Solar Eclipse observation in Radio Frequencies: A review

Shaheda Begum Shaik

April 24, 2014

Introduction

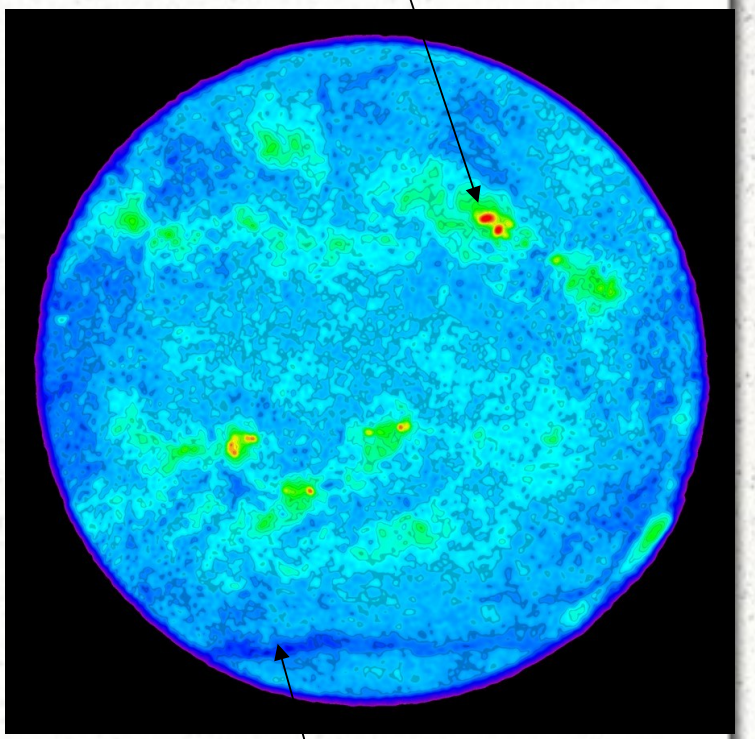
- Observations of the Sun in radio frequencies during an eclipse
- Tracking/monitoring a region of interest on the Sun's surface, when the Moon covers (uncovers) the field of view
- Similar to Lunar occultation

Motivation

- Higher angular resolution and improved sensitivity with added use of interferometric technique
- Study the structures of limb, quiet-Sun, sunspots observed during the eclipse
- Determine the coronal brightness temperature, magnetic field strength
- Interpretations of the radio emission mechanisms related to the solar atmosphere

1. Radio emission

- Radio brightness temperature
  - ➔ True temperature of the Sun's atmosphere
- Large radial distances from the solar surface
- Radio disk vs Optical disk
  - ➔ Time of obscure
  - ➔ Velocity of the Moon and the Sun



Radio emission above the Sunspots

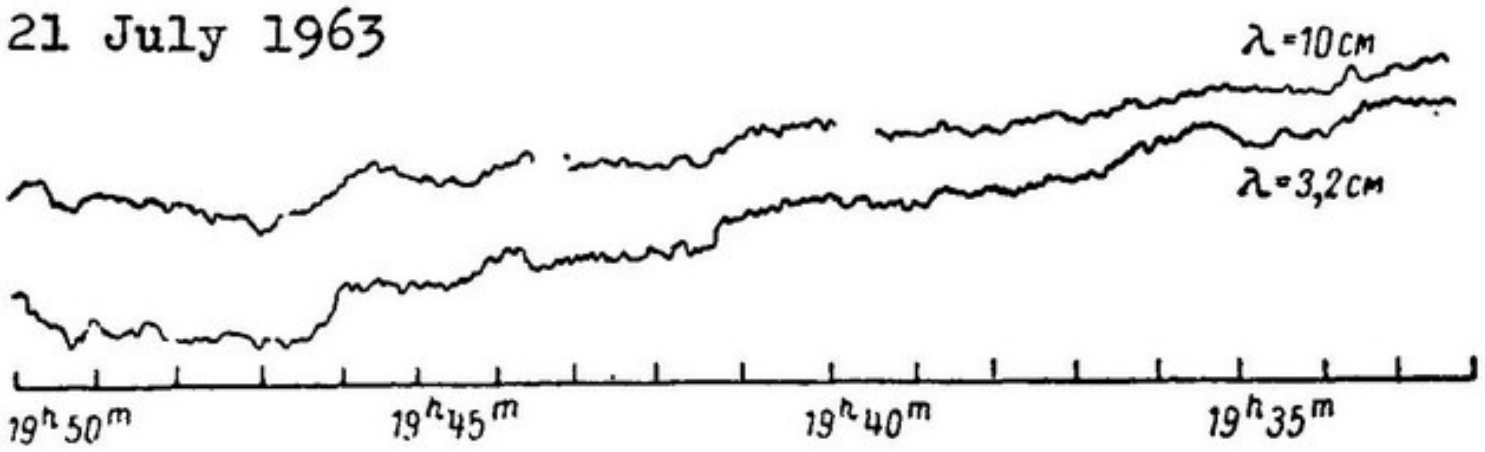
- Moment of time of optical contacts
- Moment of time of radio contacts

  Rradio > Rmoon > Rsun
- Residual fluxes of the concealed Sun's emission

  1.4 and 1 % at 3.2 and 4 cm respectively
- Characteristics of radio emission sources

