Intrinsic Short Term Variability in W3-OH and W49N Hydroxyl Masers

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The method-W3 OH

- Use the VLBA with a beam of 5 mas and a velocity resolution of 0.1 km/s. Only simple sources are analyzed. ie no confusion from multiple components within the 2 arc sec maser region. We use the bright sources that are spatially isolated and with no prominent velocity gradient over the source

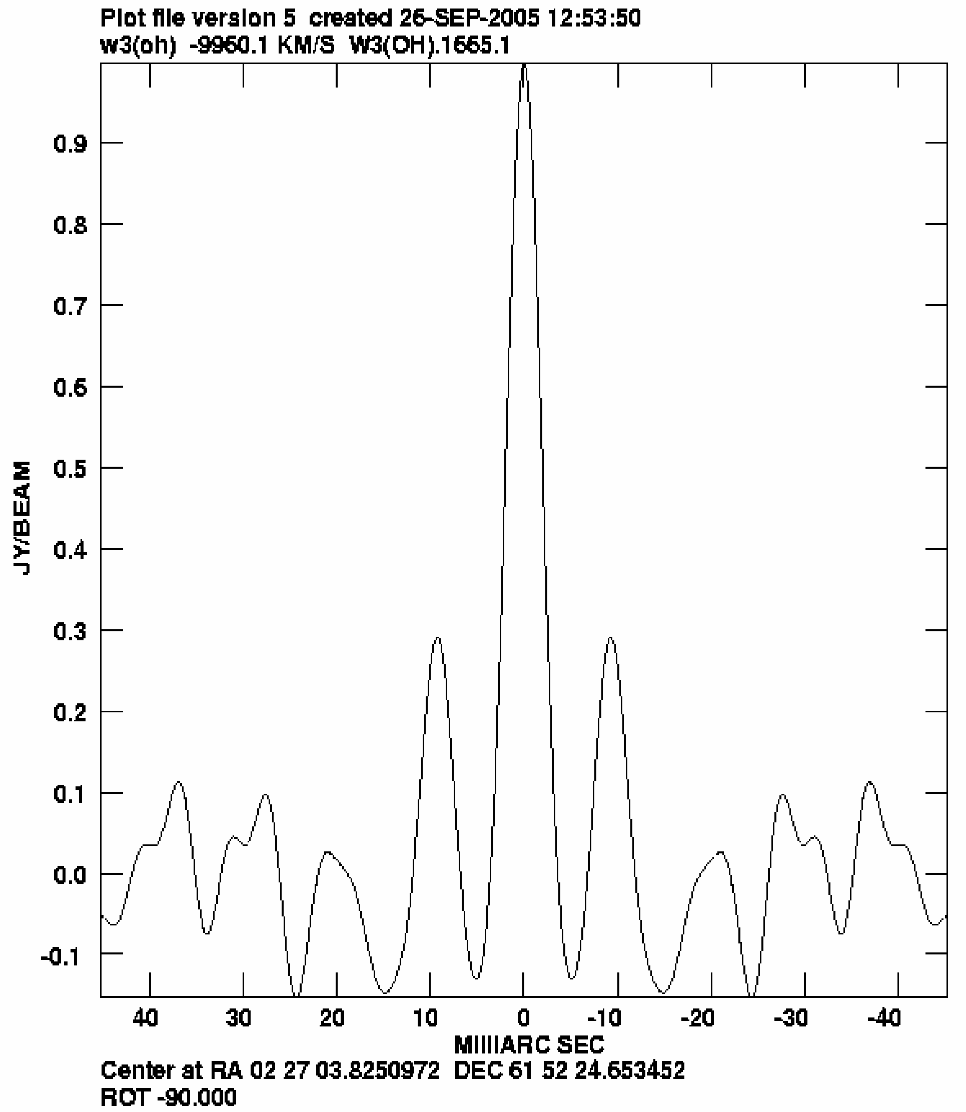
- 12 hour observations, and find that we can analyze successfully snap-shots of 1 min intervals. About 400 or so time samples. Good signal to noise for sources > 10 Jy/beam

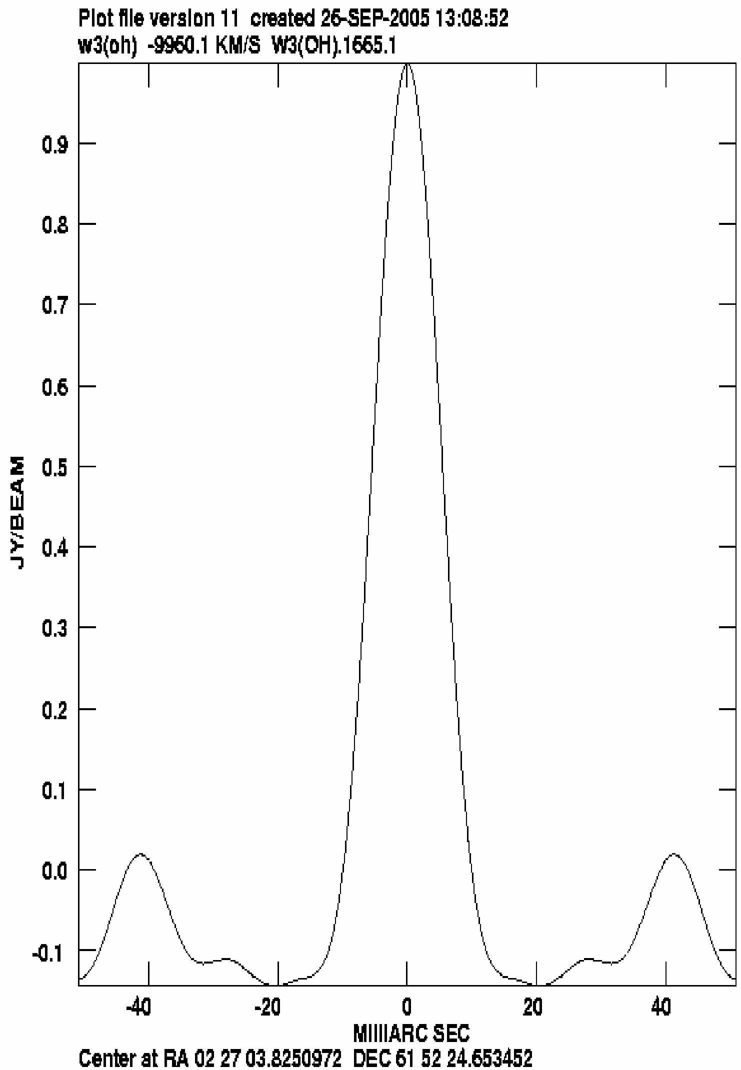
- For each line we have S(velocity, time, polarization)

