86GHz VLBP of OVV 1633+382 after a major mm flare

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Overview

- OVV 1633+382
- 3mm VLBP monitoring
- D-term correction
- EVPA check
- AGN at mm wavelength
- mm VLBP
- mm VLBI with KVN
OVV 1633+382 (4C 38.41)

- $z=1.814$, QSO, Optically Violently Variable (OVV)
  $\Delta B \sim 3$ mag (redshifted UV) (Barbieri et al. 1977)
- Gamma-ray bright AGN $\sim 5 \times 10^{48}$ ergs s$^{-1}$ (0.1-100 GeV EGRET, Mattox et al. 1993)
- Core-dominated radio feature (Murphy et al. 1993, Poladitis et al. 1995) at 1.6 GHz
- Superluminal jet components up to 10c (Barthel et al. 1995 & Xu et al. 1998, Jorstad et al. 2001) $\sim$ sub mas per year
- flat spectrum, cm & mm variable
- major mm flare 2001-2002, inverted spectrum

$\Rightarrow$ explore innermost region during/after a major flare: kinematics, spectral & polarization evolution
Poladitis et al 1995

Frequency: 1.664 GHz, sigma=1.109030

1633+382  20/09/90

Maximum: 2.059 JY/BEAM
Contours (%): −0.15 0.15 0.30 0.60 1.20 2.40 4.80 9.60 19.20 38.40
Contours (%): 76.80
Beam: FWHM 8.33 x 2.56 mas, p.a. −18.3°
File: 1633+382.cmp_n (29-Sep-1994 19:43)
Observations (still on-going)

Table 1. Observation Epochs

<table>
<thead>
<tr>
<th>Date</th>
<th>Stations</th>
<th>Notes</th>
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<tbody>
<tr>
<td>12 Jun 2002</td>
<td>FD KP LA NL OV MK</td>
<td>b</td>
</tr>
<tr>
<td>28 Aug 2002</td>
<td>FD KP LA NL OV PT MK</td>
<td>c</td>
</tr>
<tr>
<td>01 Nov 2002</td>
<td>FD KP LA NL OV PT MK</td>
<td>b</td>
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<td>03 Jan 2003</td>
<td>FD KP LA NL OV PT MK</td>
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<td>20 Mar 2003</td>
<td>FD KP LA NL OV PT MK</td>
<td></td>
</tr>
<tr>
<td>23 Jun 2003</td>
<td>FD KP LA OV PT MK</td>
<td></td>
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</tbody>
</table>

6 epochs at 86 GHz

VLBACPOL failed in the first 3 epochs.
Source evolution or System evolution?

Conservative Band Cal.
Flagging the first and the last channels of each IF

The last three of the six usual calibration steps as at 22 & 43 GHz, multi IF mode LPCAL
D-terms, LA
D-terms, KP
Offset correction in EVPA
(no p-cal...)

Sub mm EVPA

[1633+382 EVPA at 3mm] \{...C,E,F,...\}

Calibrator EVPA at 3mm (3C345)

Lower freq. VLBI EVPA

(simultaneous single dish observation at 3mm..., it can fool us too.)
86GHz VLBP 1633+382
86GHz VLBP 1633+382
86GHz VLBP 1633+382

Clean I map. Array: BEFHKLNMOPS
1633+382 at 86.226 GHz 2003 Jun 23

Map peak: 1.79 Jy/beam
Contours %: -0.3 0.3 0.6 1.2 2.4 4.8 9.6 19.2 38.4
Contours %: 76.8
Beam FWHM: 0.193 x 0.0882 (mas) at -25.9°
single dish sub mm polarimetry

**Fig. 4.** Polarization position angle of 3C 279 in the 7 days of observations. The variation is $\sim 14^\circ$. The linear fit gives a correlation coefficient of 0.97.

**Fig. 5.** Position angle of QSO B1633+382 in the 7 days of observations. There is no evidence of variability.
1633+382 at 43GHz  varying pol. angle...