Abbasov et al., 1965

Radio emission above the Sunspots



Abbasov et al., 1965

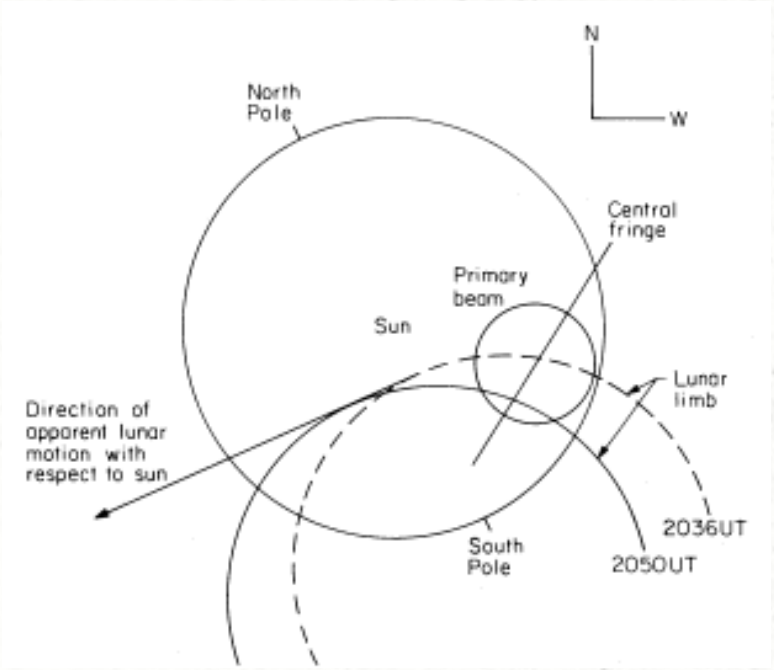
2. Quiet Sun Observations

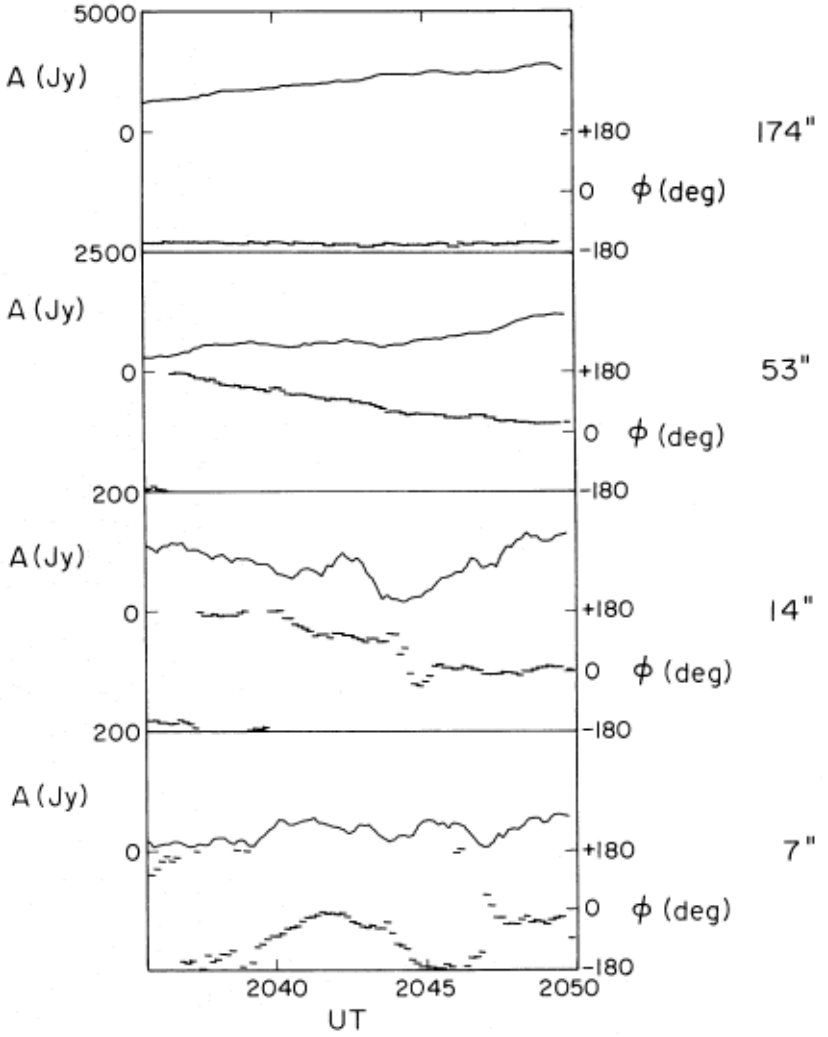
- Observation of stationary structures – coronal holes, Prominences, Sun's surface
- Phenomena related to convection and its energy

In radio,

- Height scan with changing observing frequency
- Heating events in the quiet upper chromosphere, the transition region and the corona
- Correlation with the chromospheric network

