VSOP Monitoring of the Quasar 1928+738

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Abstract

In the paper we present the results from a campaign to monitor the relatively low redshift (z=0.3) circumpolar superluminal quasar 1928+738 with VSOP during the first AO period. The four epochs of data show that there have been substantial structural changes in this source near the core on the time-scale of a few months.

Key words: radio continuum: galaxies quasars: individual (1928+738)
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1 Introduction

One limitation of the VSOP mission is that several famous superluminal sources such as 3C273 cannot be monitored with good *(u,v)* coverage throughout the lifetime of the VSOP mission at regular intervals that are spaced closely enough to follow the evolution in the fine-scale source structure. The reason for this is that HALCA spacecraft cannot observe sources outside certain restricted ranges of the time variable angle between the source and the sun. However, sources that lie within 10° of the ecliptic poles can be observed throughout the year and observations are not restricted to narrow temporal windows. Furthermore, the best ground-based *(u,v)* coverages are obtained for circumpolar sources and consequently these will be the sources for which the maximum amount of space VLBI data will be obtained with a given ground array. During the first AO period we began a monitoring campaign at 5 GHz on the relatively low redshift (z=0.3) superluminal quasar 1928+738 which is both a circumpolar source and lies 10° away from the ecliptic pole. In this paper we present the images from our four epochs of observations. For cosmological calculations we assume $H_0 = 100$ km s^{-1} Mpc^{-1} and $q_0 = \frac{1}{2}$.

2 Source Overview

1928+738 is in the S5 polar cap sample and has been well studied both on the arcsecond-scale (Johnston et al., 1987; Hummel et al., 1992; Murphy et al., 1993) and mas-scale (Hummel et al., 1992; Ros E., 1999). 1928+738 is quite unusual among core-dominated in quasars in that it has a lot of extended emission on both sides of the core with a very prominent curved one-sided jet that goes from the core to the southern lobe. This source has also been well studied on the mas-scale and proper motions have been detected in several distinct components with values that lie in the range 0.29–0.37 mas/yr which leads to apparent speeds in the range 3.4–4.1 c. The 22 GHz work of Hummel et al. (1992) showed that the motion of the VLBI components in 1928+738 was not consistent with simple linear expansion along a fixed position angle (PA) for all components. Indeed, 1928+738 was one of the first sources for which helical jet motion was proposed. Expanding upon this work, Roos et al. (1993) proposed that a massive binary black hole (MBBH) system is responsible for the sinusoidal jet ridge line observed at 22 GHz over a 5 year period. The phase of this sinusoid, in the plane of the sky, varies by ≈ 0.28 mas yr^{-1}, which implies a period in the rest frame of the quasar of 2.9 years within the framework of a ballistic relativistic jet model (Roos et al., 1993). A period this short is unlikely to be caused by geodetic precession of the primary black hole as the implied gravitational lifetime is then extremely short ($\sim$10 years !). A more realistic scenario is to assume that the observed period is associated with the binary orbital period. An alternative to the ballistic relativistic jet model is to assume that the observed wiggles in the jet are caused by Kelvin-Helmholtz (KH) instabilities also driven by the orbital motion of the MBBH system.

3 1928+738 VSOP Images

Figure 1 shows 5 GHz images of the core region of 1928+738 from our four epochs of data along with their respective *(u,v)*-coverages. These epochs are

