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Research Note

VLA observation of NVSS J191656+051126

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Abstract. We present new Very Large Array (VLA) radio observations in X, U, K, and Q bands (from 8.4 to 43 GHz) of a serendipitously detected radio source observed during a campaign on dMe stars in April 1996. Cross correlating the coordinates, we found an entry in the NRAO NVSS survey catalog at 1.4 GHz. According to the rules of this survey, we named this serendipitous source "NVSS J191656+051126". No optical or X-ray counterpart could be identified, while we find that the IRAS point source IRAS 19145+0505 could be the IR counterpart. Using the radio data, we determined that the source spectral index is compatible with synchrotron emission mechanism. We have also investigated the structure of the source that is resolved into two components and their time variability.

Key words: radio continuum: general

1. Introduction

While observing the dMe star GJ 752AB (Leto et al. 1999) with the VLA in April 1996, we detected a serendipitous source at the coordinates: RA 19h 16m 56.65s, Dec 05° 11′ 27.35″ (J2000). We later found an entry in the NRAO VLA Sky Survey (NVSS) catalogue (Condon et al. 1998, field C1912P04) that could be identified as the same source within the coordinates error box. According to the NVSS rules, we named the source "NVSS J191656+051126".

In this paper we report the observed fluxes and upper limits. We discuss the morphology of the radio source, its time variability, and derive information on the mechanism responsible for the observed emission. We also give the results of a search for the NVSS J191656+051126 counterparts at other wavelengths.

2. Observations and data reduction

The VLA observations were planned to observe the radio spectra of a sample of dMe stars in the bands X (8.42 GHz, 3.5 cm), U (14.96 GHz, 2 cm), K (22.48 GHz, 1.3 cm), and Q (43.31 GHz, 7 mm). The array was split into two sub-arrays; the first sub-array included all available antennas equipped with Q-band receivers (13), while the other 14 antennas were observing the source at the remaining frequencies. X-band observations of the calibrators were also done with the first sub-array for reference pointing to achieve an adequate pointing precision for the Q-band observations.

Table 1. VLA observation log

Date	JD	IAT [a]		On source time (min)			
		start	end	X	U	K	Q
1996 April 28	2450202.	12:52:20	15:14:00	20	30	32	92

[a] International Atomic Time

The observations were carried out in C configuration; the resulting synthesized beam in X-band was 2.05×1.81 arcsec, position angle 5.1 deg. As primary flux calibrator, we used 0137+331 because this is a compact radio source and also because the expected amplitude closure errors are better than 10% at all the observed frequencies for this source in C configuration. The selected phase calibrator (1925+211) lies within a few degrees of the target source.

The maximum allowed bandwidth (50 MHz) was used for each of the two observing frequencies inside the bands, so that a total of 100 MHz bandwidth was achieved. The complete timetable of the observation is given in Table 1. The data were reduced using the Astronomical Image Processing System (AIPS), release 15APR1998[1]. We cleaned the maps using the Cotton-Schwab algorithm (Schwab 1984). The r.m.s. noise level was evaluated for every map in a region as large as possible where no sources were evident.

3. Results

We have detected NVSS J191656+051126 as a serendipitous source in the field of GJ 752AB. The source is present only in the X band map, while we obtained only upper limits for the other bands. The contour plot of the source at 8.4 GHz is shown in Fig. 1 together with the synthetic beam.

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Table 2. Observed fluxes and 5σ upper limits of NVSS J191656+051126.

Comp.	Θ_1 [a]	Θ_2 [b]	PA [c]	S_ν(mJy)				Coordinates [d]	
	arcsec	arcsec	deg	X	U	K	Q	RA(h m s)	Dec(° ' ")
				8.4 GHz	15 GHz	22 GHz	43 GHz		
A	2.19	1.89	54.4	1.84±0.085	<1.0	<2.0	<1.85	19 16 56.65	05 11 27.35
B	2.20	1.92	161.9	1.06±0.096	"	"	"	19 16 56.52	05 11 28.35
First data sub-set, time range starting at 12h53m10s IAT									
A	2.19	1.89	54.4	2.04±0.132				19 16 56.65	05 11 27.35
B	2.20	1.92	161.9	1.16±0.135				19 16 56.52	05 11 28.35
Second data sub-set, time range starting at 13h59m30s IAT									
A	2.19	1.89	54.4	1.80±0.118				19 16 56.65	05 11 27.35
B	2.20	1.92	161.9	1.12±0.121				19 16 56.52	05 11 28.35

[a] Major axis, [b] Minor axis, [c] Position Angle, [d] J2000

A more detailed analysis of the source revealed that it has a double peak structure. This double peak is clearly seen in the 3D plot showed in Fig. 1. A fit with two Gaussian components gives the morphological parameters and fluxes summarized in Table 2.