Spatial structure in the quiet Sun at 6 cm





Amplitude and phase variations

Marsh, Hurford and Zirin, ApJ, 1980

Spatial structure in the quiet Sun at 6 cm

Radio map

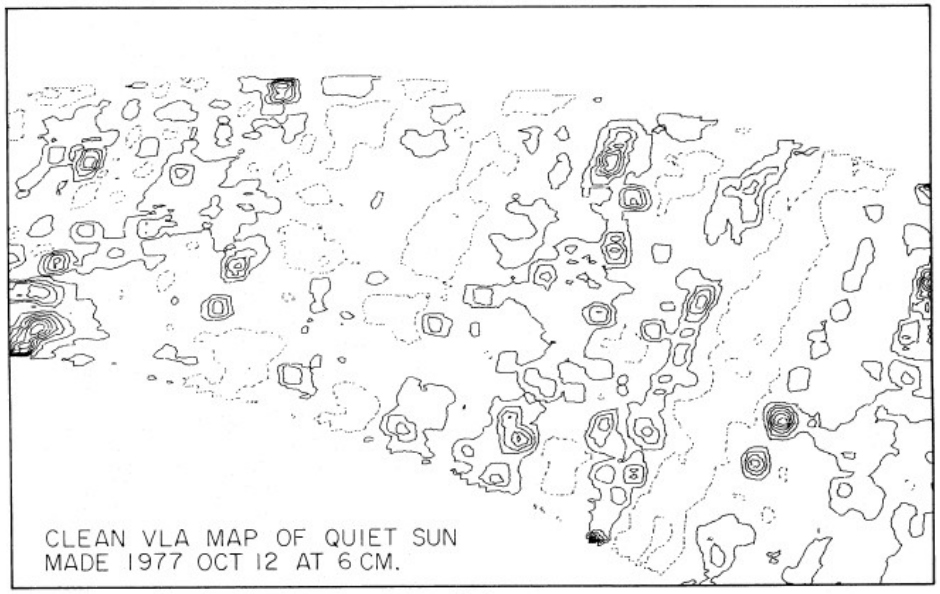
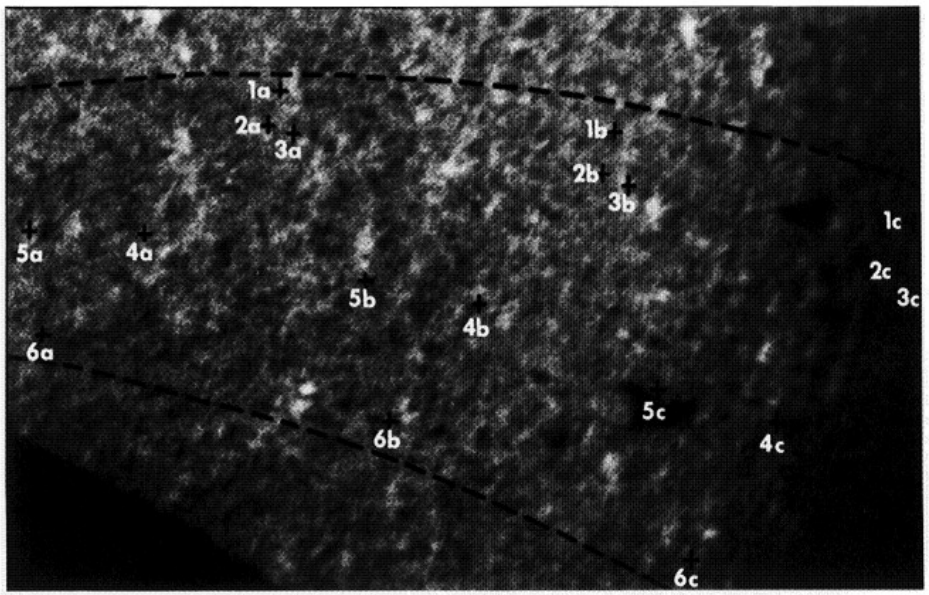


FIG. 5

Halpha map



Marsh, Hurford and Zirin, ApJ, 1980

Spatial structure in the quiet Sun

- No clear correlation with the chromospheric network
- 3 out of 6 source positions consistent with small bipolar regions
- Raises the possibility of association of radio sources with X-ray bright points

