Different properties of microwave and decimetric QPPs in a solar radio burst

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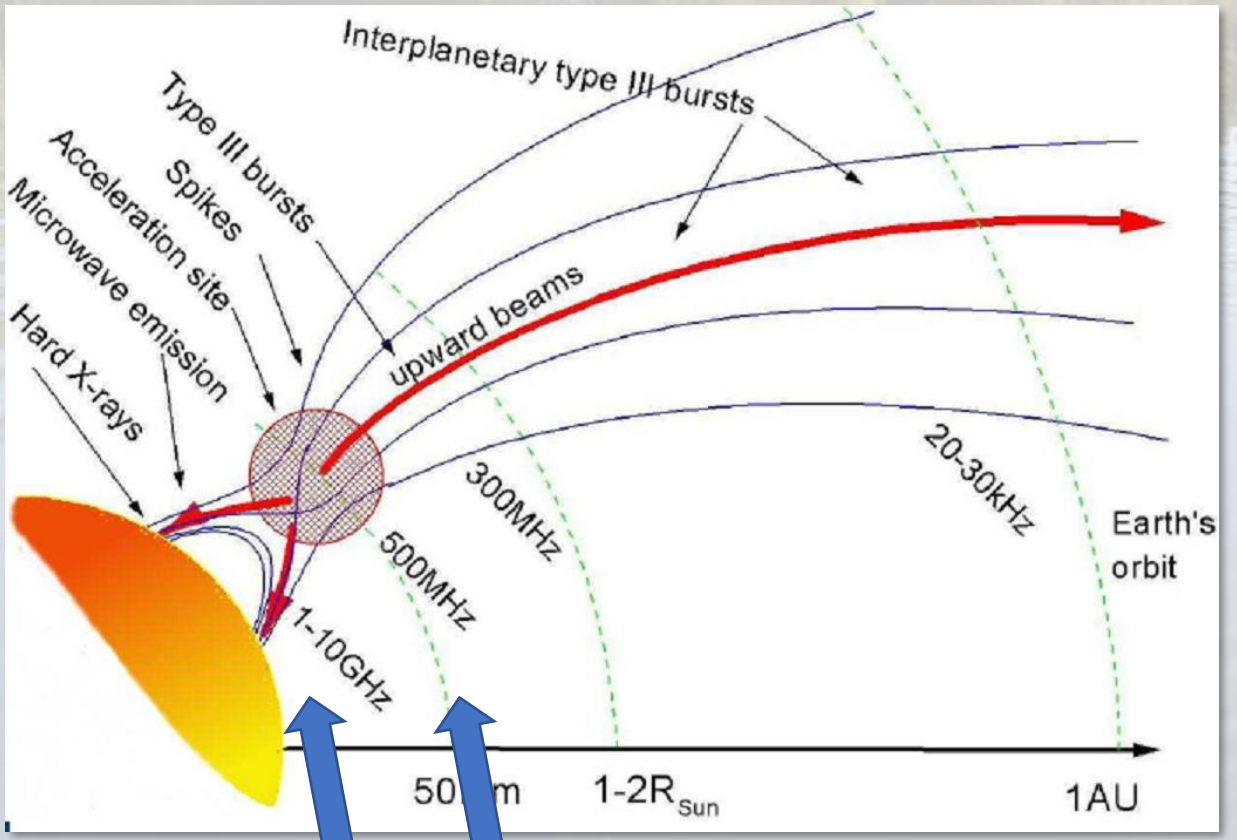
Introduction

Standard solar flare model



Gyro-synchrotron

Plasma mechanism

Ambiguity of the relationship between the microwave and decimetric emissions

Quasi-periodic pulsations (QPPs) are a helpful tool for diagnostics because of their connection with MHD processes

The aim:
to find and to study relationships between QPPs in the microwave and decimeter bands,
and to search for appropriate scenario

(Fig.: from Kontar et al. 2009 http://www.astro.gla.ac.uk/solaire/RHESSI_MATERIAL/rhessi_imaging.pdf)