Previous results on W3-OH

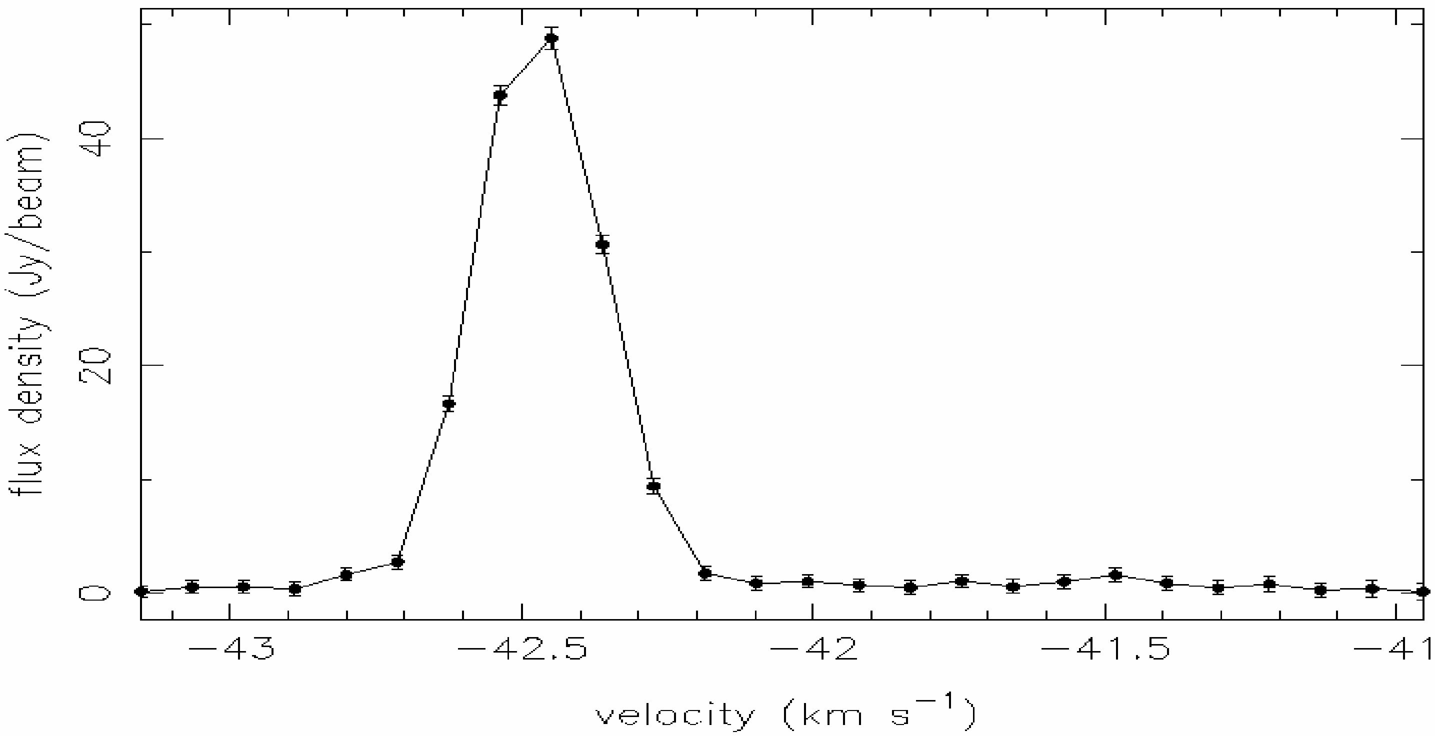
- Use the data of Wright, Gray and Diamond-2004 for 1612, 1665 and 1720.Observed in August 1996 with the VLBA. All Stokes parameters.
- 1667 MHz no isolated simple components.
- Zeeman pairs at 1612 and 1720 MHz.
- Published in ApJ, vol 653, Dec 20 2006.