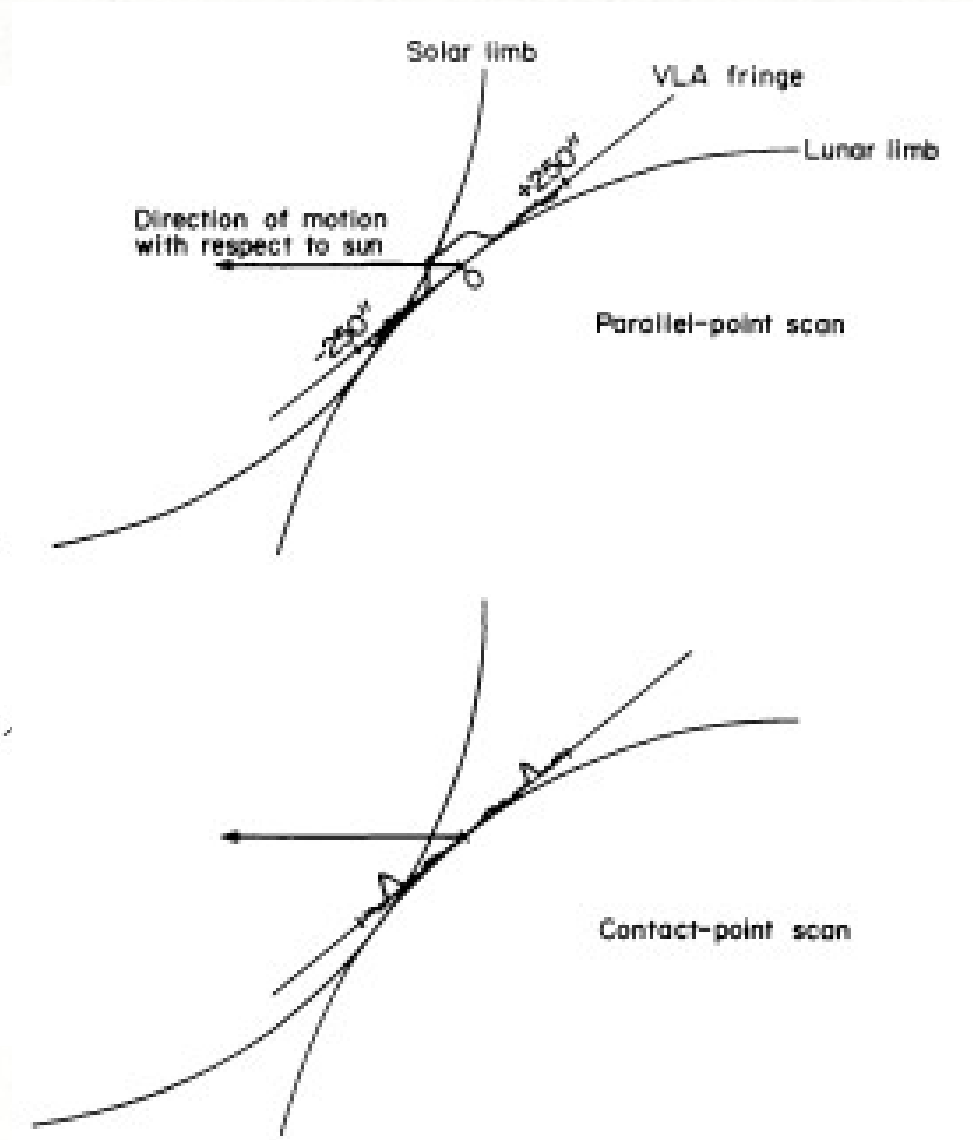
Marsh, Hurford and Zirin, ApJ, 1980

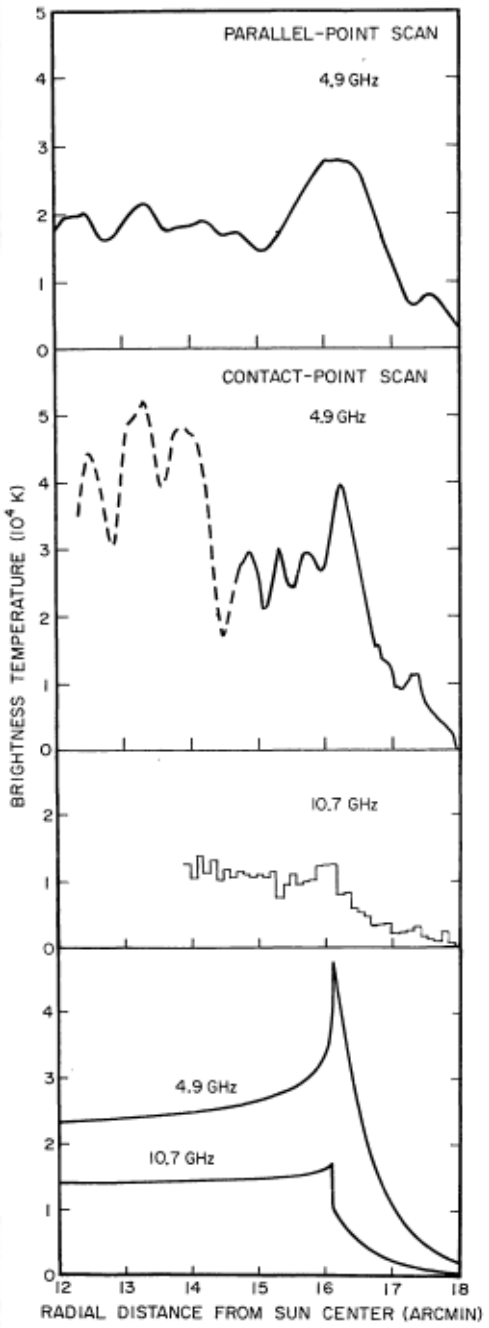
3. Solar Limb during the Eclipse

- Moon as an occulting disk provides great angular resolution for limb brightening measurements (Shimabukuro et al., 1975)

- Measurements of limb brightening at mm wavelength are important in the study of the chromospheric models?

Solar limb at 4.9 and 10.7 GHz during the Solar Eclipse





Marsh, Hurford and Zirin, Astron. Astrophys, 1981

Solar limb at 4.9 and 10.7 GHz during the Solar Eclipse

- Limb brightening at 4.9 GHz with T_b=40,000 K
- Little or no measurable limb brightening at 10.7 GHz

