Session 1. VLBI for Astronomy

Convener: Dr. Chopo Ma (NASA GSFC, USA)

RATAN-600 AND EVN OBSERVATIONS OF QUASAR 0642+449

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Observational results for the high redshift quasar OH 471 obtained by means of RATAN-600 in March and May 1998 at 0.96, 2.3, 3.9, 7.7, 11.2, 21.7 GHz are presented. The radio spectrum of source has a peak at about 20 GHz.
We present 1.6 GHz EVN observations of OH 471. Our VLBI data showed that 0642+449 has an extended structure like core-jet. The jet was elongated for about 5 mas to the East. The flux density of the core component was 0.328 Jy.

1. INTRODUCTION

The OH 471 radio source coincides with the highly redshifted QSO having $z = 3.4$ (Carswell and Strittmatter, 1973). Gearhart *et al.* (1974) determined its radio spectrum in wide frequency range from 16.7 MHz up to 85.3 GHz and pointed out possible day to day variability at high radio frequencies. According to their study the OH 471 radio source had radio spectrum peaked at about 1 GHz and flatted at frequencies above 5 GHz in 1970–1973. Jones and O'Dell (1974) decomposed this spectrum into three hypothetical homogeneous synchrotron components and predicted angular size of about 2 mas for component dominated at frequencies below 5 GHz.

Several years later Efanov *et al.* (1980, 1981) found distinctly that at the beginning of 1978 this quasar had a strong millimeter wave spectral component and showed that it is actually variable at 22 GHz. Optical monitoring in photographical band by Pica *et al.* (1980) revealed a high probability that QSO is variable in this part of spectrum too.

In this paper we present RATAN-600 and EVN observations of OH 471.

2. THE SAMPLE

Table 1 shows parameters of source. Column (1) shows IAU source designation, Columns (2) and (3) are right ascension and declination (J2000), Column (4) is optical magnitude, Column (5) is redshift.

Table 1: Source parameters[(1)]

Source	RA (J2000)			Dec (J2000)			Optical magnitude	z
	(^{h})	(^{m})	(^{s})	($^\circ$)	($'$)	($''$)		
0642+449	06	46	32.026	+44	51	16.590	18.5	3.41

(1) according to Kellermann *et al.*, 1998

RATAN-600 and 1.6 GHz VLBI observations is a part of program of investigation of the spectrum and structure of the source. In accordance with this program we have completed:

– observations on 22-m radio telescope of Crimean Astrophysical Observatory at 22 and 37 GHz (since 1973);

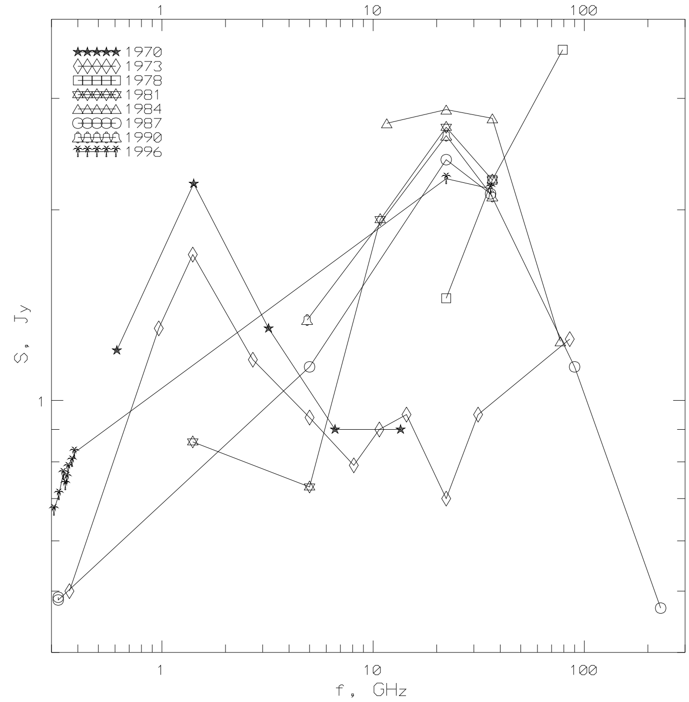

Figure 1: The radio spectra OH 471 for several epochs

– observations on the Westerbork radio telescope of aperture syntheses (WSRT) at 307–385 MHz (in 1996);
– the re-processing data from the WSRT archive at 307–385 MHz and 4874 MHz (completed in 1987–1990);
– the processing data on this source at other frequencies (published since 1964).

Figure 1 shows OH 471 radio spectra for several epochs since 1970 (Nesterov *et al.*, 2000).