Instruments: new-generation radioheliographs

Siberian Radioheliograph-48
(SRH-48)
4-8 GHz

Mingantu Spectral Radioheliograph
(MUSER)
0.4-2 GHz (Δt=0.25), 2-15 GHz

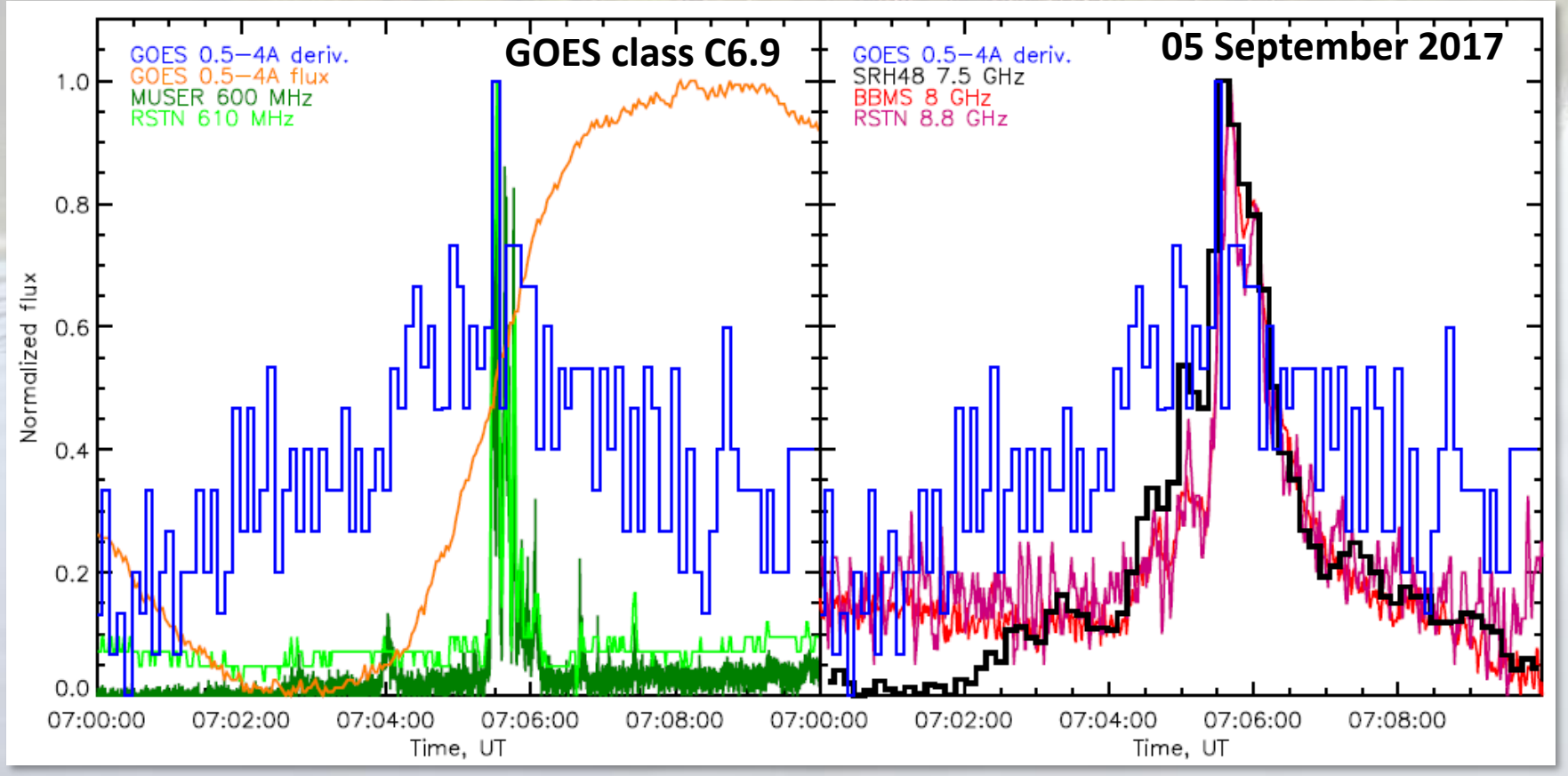
… as well as

RSTN

BBMS

GOES

Time profiles

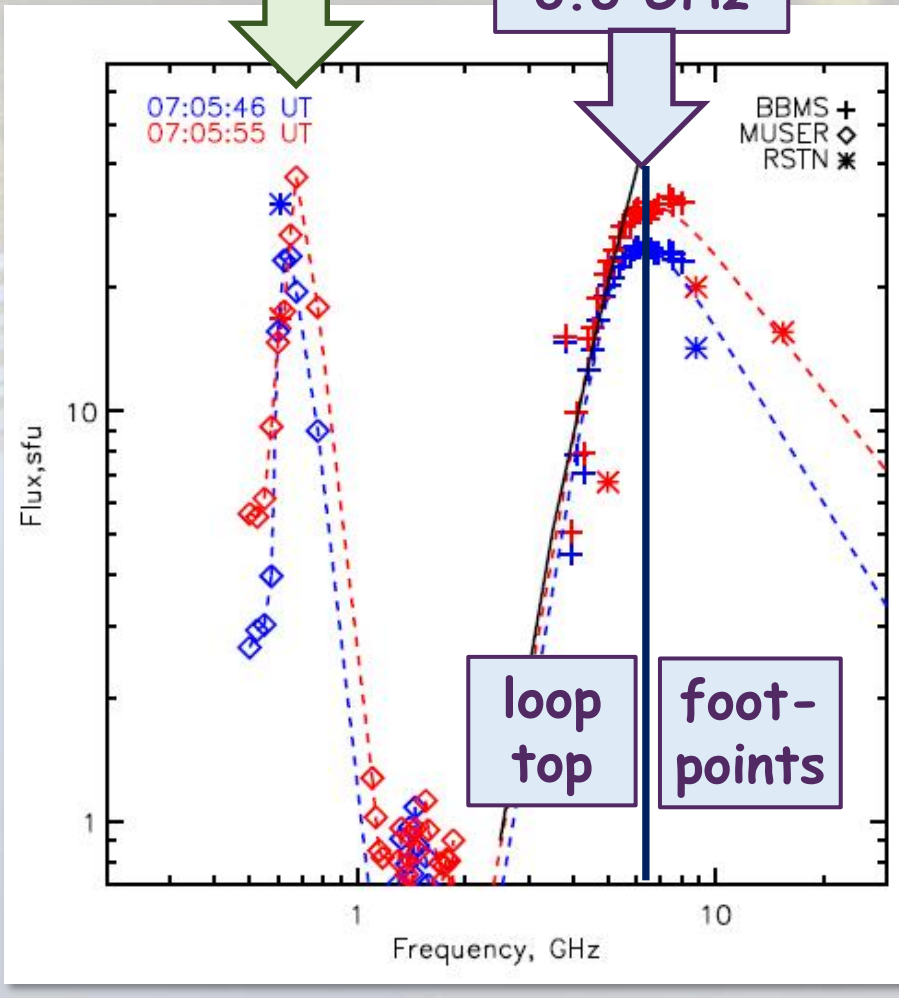