Marsh, Hurford and Zirin, Astron. Astrophys, 1981

4. Magnetic Field of the Solar active regions

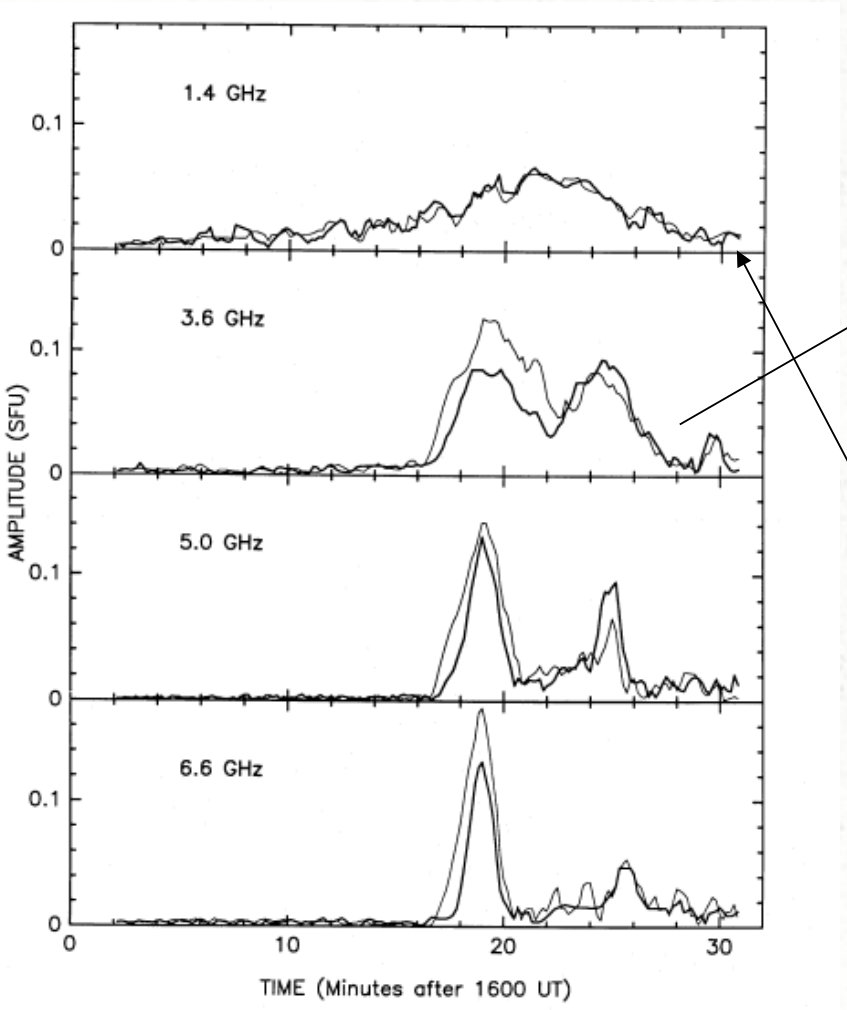
- The electron gyrofrequency for magnetic field strengths of ~100-2000 G

