Astrophysical Phenomena Revealed by Space VLBI
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Why Space VLBI is of Special Value for Studies of High-Redshift Radio Sources

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Abstract

Space VLBI brings a special benefit in the studies of milliarcsecond radio structures of extremely high redshift sources. This property is illustrated by the simulated SVLBI and real VSOP data.

1 Introduction

Dual frequency VSOP studies of a sample of high redshift quasars constitute one of the General Observing Time (GOT) projects of the mission. At the time of this Symposium the project is not yet completed. Some preliminary results of the high-z VSOP project have been or will be soon presented by Hirabayashi et al. (1998), Gurvits et al. (2000a; 2000b) and Lobanov et al. (2000). The project is aimed at two goals: *(i)* to search for potential evolutionary effects intrinsic to the quasars in the milliarcsecond scale radio structures, and *(ii)* to investigate possible imprints of the cosmological model by studying the milliarcsecond scale structural properties as a function of redshift.

VSOP, as the first dedicated Space VLBI (SVLBI) mission, in addition to its self-standing scientific value, provides the most important practical experience and experimental basis for planning future SVLBI missions, in particular those described in these proceedings by Marscher (ARISE), Hirabayashi (VSOP-2) and Gurvits (SVLBI observatory assembled in space). It is expected that the next generation SVLBI mission will operate in a significantly broader range of frequencies than VSOP. There is a strong and well motivated move toward as high observing frequencies as feasible: all next generation SVLBI missions include 43 GHz as a nominal band, and some aim at the challenging 87 GHz. However, as stressed in several presentations at this symposium, frequencies of 5 GHz and lower could be of high importance for the future SVLBI studies of pulsars (Gwinn, these proceedings), Galactic OH masers (Diamond, these proceedings) and radio stars (Taylor et al. these proceedings).

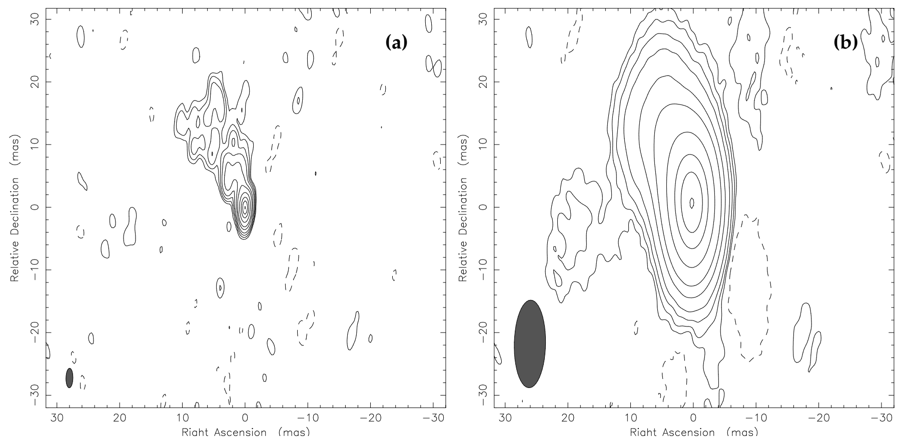

Figure 1: A simulated source as seen by the global ground-based VLBI array at **(a)** $z = 0.1$ and $\nu = 8$ GHz and **(b)** $z = 3.6$ and $8/(1+z) = 1.6$ GHz. Both images have noise close to the expected thermal limit.

High redshift quasars (and other types of AGN) also represent a class of targets for future SVLBI missions, for which the lower end of the overall frequency coverage is promising to be very productive.

2 What is Special About High Redshift Targets for SVLBI

It is a well established fact that the most compact components in milliarcsecond scale radio structures of AGN have flatter spectra than the extended features. In fact, this spectral difference is widely accepted as the most reliable criterion which makes it possible to distinguish "core" components which are believed to be close to the central engine and the "jets". As shown recently by Frey et al. (1997) and Paragi et al. (1999), the average difference between the spectral indices of compact "jets" and "cores" in quasars is $\alpha_j - \alpha_c = -0.62 \pm 0.45$. Due to this difference, the extended "jets" fade faster with growing emitting frequency than the flatter spectrum "cores". Not surprisingly, on average, at any fixed receiving frequency, sources at a higher redshift appear more compact than their lower redshift counterparts. Thus, in order to study milliarcsecond scale "core–jet" structures in high-redshift quasars it is beneficial to operate at a lower observing frequency. However, this comes at a high cost in terms of angular resolution which is proportional to the observing wavelength. It is virtually impossible to match in angular resolution and emitting frequency observations of high and low redshift sources on the milliarcsecond scale while using ground-based VLBI networks only.