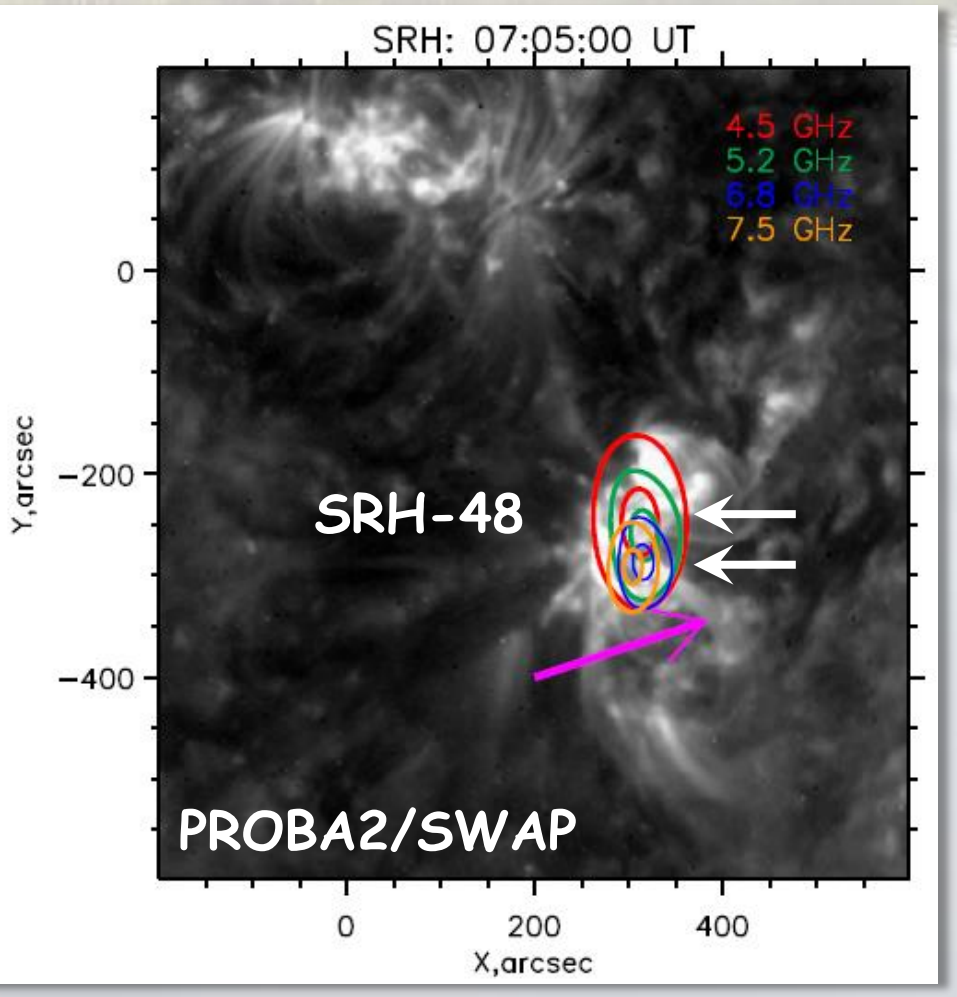
- The cross-instrumental analysis at similar frequencies => solar origin of the variations.
- MW and the SXR derivative time profiles => the absence of the magnetic trap in the flare topology.
- The 600 MHz burst occurred at the maximum of the time profile of the SXR derivative.