RA and Dec cut





Profile at 1665 for one min



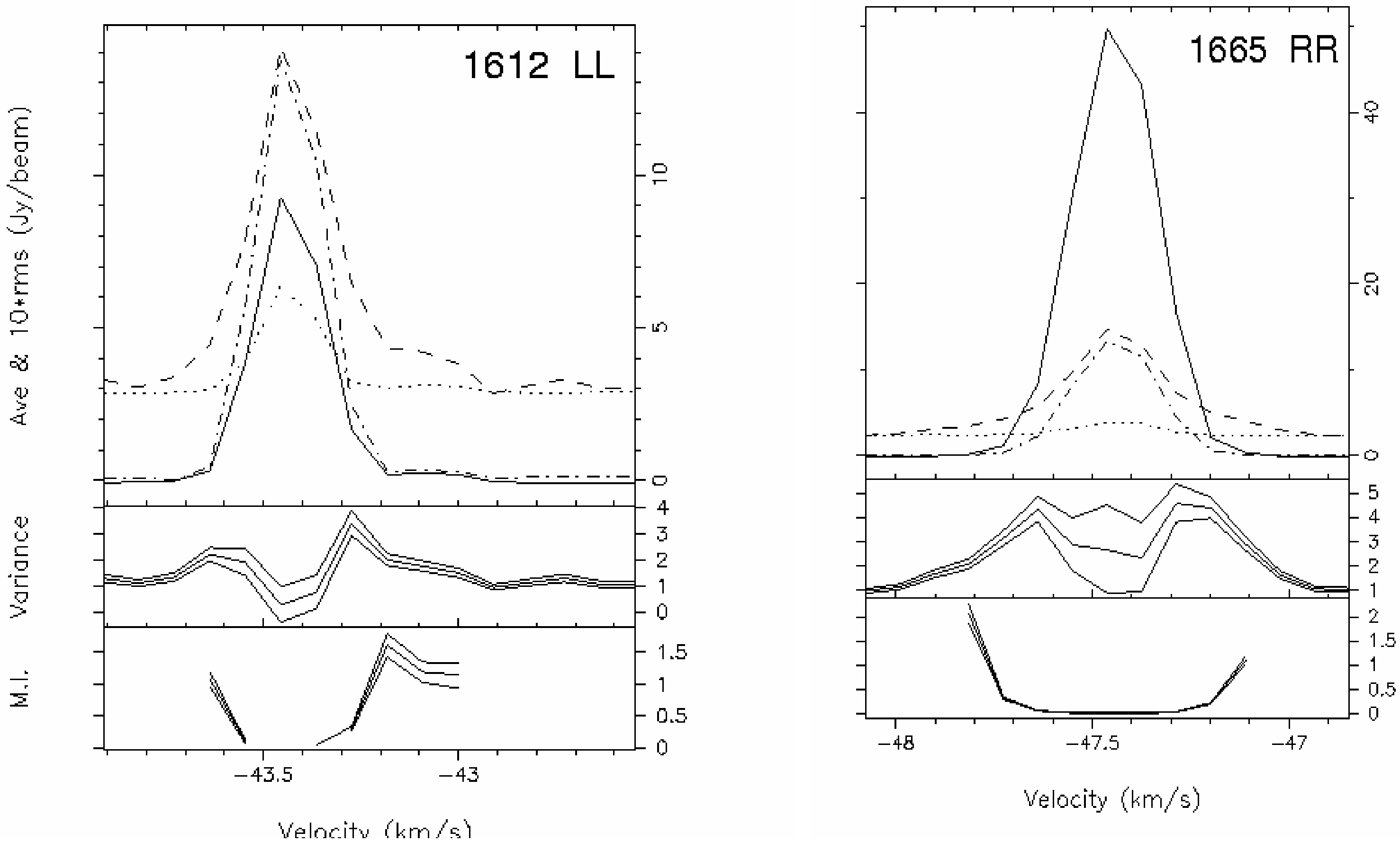
The method continued

- We must separate the extrinsic sources of variability in order to isolate the possible sources of *intrinsic* variability- assumed to be narrow bandwidth (e.g. < 0.5 km/s)
- Diffractive scintillations. Estimate the decorrelation bandwidth and the diffractive scintillation timescale. The former is estimated to be greater than 35 kHz- much greater than the 1-2 kHz line widths
- Also expect that instrumental gain instability are expected to correlated over a velocity range much larger than the line widths and treated as *broadband- common to all observed spectral channels*

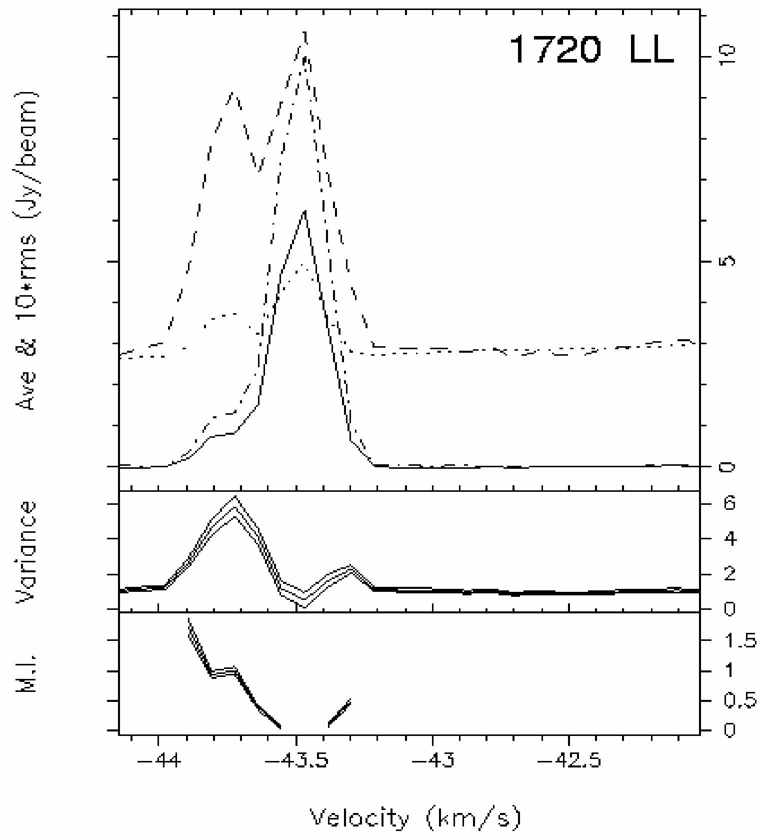
Method-continued

- In the end we look for narrowband variations that are distinguishable from the instrumental and interstellar effects
- The paper shows the details – cross correlations between the intensity fluctuations in all velocity-channel pairs. We separate the noise components with broadband components (amplitude modulation) , measurement uncertainty (take into account the increase noise due to the presence of the maser at a particular velocity) and POSSIBLE intrinsic narrow band fluctuation.