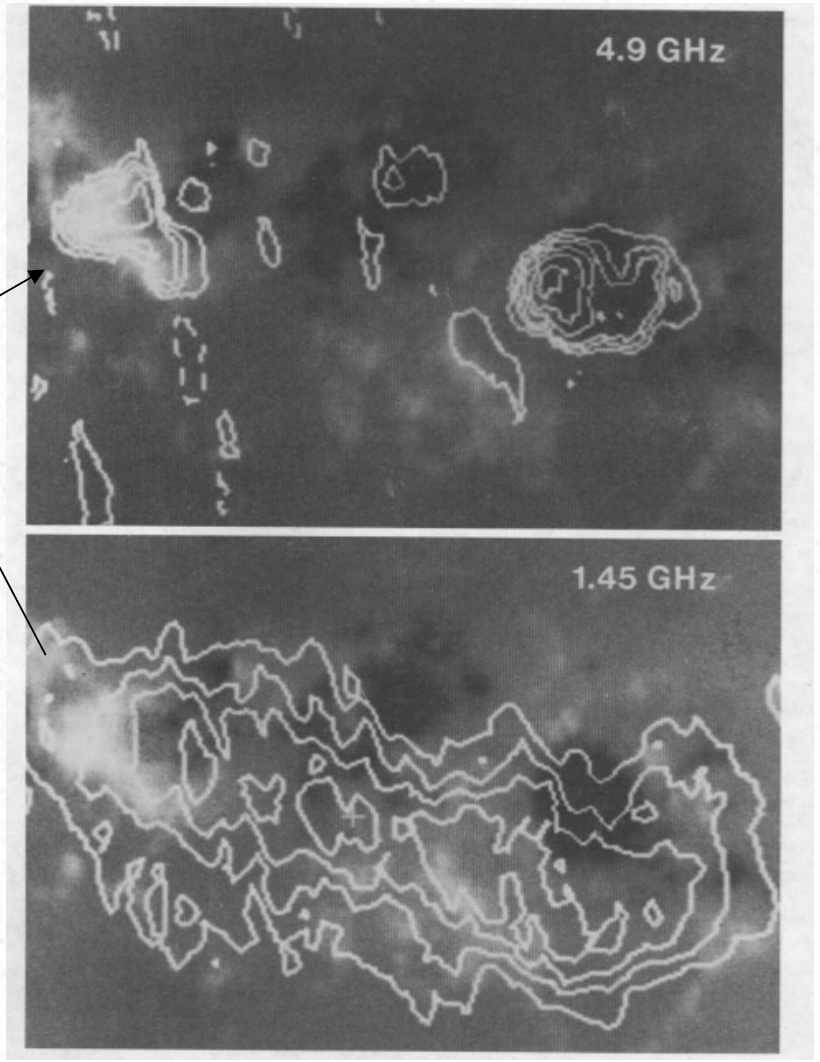
- Gyrofrequency

$$\nu_B = 2.8 \times 10^6 B.$$

is strong wherever B > 300 G

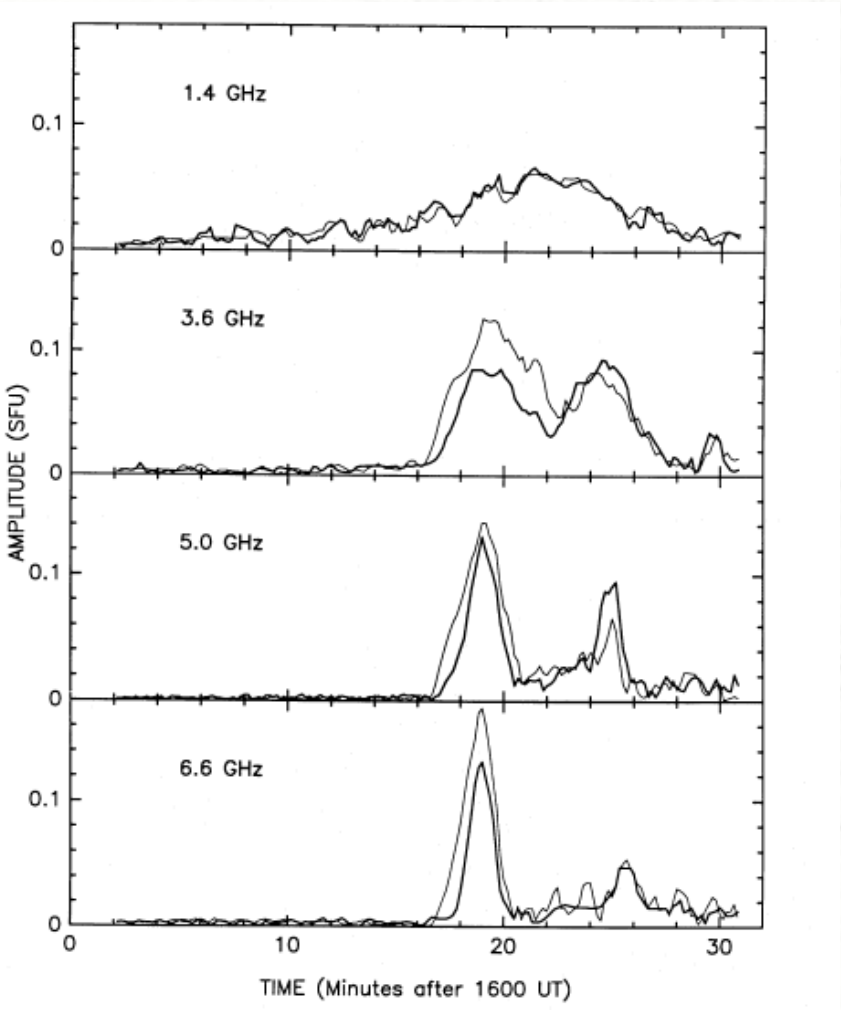
Multifrequency Observations of a Solar Active Region