Spectra and spatial structure

675 MHz

6.6 GHz





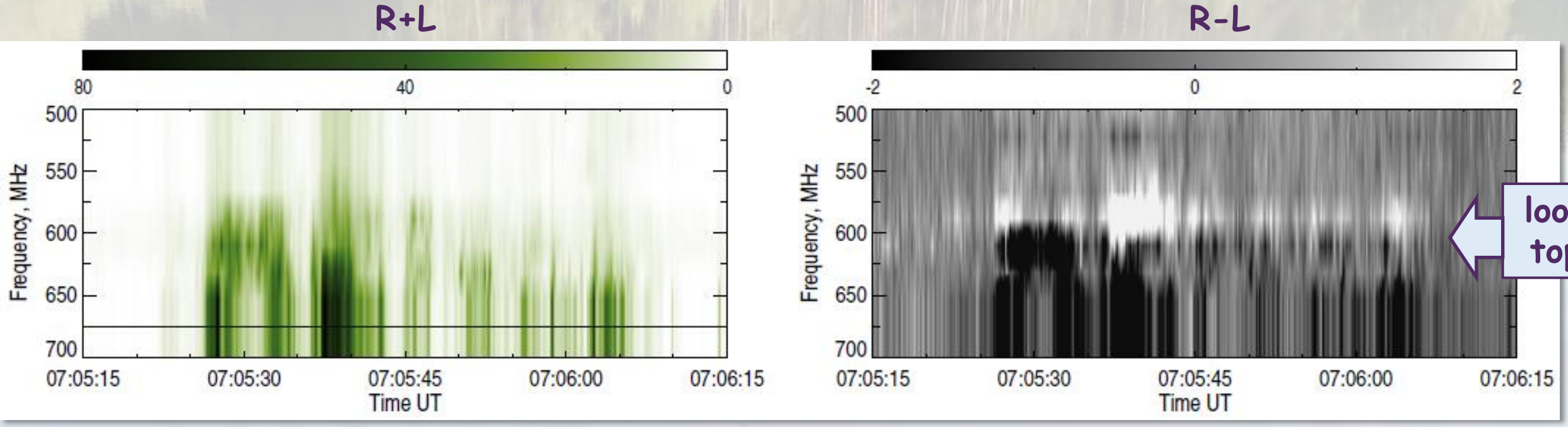
Preflare microwave image was subtracted to exclude effect of gyroresonance emission

Distance between centroids is 43'' => a loop height 41 Mm

Narrowband plasma emission

Gyrosynchrotron spectrum, photon spectral indices are 2.9 and 2.5 for two moments. No Razin effect => the density is not anomalously high