Solid-observed. Then three sigmas times ten: observed variance dashed,measurement noise dotted,bb modulation dot-dashed



Second panel is observed nb variance divided by measurement noise



Velocity Resolved Fluctuation Spectra- few min to 12.5 hour

- Based on the same ideas as Longitude Resolved Fluctuation Spectral Analysis for Pulsars .
- Here we normalize by the peak of the profile since the correlation based procedure for the BB correction produces TIME AVERAGED quantities.
- Fluctuation Power Spectra for each velocity channel separately- where a single temporal sequence is Fourier transformed and the power at each frequency is calculated

From Deshpande and Rankin

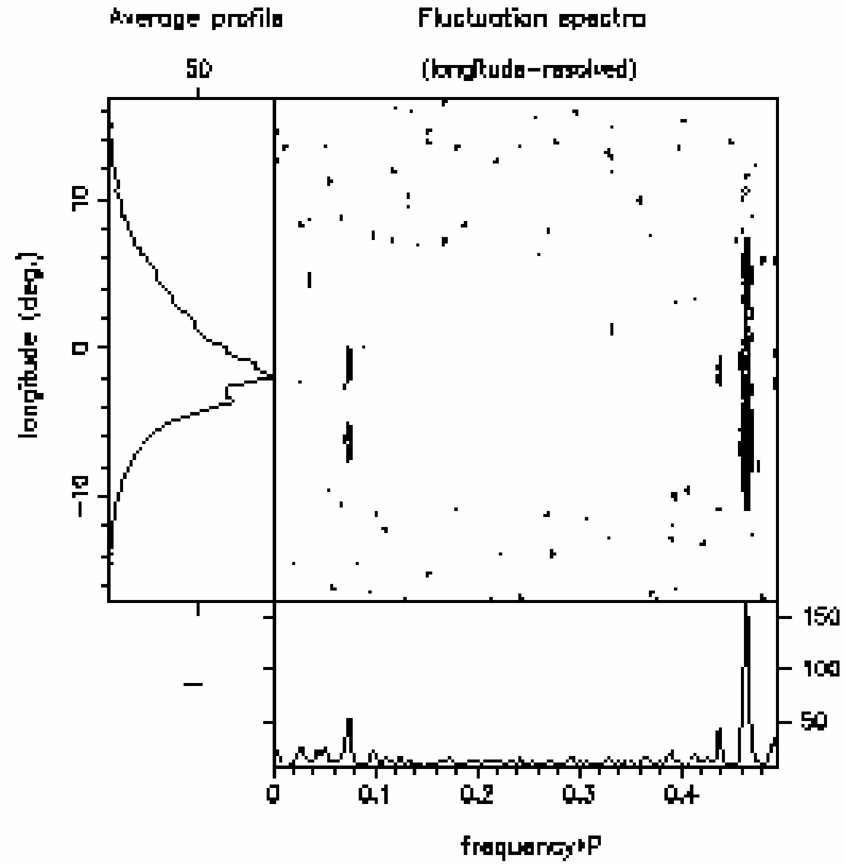
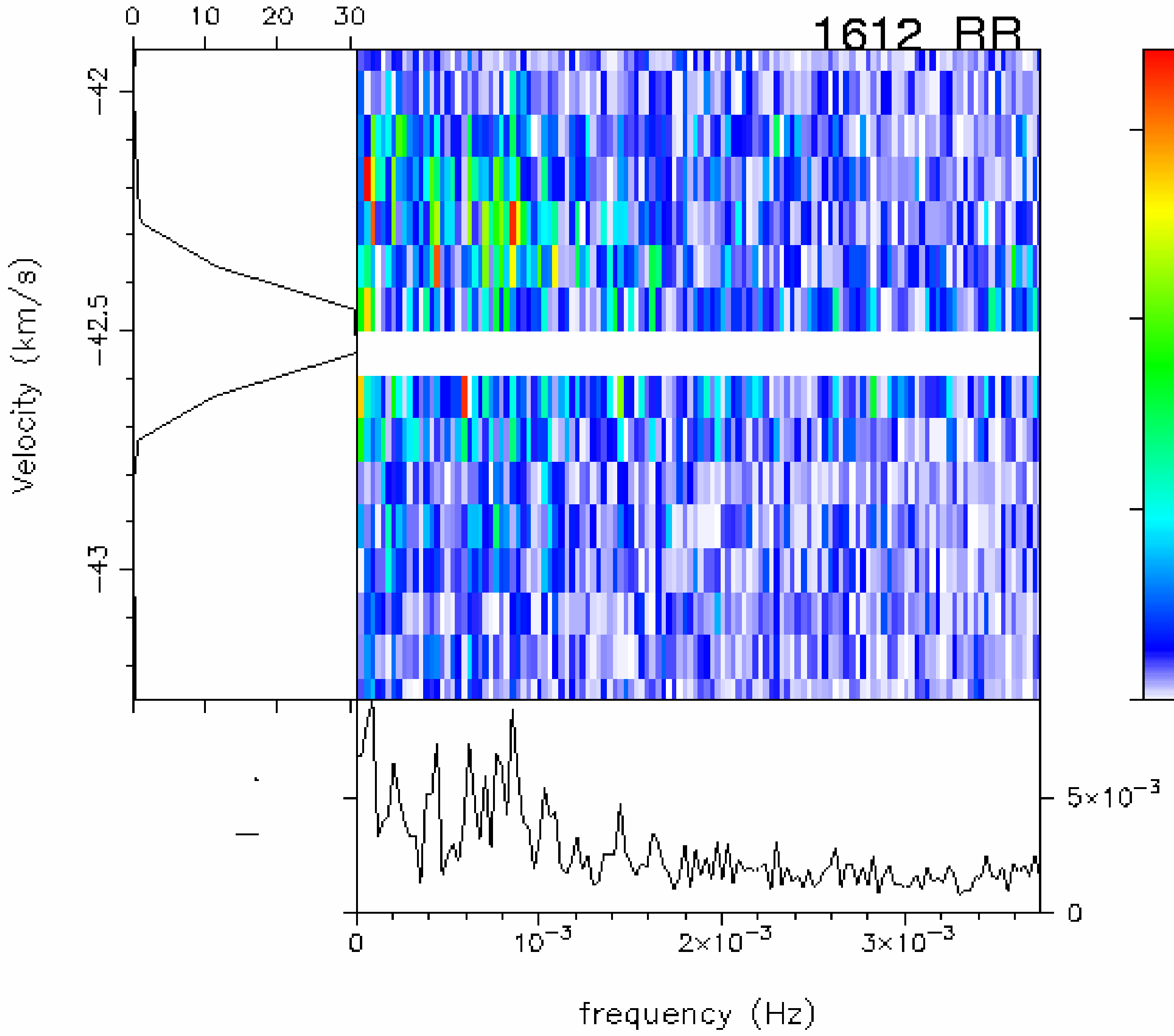
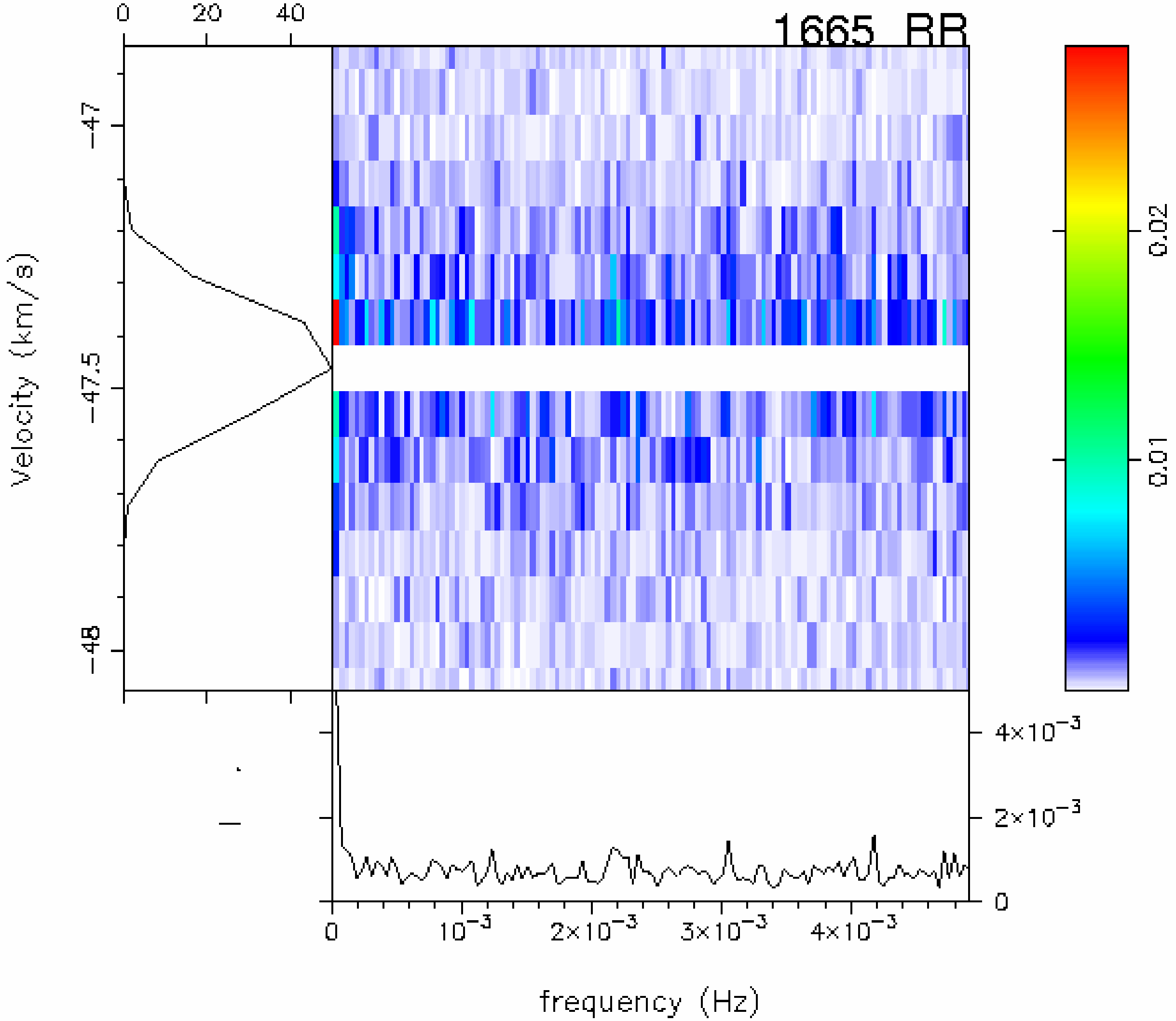


FIG. 2—Fluctuation-spectral power (*center panel*) as a function of lon gitude and frequency as well as the integral spectrum (*bottom panel*). Not the primary and secondary features at about 0.46 and 0.07 cP_1^{-1} as well a the symmetrical sidebands around the former.