In 1998 NVSS J191656+051126 was also observed by Krishnamurthi et al. (1999). These authors observed in X band with a longer integration time achieving an rms noise level of 26.6 μJy/beam, and detected the source with a flux of 0.516 mJy, that is about 4 times less than the flux of the "A" component and 6 times less than the sum of the fluxes of both "A" and "B" component reported in this paper. During the NRAO VLA Sky Survey (NVSS), the 1.4 GHz flux of this source (Condon et al. 1998, field C1912P04) was 11.4±0.6 mJy. Since the resolution of the NVSS observations is about Θ=45 arcsec, the source could not be resolved, and the authors derived upper limits for the source major and minor axis of 28.0 arcsec and 23.9 arcsec, respectively.

Assuming that the radiation intensity is a power law of the frequency ν:

$$I(\nu) \propto \nu^{\alpha}, \quad (1)$$

and using the 1.4 GHz flux observed by Condon et al. (1998) and the flux at 8.4 GHz in the present paper, the spectral index of the source SED is $\alpha = -1.01$. Using instead the data of Krishnamurthi et al. (1999), we obtain $\alpha = -1.74$. Even though the spectral indices we have computed are affected by the lack of simultaneous measurements at the two used frequencies, there is no question that the spectral index is negative. Therefore, the emission mechanism is nonthermal.

If the radio flux is emitted from a homogeneous and isotropic electron ensemble moving in a uniform magnetic field with energy distribution given by a power law with spectral index γ, α and γ are related by:

$$\gamma = 1 - 2\alpha. \quad (2)$$

The Eq. 2 leads to γ=3.02, and γ=4.48 for the two values of α, respectively. Thus the involved electrons are definitely relativistic and the observed spectrum is compatible with a synchrotron radiation emission mechanism.

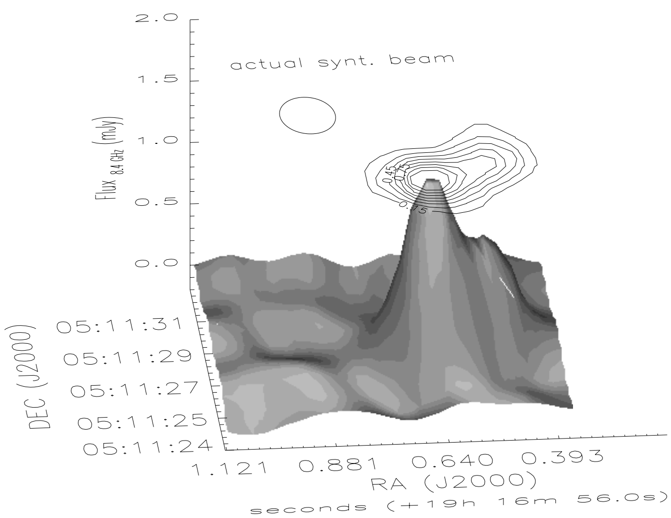

Fig. 1. X band map of NVSS J191656+051126.

The difference between our and the Krishnamurthi et al. (1999) 8.4 GHz fluxes indicates that the source emission varies on a time scale at least of a few years. To investigate the source variability on short time scales, we split our data into two separate temporal samples. Even though the rms noise level of each separate synthesized map increases, the source flux is still detected at more than the 20σ level; therefore it is possible to evaluate the flux in each of the two data sub-sets without major information loss. In order to obtain consistent fluxes, the fits on the two separate maps were done by freezing the positional parameters (position, major axis, minor axis, and position angle) of the two Gaussian components at the values obtained by performing a free fit over the total map. The results are summarized in Table 2. There is a clear variation in the flux from the "A" component by about 13%, corresponding to about 2σ, where σ (0.13 mJy) is the largest uncertainty in the flux determination obtained from the two maps. The "B" component, however, shows an almost steady emission (3% variation, 0.3σ).

4. NVSS J191656+051126 at other wavelengths

We have searched for a possible counterpart of NVSS J191656+051126 at other wavelengths. We assume that the astrometric uncertainty for NVSS J191656+051126 is of the order of ∼2 arcsec, because we find that the differences between the positions of the detected sources and the known coordinates of the optical counterparts are always within 1 beam (2 arcsec) in all the maps obtained during the same observing campaign. We find that no optical source is present in the Palomar Sky Survey within 4 arcsec of the radio coordinates.

We have also searched through some astronomical databases, both galactic and extragalactic: a search in the NASA/IPAC Extragalactic Database (NED[2]) gives negative results within 5 arcmin from the radio source coordinates. According to the SIMBAD CDS database, an infrared source, IRAS 19145+0505, is the closest object to NVSS J191656+051126, but it is still 1 arcmin away from the radio source coordinates. In order to assess the possible identification, we have evaluated the beam size on the IRAS maps (Beichman et al. 1988) at the source position using HIRES maps obtained from the Infrared Processing and Analysis Center (IPAC). At 12 μ the beam axis in the direction of the radio source is 34 arcsec, and at 25 μ it is 37 arcsec. So the IRAS source at 12 and 25 μ is about 2 beams away from the radio source, too much for a clear identification. At 60 and 100 μ, HIRES maps show diffuse emission and the point source is no longer clearly detectable. Hence IRAS 19145+0505 could be the infrared counterpart of NVSS J191656+051126, but we consider this only a possibility.