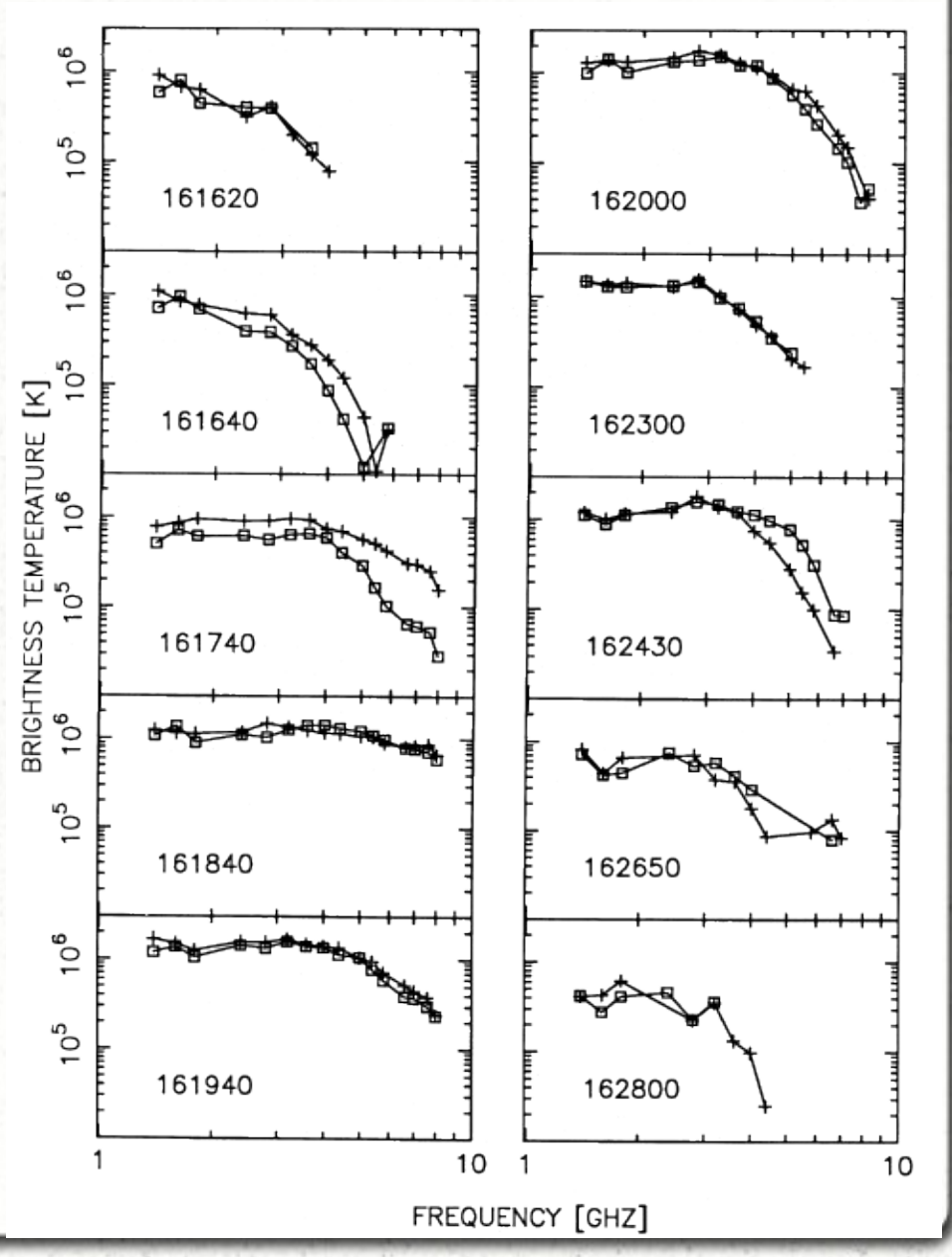




Gary and Hurford, ApJ, 1987

Multifrequency Observations of a Solar Active Region





Gary and Hurford, ApJ, 1987

Multifrequency Observations of a Solar Active Region

- Direct observation of the change in the emission mechanism
  - Free-free —> Gyroresonance
    - 3 GHz

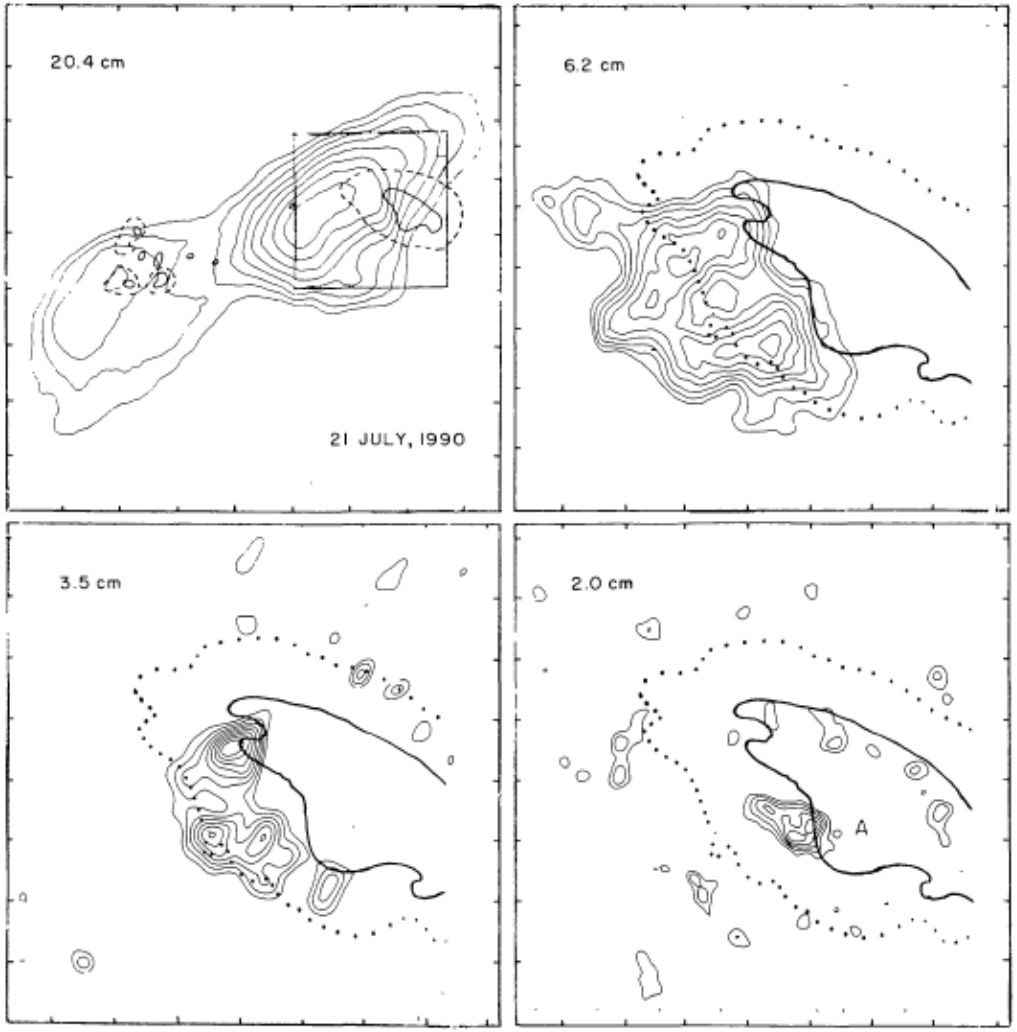
Gary and Hurford, ApJ, 1987

Gyroresonance emission

- High frequencies – emission above the sunspots

- Low frequencies – emission near magnetic neutral lines of the loops joining underlying sunspots