Clean I map. Array: BFHKLNOPSM
1633+382 at 43.217 GHz 2003 Jan 03

Map peak: 3.17 Jy/beam
Contours %: -0.15 0.15 0.3 0.6 1.2 2.4 4.8 9.6
Contours %: 19.2 38.4 76.8
Beam FWHM: 0.25 x 0.16 (mas) at -9.17°
1633+382 at 43GHz  varying pol. angle...

Clean I map. Array: BEFHKLNOPM
1633+382 at 43.217 GHz 2003 Mar 20

Map peak: 3.49 Jy/beam
Contours %: -0.1 0.2 0.4 0.8 1.6 3.2 6.4 12.8
Contours %: 25.6 51.2
Beam FWHM: 0.36 x 0.18 (mas) at -26.2°
3C345 at 86GHz (Calibrator...)

Clean I map. Array: BFHKLNOPSM
3C345 at 86.226 GHz 2003 Jan 03

Map peak: 0.908 Jy/beam
Contours %: -1 1 2.4 8 16 32 64
Beam FWHM: 0.237 x 0.091 (mas) at -22.1°
3C345 at 86GHz (Calibrator...)

Clean I map. Array: BEFHKLNOPM
3C345 at 86.226 GHz 2003 Mar 20

Map peak: 1.71 Jy/beam
Contours %: -0.7 0.7 1.4 2.8 5.6 11.2 22.4 44.8
Contours %: 89.6
Beam FWHM: 0.213 x 0.0839 (mas) at -19.4°
3C345 at 86GHz (Calibrator...)

Clean I map. Array: BEFHKLNMOPS
3C345 at 86.226 GHz 2003 Jun 23

Map peak: 1.66 Jy/beam
Contours %: −0.7 0.7 1.4 2.8 5.6 11.2 22.4 44.8
Contours %: 89.6
Beam FWHM: 0.21 x 0.0888 (mas) at −24.1°
3C345 at lower freq.

Fig. 8. Single dish \( m \) and \( \chi \) of 3C345 (UMRAO).

Fig. 9. VLBA \( J, p \) and \( \chi \) images of 3C345 at 22 GHz, epoch 1995.84. The total intensity \( I \) is represented with contours (value of 6 mJy/beam × 1, 1, 2.24, 5, 11.18, 25, ...), superimposed over a grey scale polarized intensity map (peak of brightness of 112.4 mJy) and the superimposed electric vectors (\( \chi \), length proportional to \( p \), 1 mas in the map is equivalent to 100 mJy/beam).
VLBP at 86 GHz

- is possible, *but be patient*.
- 1633+382 varying too fast. (>100c?)
  - or opacity?
    - high [B * n_e] media with low filling factor?
  - very low linear pol. after mm flare
    - source evolution or system evolution?

- Calibrators are varying too…
  Sources are different at mm wavelength
  (resolution + opacity)?

Better baseline & image sensitivity are needed.

*(at mm wavelength)*
mm VLBP study of AGNs is interesting…, and probably very important

- SKA – will be great, but cm facility (Opacity problem (dust torus, SSA), resolution …).
- ALMA – will be great, but on the southern hemisphere (RM from G-Plane, GC plus Magellanic stream, e.g. Kronberg et al).
  - be aware that $R_{M_{o.f.}}$ prop. to $(1+Z)^{-2}$

Sensitive mm VLBI on the northern hemisphere will be a great asset for AGN study…

sub-mas structure beyond opaque media…
KVN included mm VLBI…

- At the expense of FoV…, sensitive imaging is possible (long $t_{\text{int}}$ at 3mm will be possible).
  - For wide FoV, you could use local (e)VLBI facilities (e.g. EVN, VLBA, VERA + KVN, …)

Jung (2004)
Summary and Outlook

• 3mm VLBP is possible (without magic).
  – (mm)VLBI(P) could survive quite long.
    • since there are resolution, sensitivity, opacity-frequency, and space (n. h.) gaps.
  – Study of inner most AGN structure will benefit from filling the gaps.
    mm VLBI could be more than a niche product…

• 8\textsuperscript{th} EVN, more physics of 1633+382

• 10 \textsuperscript{(+ - 1)} \textsuperscript{th} EVN, KVN included 2 & 3mm VLBP