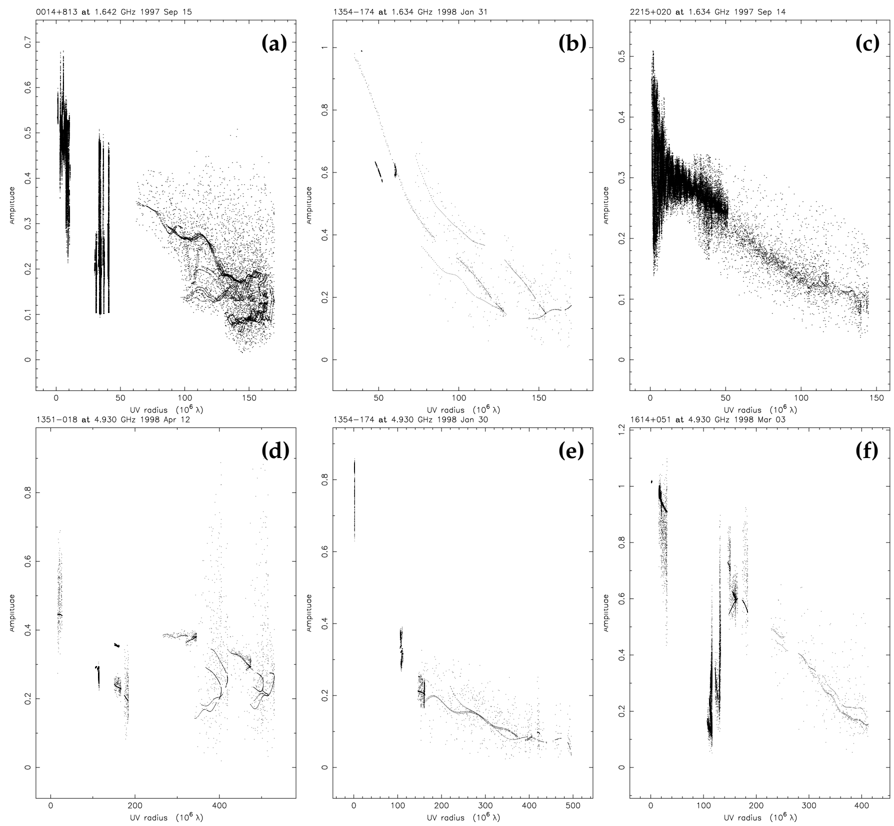

Figure 2: Correlated flux density (amplitude, Jy) versus projected baseline (mega-wavelengths) from VSOP observations of quasars **(a)** 0014+813, **(b)** 1354−174, **(c)** 2215+020 at 1.6 GHz and **(d)** 1351−018, **(e)** 1354−174 and **(f)** 1614+051 at 5 GHz.

Figure 1 illustrates this problem (see Gurvits 2000 for details). It shows simulated images of two similar sources, both observed with the global ground-based VLBI arrays. The left image corresponds to the source at $z = 0.1$ and observed at 8 GHz, while the right image corresponds to the source "moved away" to $z = 3.6$ and observed at the source-frame-matched frequency $8/(1+z) = 1.6$ GHz. The insufficient sharpness of the image on the right is obvious. The only cure for this problem is to extend the baselines beyond the Earth's diameter as VSOP does.

3 VSOP High Redshift Project: Status and Conclusion

The high redshift VSOP project includes observations of 21 quasars at $z \geq 3$ at either one or both VSOP frequencies, 1.6 and 5 GHz. The sources included have total flux density $\gtrsim$ 400 mJy at the frequency of observation. To date, the VSOP high-redshift observing project is $\approx$ 50% complete. Its preliminary results do prove the expectation on the efficiency of SVLBI observations of high-redshift targets. All sources observed so far are resolved (Figure 2), with the typical correlated flux densities $\lesssim$ 200 mJy at the longest VSOP projected baselines ($\approx$ 170 Mλ at 1.6 GHz and $\approx$ 500 Mλ at 5 GHz). Qualitatively, this result is in agreement with the statistical result of the VSOP Survey Programme (Lovell et al. these proceedings).

The high angular resolution of SVLBI at lower frequencies is of special importance for studies of extremely high redshift sources. For steeper spectrum components, this property of SVLBI cannot be matched by ground-based VLBI at a higher frequency. From this perspective, it is important not to exclude lower frequencies $\leq$ 5 GHz from the ongoing studies of the next generation SVLBI missions.

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