spectrum shorter than 2.7 cm
 - Non thermal emission with very steep spectrum in 3-5 cm
 - Smooth maximum at 7-10 cm
- The polarized halo emission show inversion of polarization depending on the heliographic longitude of the AR



Summary

- Microwave source size varies with frequency due to magnetic field and accelerated electron density variation
- Halo sources as an extended sources can be visible in the low frequency range
- Halo sources with structures need higher angular resolution
- With EOVSAs,
3.1" – 22.8" NS 2.8" – 20.4" EW angular resolution
 - Halo source observation
 - Halo sources during a flare

Thank you