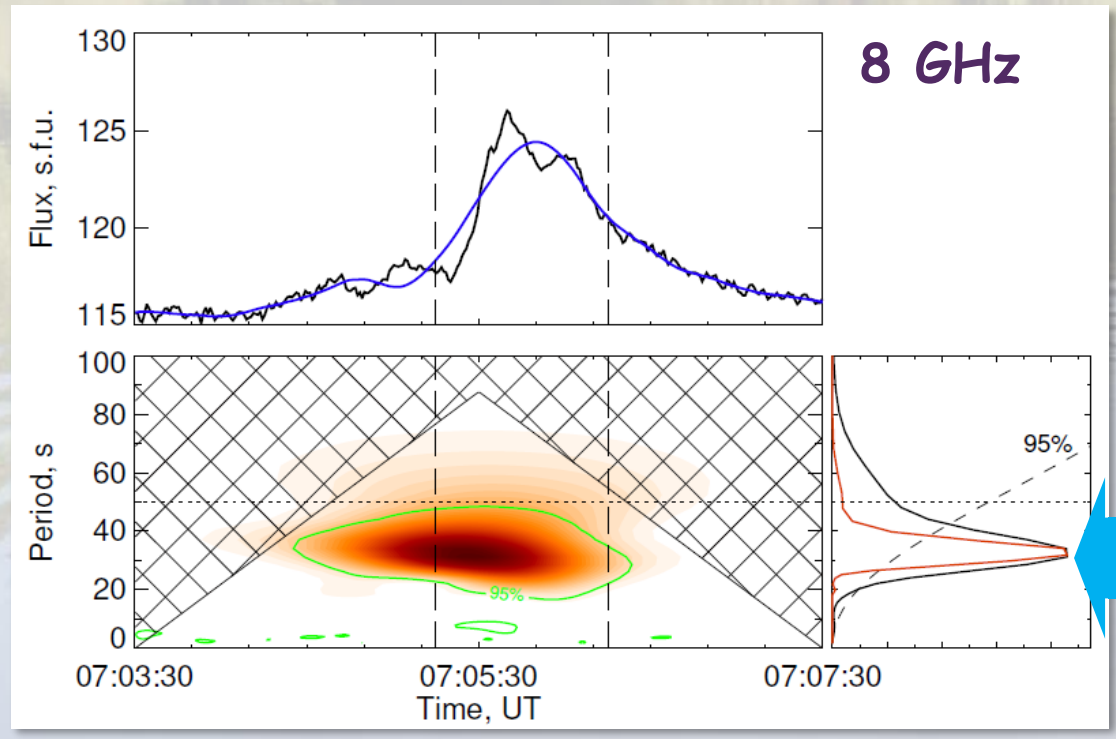
Dynamic spectra



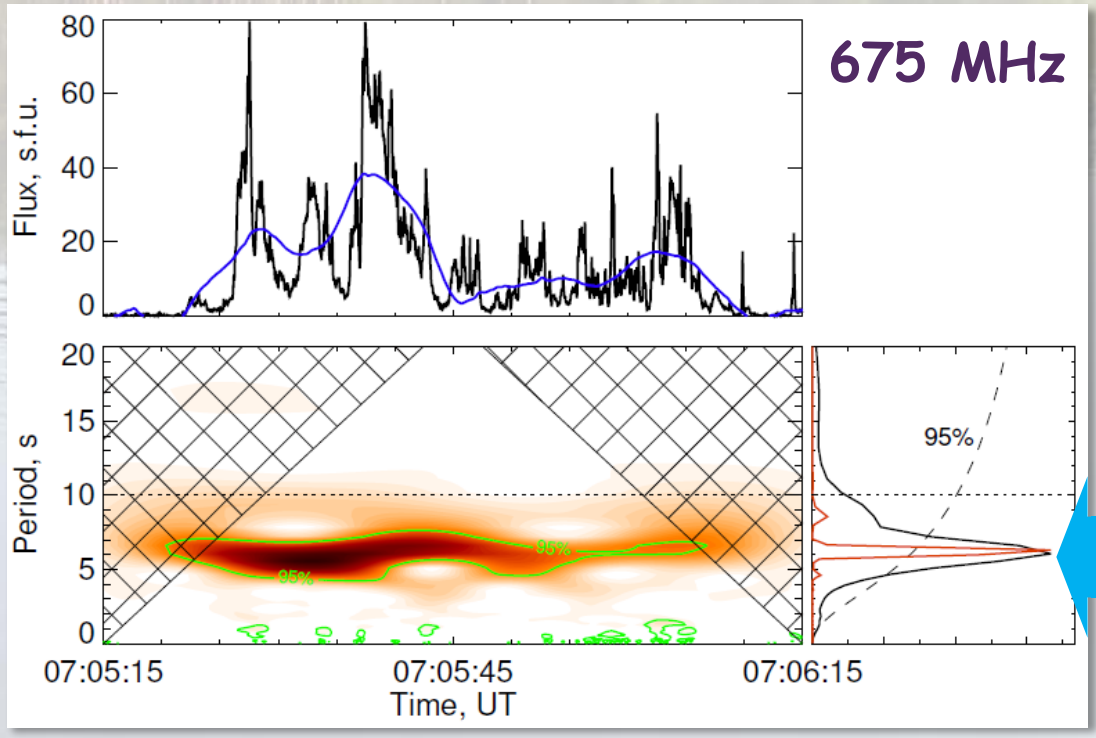
The classical type I noise storms: are narrow bandwidth and short duration and are usually observed below 400-450 MHz and locate at about 1.2 of the solar radius (Mercier et al., 2015). Non-thermal emission of electrons.