1612 RR
0
10
20
30
−42
−42.5
−43
Velocity (km/s)
0.03
0.02
0.01
0
5×10⁻³
0
10⁻³
2×10⁻³
3×10⁻³
frequency (Hz)



1665 RR
0
20
40
-47
-47.5
-48
Velocity (km/s)
0.02
0.01
4×10^{-3}
2×10^{-3}
0
10^{-3}
3×10^{-3}
frequency (Hz)

Time scales

- Fluctuations up to 10^{-3} Hz or time scales >15-20 min- after the normalization has removed any extrinsic variability
- Palmer and Goss have measured sizes of the maser spots of about 3 mas – or 6 AU at the adopted distance of 2 kpc (Xu et al and Hachisuka et al -2006)
- If the time scale reflects the dimension of the source based on travel time then the inferred longitudinal scale would be 2-5 AU.

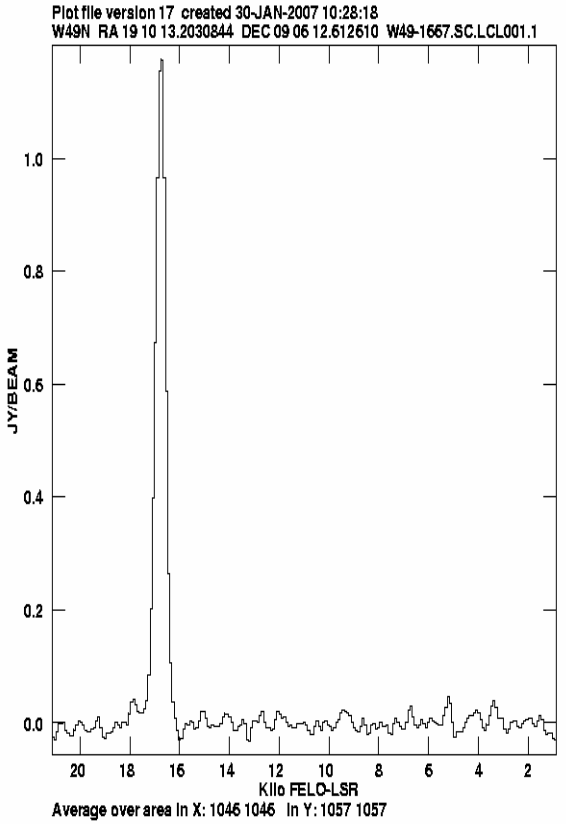
New Data from VLBA 2005-W3OH and now W49N

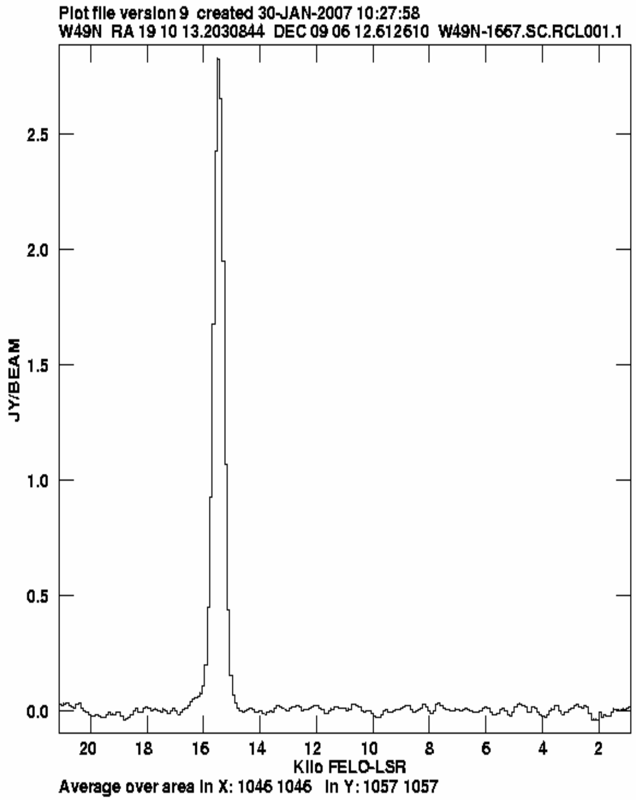
- Here some preliminary results from W49N
- 1612,1665 and 1667 MHz data
- Beam is 19 mas – scatter broadened source with typical size 40 mas and axial ratio about 1.5 to 2. Alignment is minor axis parallel to the galactic plane