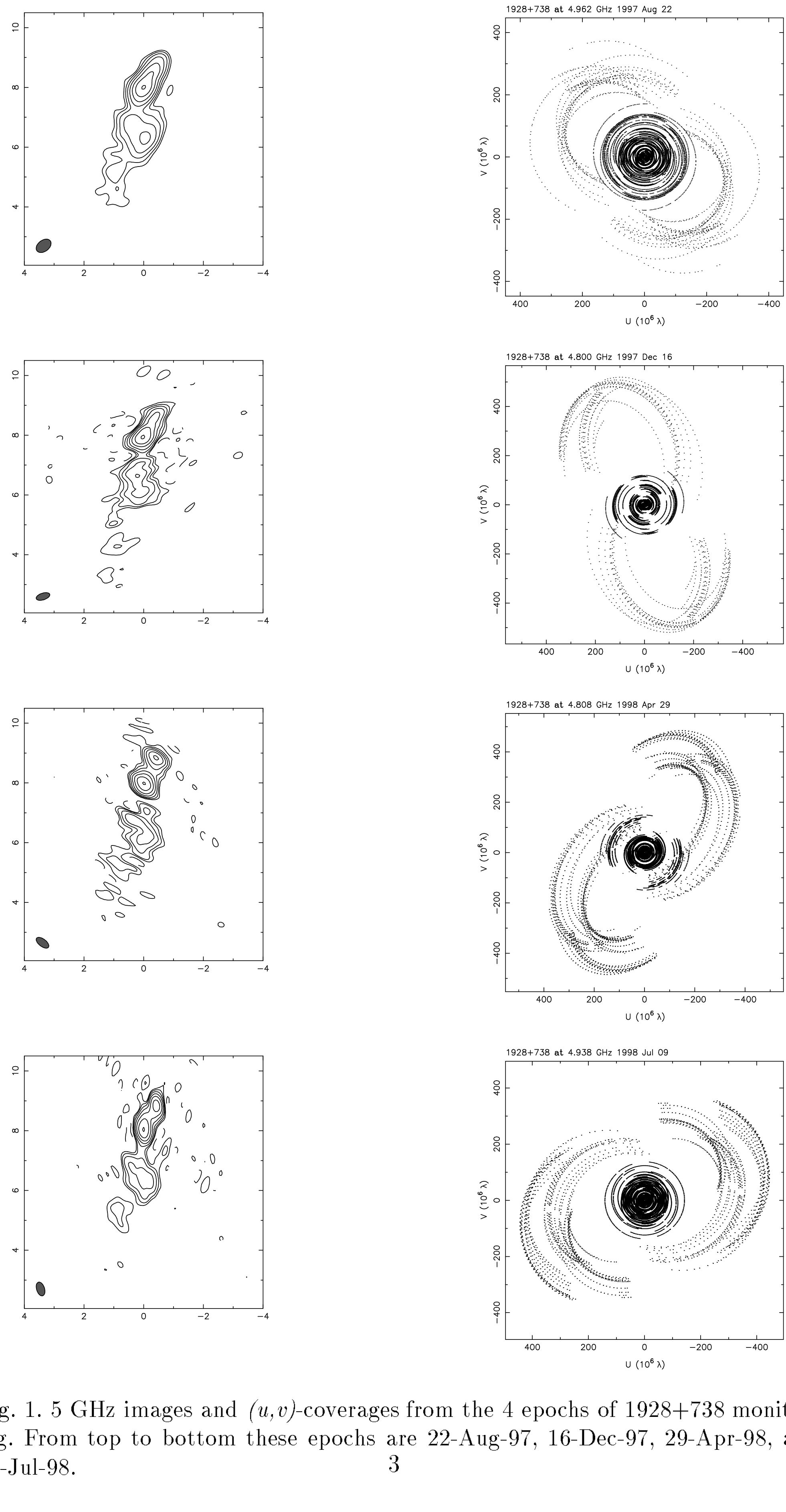

Fig. 1. 5 GHz images and *(u,v)*-coverages from the 4 epochs of 1928+738 monitoring. From top to bottom these epochs are 22-Aug-97, 16-Dec-97, 29-Apr-98, and 09-Jul-98.

22-Aug-97, 16-Dec-97, 29-Apr-98, and 09-Jul-98. Contours for each image are at -1.5, 1.5, 3, 6, 12, 24, 48, 96 % of the peak flux densities which are 0.908, 0.488, 0.508, and 0.502 mJy/beam for the four images respectively. The beams are 0.588×0.373 (mas) at -52.9°, 0.474×0.223 (mas) at -72.2°, 0.497×0.245 (mas) at 52.7° and 0.477×0.266 (mas) at 17.9° respectively.

The *(u,v)* data were fringe-fit and amplitude calibrated using the AIPS package. The 1024 by 1024 images were made using the Caltech Difmap package with a cell-size of 0.05 mas and the uvweight parameter had the value of 2,0. That is, uniform weighting was applied but there was no weighting based on the noise level attached to each visibility. As can be seen, there are very distinct structural changes in the core region. The core is located in the northern most part of the image and is not the brightest feature on the images. Examining our first epoch of data, we see that initially the jet has a position angle (PA) of about 150°. However, at a distance of roughly 2.3 mas (6.3 pc) from the core the jet goes through a apparent bend of 73°. This behavior has not been in seen in other other observations of this well-studied source (Hummel et al., 1992; Ros E., 1999). One might question the validity of VSOP images given the large size of the holes in the *(u,v)* plane. However, we are monitoring this source both at 43 GHz with the VLBA and 86 GHz with the CMVA. A 43 GHz image made from data taken on 07 July 1997 also shows the same pronounced bend in the jet 2.3 mas from the core. This 43 GHz image also enables the core to be identified based on spectral index arguments.

However, in the second epoch of data the jet bends by only 41° 2.3 mas from the core. Thus, in only 0.32 years there has been a substantial change in the jet bend angle at this point. Depending on how one interprets this change an apparent speed of about 30 c can be derived. This speed is much higher than the speed of other components in this source which have apparent speeds of about 4 c (Hummel et al., 1992; Ros E., 1999). This is all very unusual but the situation is made even more intriguing by the third epoch of data which shows that the structure following the bend at 2.3 mas has a more complex morphology which is somewhat intermediate between the the first and third epochs of data. Interpreted naively, this might provide evidence for superluminal contraction in this source. The morphology of the inner jet region of the fourth epoch of data is similar to the first epoch.

It should be pointed out that the images presented here are preliminary and more work is needed to produce them in their final form. The ground array that observed with HALCA for all 4 epochs was primarily the VLBA. However the VLBA was augmented by Effelsberg for all four epochs, by the Usuda 64m and Noto for the third epoch, and by Green Bank for the fourth epoch. The observation length was 12, 8, 15, and 16 hours for the four epochs respectively.

4 Summary

We have imaged 1938+378 at 4 epochs that span a time range of 10.5 months. In that time, we have observed structural changes of a type never before seen in this source. The validity of our VSOP image is confirmed at one epoch by a complementary 43 GHz VLBA observation. The jet bend angle 6.3 pc from the core is seen to vary dramatically with time.

5 Acknowledgments

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