3. OBSERVATIONS, CALIBRATION AND DATA REDUCTION

3.1. RATAN-600

The observations were made at 21.7 GHz, 11.2 GHz, 7.7 GHz, 3.9 GHz, 2.3 GHz, and 0.96 GHz by transit way mode at the North sector of the RATAN-600 radio telescope (Berlin *et al.*, 1997; Parijskij, 1997). We have used two strong radio sources NGC 7027 and DR21 as a flux standard. The assumed flux densities for NGC 7027 are following: 5.5 Jy, 6.02 Jy, 6.33 Jy, 5.0 Jy, and 2.6 Jy at 21.7 GHz, 11.2 GHz, 7.7 GHz, 3.9 GHz, and 2.3 GHz, respectively; and for DR21 5.0 Jy at 0.96 GHz. The correction factor due to an angular extension of NGC 7027 and beam size were calculated at 7.7, 11.2 and 21.7 GHz. Each scan was corrected for baseline slope when fitted to Gaussian response using FGR data reduction software developed by Verkhodanov (1997). The accuracy of flux densities was determined as the standard error of the mean value from N observations of a set. The flux density measurement procedure at the RATAN-600 is described by Aliakberov *et al.* (1985) in more detail.

The flux densities measured at the RATAN-600 are given in Table 2. The columns in this table are following: Column (1) – Frequency of observations, Column (2) and Column (3) – Flux densities and the rms errors of the flux densities measured in March and May.

Table 2: RATAN-600 measured flux densities of OH 471

	March		May	
Freq (GHz)	Flux (mJy)	rms (mJy)	Flux (mJy)	rms (mJy)
0.96	–	–	173	17
2.3	630	13	597	14
3.9	1483	16	1465	11
7.7	2516	13	2540	13
11.2	2710	84	2958	25
21.7	2807	80	3099	111

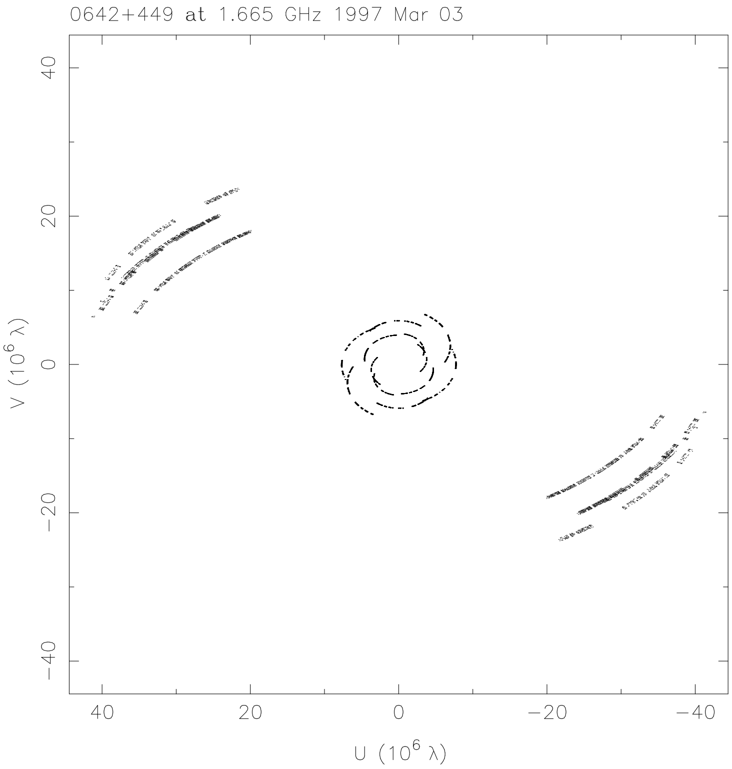

Figure 2: The $u - v$ coverage ENV observations of OH 471

3.2. EVN NETWORK

The source 0642+449 was observed in left circular polarization at 1.6 GHz in EVN session in 1997 (see Table 3).

Table 3: VLBI telescopes experiment and their characteristics at 1.6 GHz (March, 1997)

Radio telescope	Diameter (m)	SEFD[a] (Jy)
Effelsberg	100	20
Medicina	32	580
Onsala	25	390
Jodrell Mk2	26	320
Torun	32	200
Shanghai	25	2000

[a] System Equivalent Flux Density

The data were recorded using the Mark-III VLBI system and correlated at the Bonn correlator. In Figure 2 we show the $u - v$ coverage for the source.

Initial editing, amplitude calibration using the nominal gain curves determined for each antenna, and fringe fitting were performed using the standard NRAO Astronomical Image Processing System (AIPS) package. The initial amplitude calibration for each of eight IFs was accomplished using system temperature measurements taken during the observations. After correction for residual delay and delay rate, the data were written to FITS disk files.

The amplitude calibration was improved by observations of the 0552+398 (DA193) and 1328+307 (3C286) compact sources. The visibility data for each frequency band were selfcalibrated and cleaned using DIFMAP.