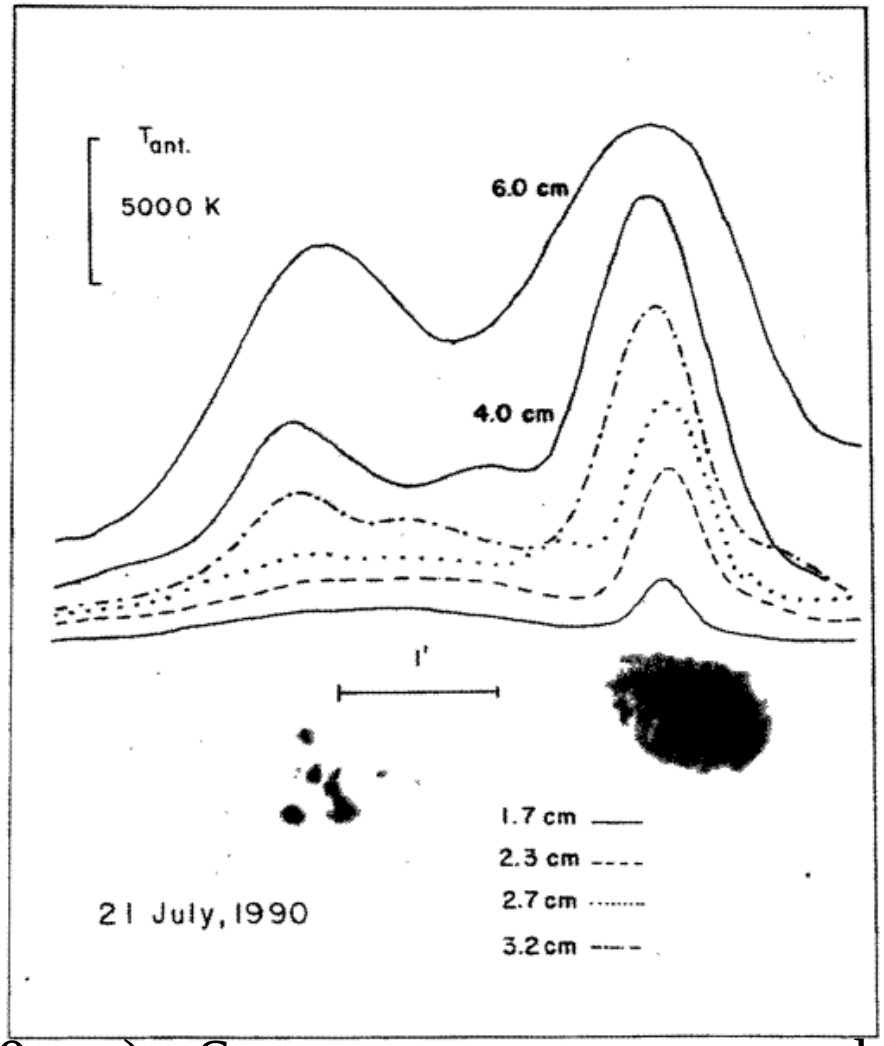
Very Large Array-RATAN 600 observations of a solar active region



VLA maps show shift in the emission away from the leading spot with increasing wavelength

Bogod et al, SolPhy, 1992

Very Large Array-RATAN 600 observations of a solar active region



RATAN (1.7 -4.0 cm) - Stronger sunspot source shifts inward toward the center of the AR with increasing wavelength

Bogod et al, SolPhy, 1992

Very Large Array-RATAN 600 observations of a solar active region

- Compact sources of size 10-40" with T_b=0.2-2.2 x 10^6 K above penumbra (2, 3.5, and 6.2 cm)
- Extended looplike structure of size 4.5' with $T_b \sim 10^6$ K between dominant spots (20 cm)
- Comparisons with the predicted gyroresonance radiation indicate source heights of 2500-17500 km

Summary

During Eclipse, in **Radio wavelengths**

- 1965, Emission above the sunspots *by Abbasov et al.*,
- 1980, 2.5" x 12.7", Correlation of the chromospheric network, Quite Sun *by Marsh, Hurford & Zirin*
- 1981, 13.8" and 7.4", Limb brightening, Solar limb *by Marsh, Hurford & Zirin*
- 1987, 2.6", Structure and characteristics of solar active region with emission mechanism during eclipse *by Gary & Hurford*
- 1992, Structure and emission mechanism in solar active region around the time of eclipse *by Bogod et al.*,
- 2012, 1.2", Observations with JVLA for active regions

Current Study

- JVLA 2 to 4 GHz observation of the annular eclipse
- The peak and the height of the differenced emission light curves show the core of the radio sources over the active region
- Active region picture with differencing technique
- Correlation with the other wavelength data

Challenges in the current study

- Delay clunking – solved- reduced frequency resolution
- Calibration – Attempt with self-calibration

Ongoing work

- Calibration – CASA and AIPS

References

1. Abbasov A. R., Grebinskiy A. S., Durasova M. S., and Yasnov L. V., NASA, 1965

2. Bogod V. M., Gelfreikh G. B., Willson R. F., Lang K. R., Opeikina L.V., Shatilov V., and Tsvetkov S. V. 1992, SolPhy, 141, 303-323

3. Gary, Dale E., and Hurford, G. J. 1987, Astrophys. J, 317:522-533

4. Marsh, K. A., Hurford, G. J., and Zirin, H. 1980, Astrophys. J, 236:1017-1025

–. 1981, Astron. Astrophys, 94, 67-71

1. Shimabukuro et al., SolPhy, 40, 359-370, 1975

2. Solar and Space weather radiophysics, Gary, Dale E., Keller, Christoph U.,

3. Physics of the solar corona, Aschwanden Markus

Thank you