The closest unidentified X-ray source lies about 57 arcsec away from the radio coordinates of NVSS J191656+051126. There are three observations reported for this X-ray source, all from the Einstein satellite. Two of them were made with the Einstein High Resolution Imager (HRI), the other with the Einstein Imaging Proportional Counter (IPC). The error box for the HRI is about 4 arcsec and for the IPC is 35 arcsec. Therefore, a possible identification with our radio source is ruled out by the X-ray and radio errorboxes not overlapping.

5. Discussion and conclusions

We have detected NVSS J191656+051126 at 8.4 GHz as a serendipitous source in the field of the dMe star GJ 752AB. The source appears extended and with a double peak structure. Our data suggest that the flux of the "A" component is variable by at least ∼13% on time scale of few hours. A comparison with other observations by Krishnamurthi et al. (1999) reveals that at 8.4 GHz the source variability is as high as 600% on time scale of ∼2 years.

By using the 1.4 GHz flux observed during the NVSS and our 8.4 GHz flux, we find that the source spectrum is compatible with a nonthermal emission mechanism, e.g., synchrotron emission. We have not detected the source in the U, K, or Q bands. From the derived spectral energy distribution, the source fluxes extrapolated to the frequencies of the U, K, and Q bands are 0.3, 0.15, and 0.06 mJy, respectively. These values lie well below our upper limits (see Fig. 2). Therefore, the observed upper limits are consistent with the SED inferred from the 1.4 and 8.4 GHz fluxes.

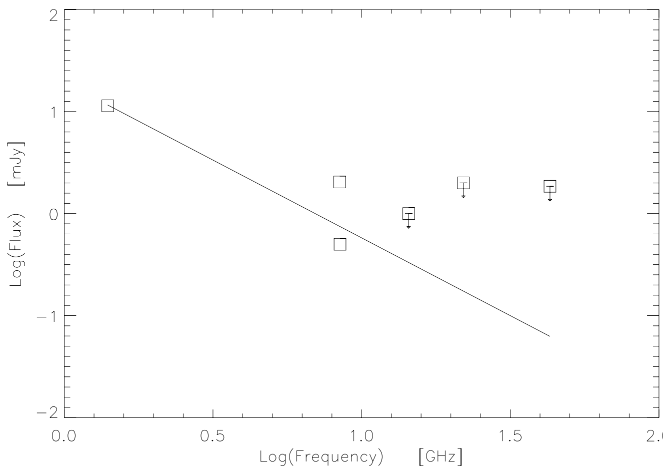

Fig. 2. NVSS J191656+051126 spectral energy distribution from a fit to the 1.5 and 8.4 GHz data.

What is NVSS J191656+051126? We find that NVSS J191656+051126 could be identified with the infrared source IRAS 19145+0505. However, no optical or X-ray counterpart was found. If NVSS J191656+051126 were a star, the lack of an optical counterpart together with the nonthermal spectrum suggests it could be only a late-type star. In this case, however, the radio source would have an X-ray counterpart producing a flux at Earth of $\sim 9\times 10^{-11}$ erg s^{-1} cm^{-2} according to the relation between the X-ray and radio luminosity, $L_X \sim 10^{15.5} L_R$, found by Güdel & Benz (1996) that holds for active late-type stars and binary systems over at least 6 orders of magnitude in both variables. Such a bright X-ray object would have been discovered, for example, by the ROSAT All Sky Survey (Thomas et al. 1998). Therefore, the lack of an observed X-ray counterpart, together with the fact that the observed 8.4 GHz radio flux of NVSS J191656+051126 definitely originates from a non thermal emission mechanism, suggests that NVSS J191656+051126 is an extragalactic source. Moreover, the observed spectral index (variable between -1.0 and -1.7 because of the observed variability at 8.4 GHz) falls in the typical range of spectral indices of radio galaxies and quasars, and also the double peak structure and variability are typical characteristics of these extragalactic objects. Therefore, NVSS J191656+051126 is probably one of the several unidentified extragalactic radio sources whose optical counterpart is beyond the plate limit of the Palomar Sky Survey. However, more observations at radio wavelengths, possibly carried out at least in two frequencies simultaneusly, are necessary to shed light on the nature of this object.

Assuming that the actual antenna system temperatures and efficiencies for the VLA are the standard ones as tabulated in the VLA web site, we have estimated that follow-up detections

[2] NED is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

of this source would be possible with ∼1 h, ∼8 h, and ∼8 h on-source time in the U, K, and Q bands, respectively. If the SED of NVSS J191656+051126 is as we have determined, the exposure times listed above would give 5σ detections in the U and K bands and a 2σ detection in the Q band.

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