DISCUSSION

Correlated flux density (Jy) versus projected baseline length for 0642+449 (Fig. 3) shows a gradual drop in amplitude as the projected baseline length increases, indicative of slightly resolved structure. Our VLBI data

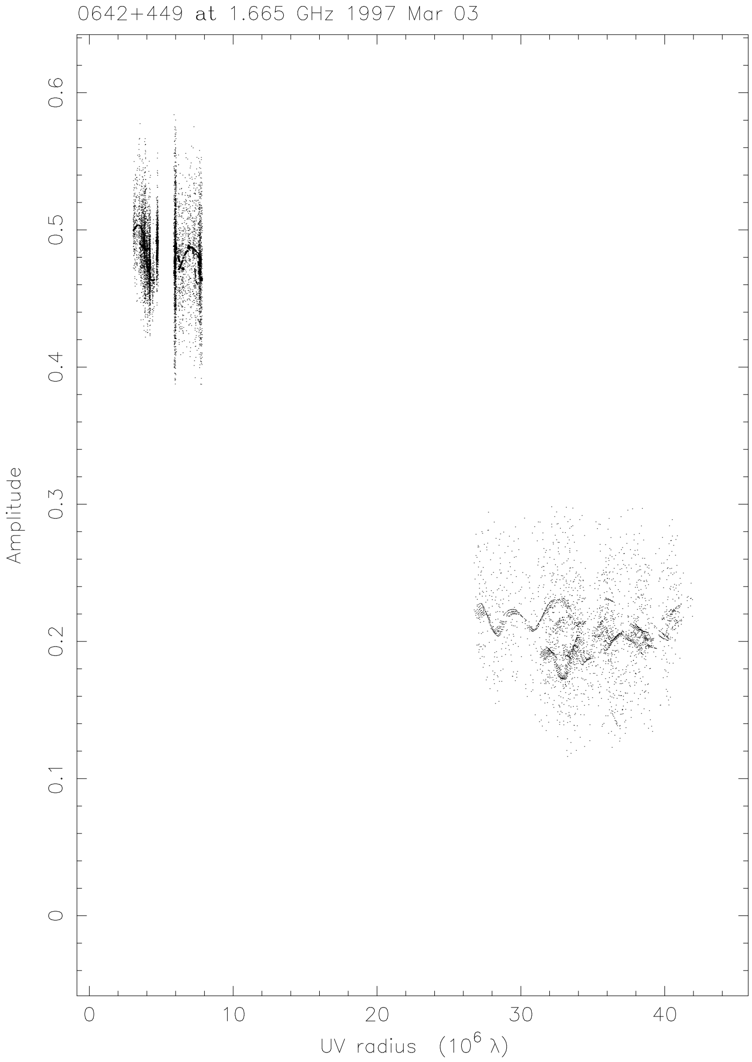

Figure 3: Correlated flux density versus projected baseline length for 0642+449

show that slightly resolved structure of 0642+449 has an extended structure like core-jet. The jet is elongated for about 5 mas to the east. The flux density of the core component is equal to 0.328 Jy.

Our VLBI observations have a very elongated beam (HPBW=12.8×2.55 mas) oriented in position angle of −24°. It would slightly mask a compact structure on VLBI scales which may be aligned with the arcsec scale structure.

It was found that at the beginning of 1970s the spectrum of OH 471 had a peak at frequencies near 1 GHz (see Fig. 1). The spectrum at frequencies above 5-10 GHz was always flatter than at lower frequencies. In Figure 4 we show 1–22 GHz spectra of OH 471 for 1998 epoch obtained at the RATAN-600. Our measurements at the RATAN-600 overlay a gap in low frequency observations of OH 471 for the 1980–1996 period. It is apparent that in 1998 the spectrum of source had peak at frequencies near 20 GHz. The apparent spectrum variability is attributed to the birth and the fading of new compact jet components.

CONCLUSION

The radio spectrum of OH 471 had a peak at about 20 GHz according to the RATAN-600 observations completed in 1998.

Our VLBI data showed that slightly resolved structure of source has an extended structure like core-jet, which is in agreement with earlier VLBI observations. The jet was elongated for about 5 mas to the East. The flux density of the core component was equal to 0.328 Jy.

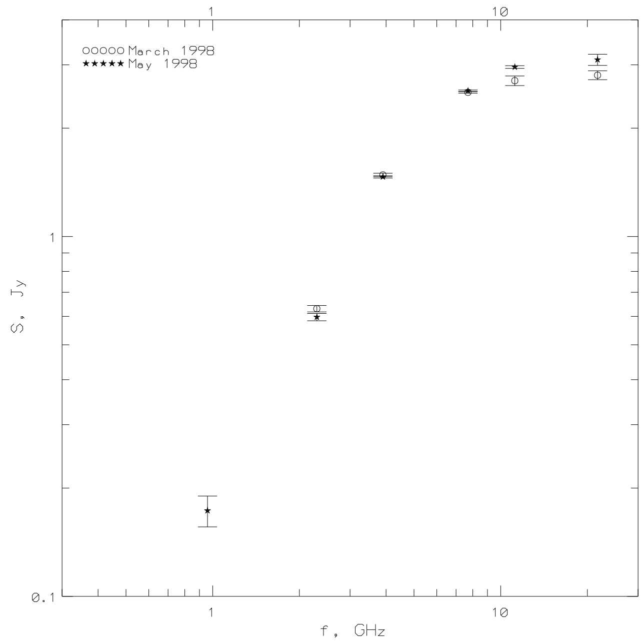

Figure 4: 1–22 GHz spectra of OH 471

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