1667 MHz Zeeman pair

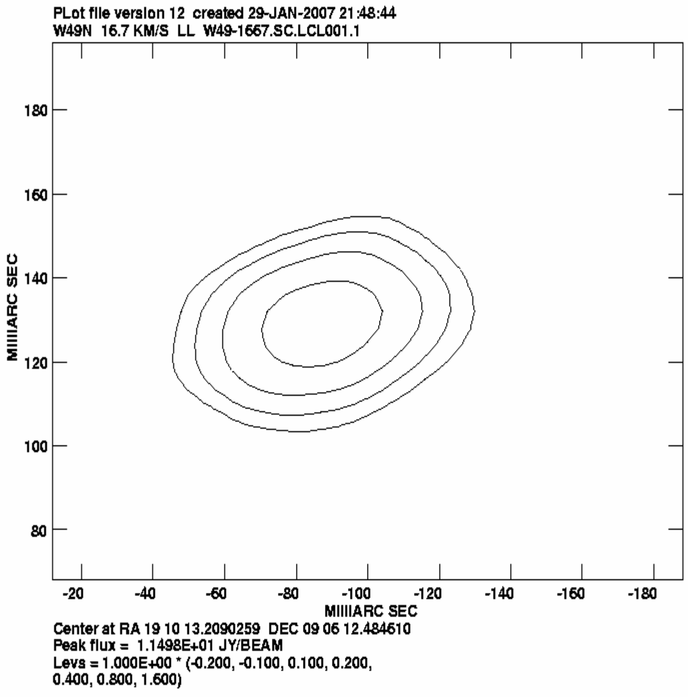
LH RH

Major axis 38 mas - Minor 19mas

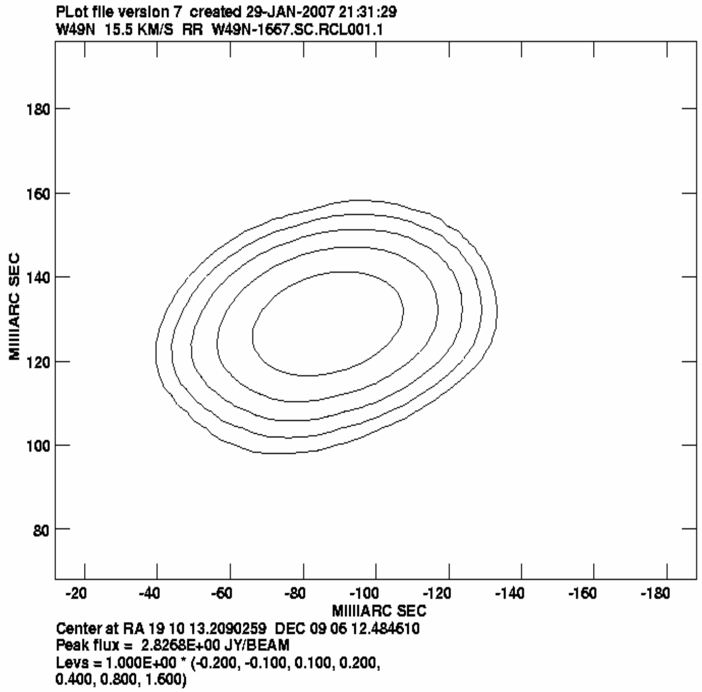




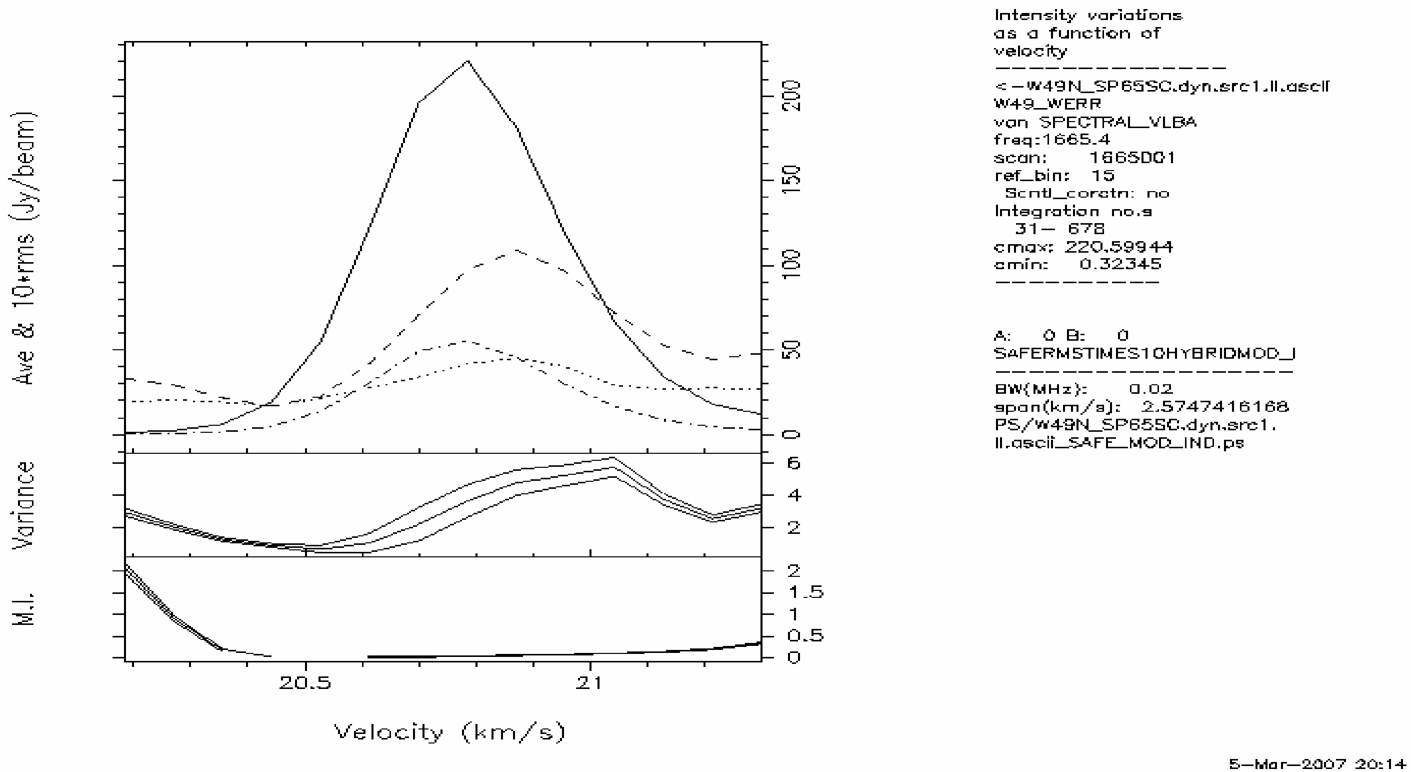
LH


PLot file version 12 created 29-JAN-2007 21:48:44
W49N 16.7 KM/S LL W49-1667.SC.LCL001.1
MIlliARC SEC
MIlliARC SEC
Center at RA 19 10 13.2090259 DEC 09 06 12.484610
Peak flux = 1.1498E+01 JY/BEAM
Levs = 1.000E+00 * (-0.200, -0.100, 0.100, 0.200,
0.400, 0.800, 1.600)