- Polarisation indicates the non-thermal origin of the emission.
- The sign of polarisation does not change with time.
- Inversion at frequencies ~600 MHz.
- The detected change of the polarisation sing indicates that the emission at those frequencies could originate near the top of a high loop

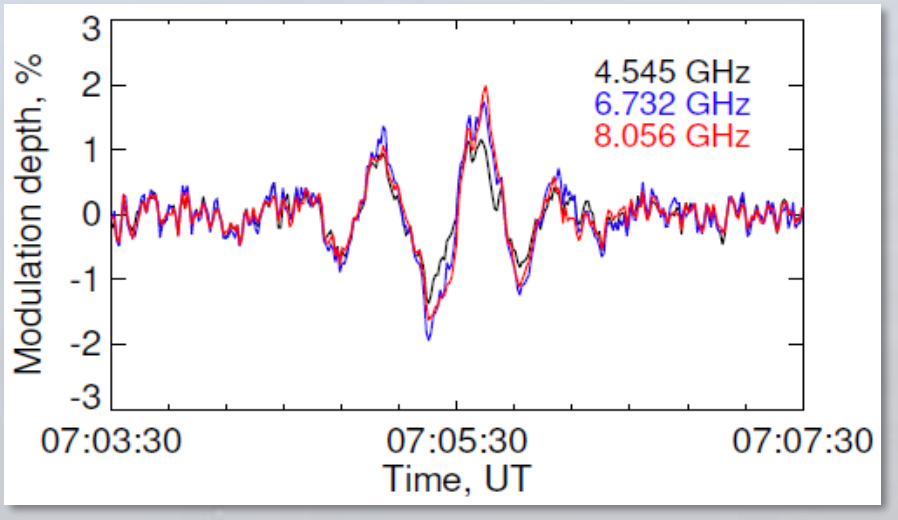
Analysis of the periods

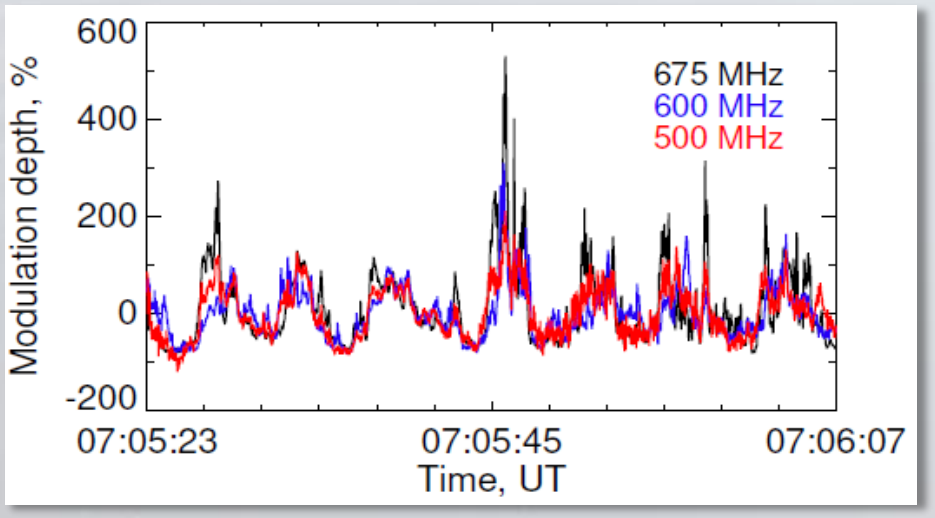


30 s



6 s





Results

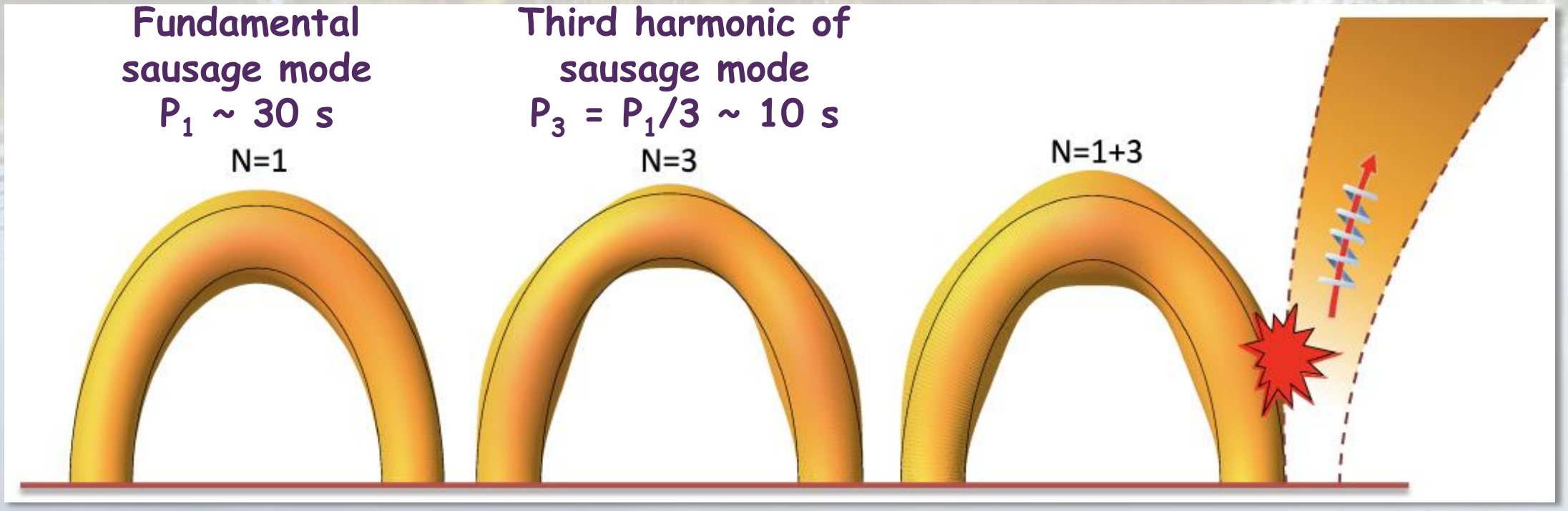
Microwaves

1. Three clear cycles with the oscillation period of about 30 s.
2. Both the peak frequency of the microwave spectrum and photon spectral index did not change during the QPPs.
3. The spectral index at low frequencies indicates the absence of the Razin effect.
4. Time profiles of the MW oscillations demonstrate an in-phase behaviour both in the optically thick and optically thin emissions.
5. The modulation depth of the oscillations is similar at different frequencies, and its values are about a few percent.

Decimeters

1. At least seven oscillation cycles with the period of about 6 s.
2. The frequency of the maximum intensity is about 675 MHz, and it did not change during the event.
3. The QPPs appear in the narrow spectral band 500-700 MHz.
4. The sign of Stokes parameter V did not change in time during the event, but it changed over the frequency.
5. Time profiles of the decimeter oscillations demonstrate an in-phase behaviour.
6. The modulation depth of the oscillations is about 100%.

A schematic illustration of a spatial structure and conclusion



- The fundamental sausage mode modulates microwave emission with period 30 s.
- The sausage-oscillating loop (its third harmonic) modulates the plasma conditions at the interface, in particular, the local electric current density with the period $P_3 = P_1/3$ ~ 10 s.
- The extreme values of the current density are achieved at both positive and negative half-cycles of the oscillation (Nakariakov et al., 2006) => ~ 5 s seen in decimetric band.