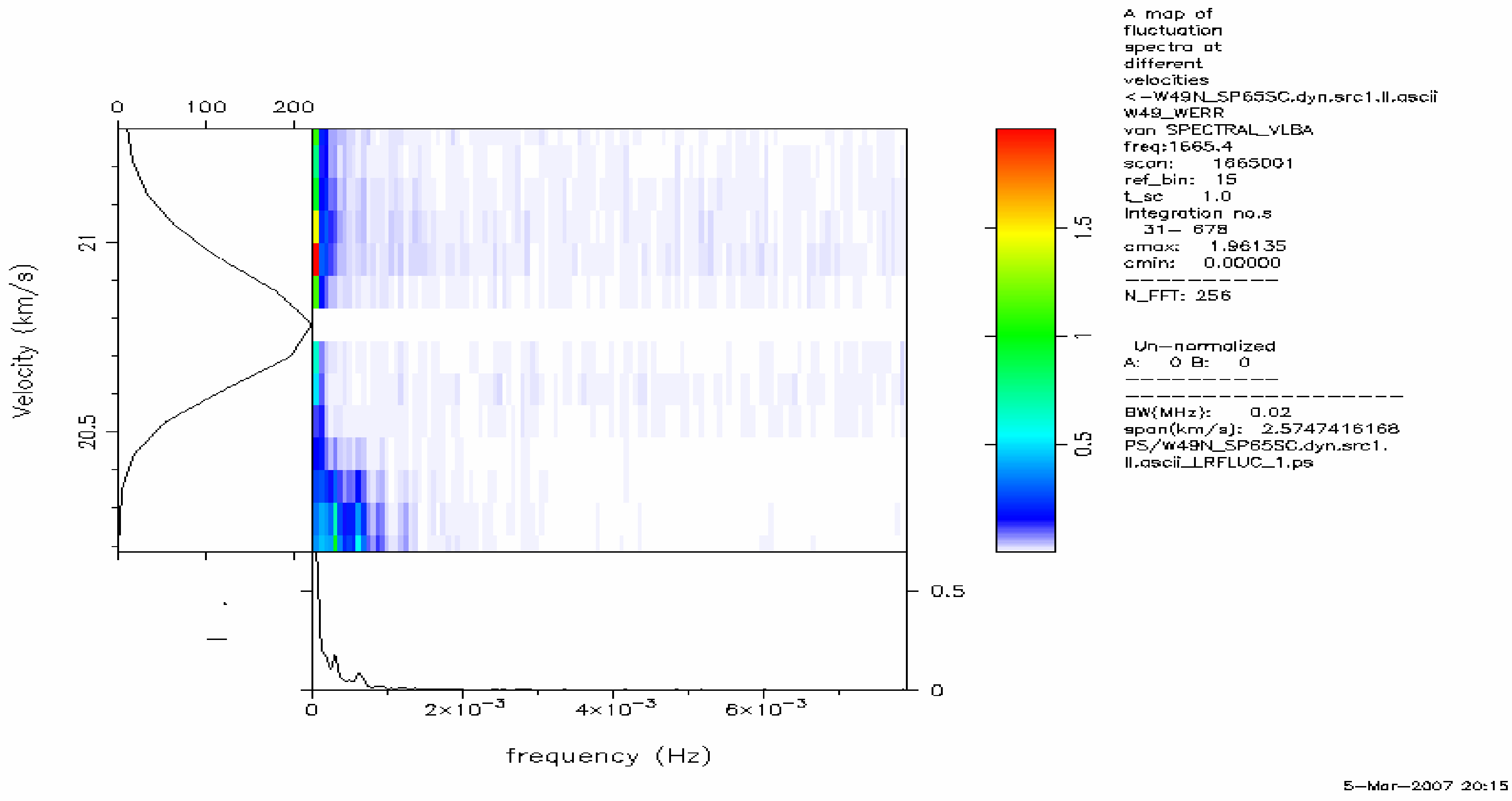
RH


PLot file version 7 created 29-JAN-2007 21:31:29
W49N 15.5 KM/S RR W49N-1667.SC.RCL001.1
MIlliARC SEC
MIlliARC SEC
Center at RA 19 10 13.2090259 DEC 09 06 12.484610
Peak flux = 2.8268E+00 JY/BEAM
Levs = 1.000E+00 * (-0.200, -0.100, 0.100, 0.200,
0.400, 0.800, 1.600)

1665 MHz W49N source



1665 W49N



A map of fluctuation spectra at different velocities
<-W49N_SP65SC.dyn.src1.ll.ascii
W49_WERR
von SPECTRAL_VLBA
freq:1665.4
scan: 1665001
ref_bin: 15
t_sc 1.0
Integration no.s 31- 678
cmax: 1.96135
cmin: 0.00000
N_FFT: 256
Un-normalized
A: 0 B: 0
BW(MHz): 0.02
span(km/s): 2.5747416168
PS/W49N_SP65SC.dyn.src1.ll.ascii_LRFLUC_1.ps
Velocity (km/s)
frequency (Hz)
5-Mar-2007 20:15

Summary

- We have proposed a method to combine the cross correlation procedure and the variance analysis to create an effective tool for estimation of and the elimination of the “broadband “ contribution from instrumental effects and interstellar diffractive scintillations and thus identify the instrinsic and “narrowband” variations.

Summary continued

- Intrinsic narrowband variability is observed over most of the profile except at the peak
- The velocity resolved fluctuation spectra suggest intrinsic variability of 15-20 min or longer for W3OH and longer at the hour range for W49N.
- We observe many scattered maser spots in W49- a source of information about the scattering and magnetic structure functions over a scale of 20-30 AU.