Astrophysical Phenomena Revealed by Space VLBI
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The VSOP Survey III: Statistical Results

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Abstract

In the third paper on the VSOP Continuum Survey, we present an initial statistical analysis of the data reduced to date. We find that nearly all sources are resolved to some degree with the BL Lac sources being more compact than quasars. We also find that 51% of the sources have source-frame brightness temperatures in excess of 10^{12} K.

1 Introduction

This is the third paper in this proceedings that describes the VSOP Continuum Survey. In Paper I (Fomalont et al., these proceedings) the organisation of the survey is presented and in Paper II (Moellenbrock et al., these proceedings) a description of the data reduction is given. This paper presents a statistical analysis of the results from the first 67 sources to be reduced and analysed.

We stress however that this is not a random sample of the sources being observed by the VSOP for the Survey. Most of the data reduced to date consists of sources with strong ground-space fringe detections as many observations where these fringes are weak or absent are still under investigation by the Survey data analysts or are being scheduled for re-observation.

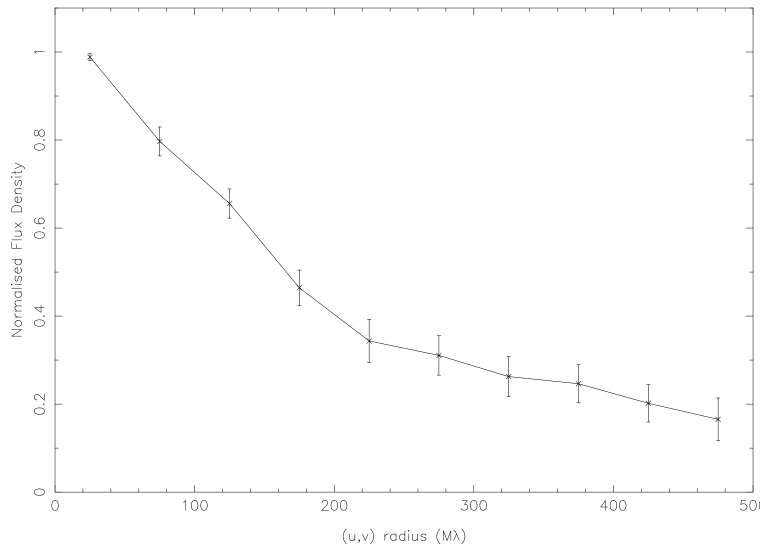

Figure 1: The weighted mean of the normalised flux density distribution for the survey sources so far analysed.

2 Flux Density Measurements

For the purposes of a statistical analysis, the visibility amplitudes for each source have been divided into 50 Mλ bins from 0 to 500 Mλ. The average visibility function (normalized to the 0–50 Mλ bin[1]) for the currently reduced sample is shown in Figure 1. At 200–250 Mλ, the

[1]Note: The 0–50 Mλ fluxes used in this analysis represent the flux density on the shortest VLBI baselines and not the total, zero-baseline, flux density.

visibility functions clearly flatten significantly, indicating a less-resolved component tends to dominate on the space-VLBI scale at 5 GHz.

The normalised long baseline (400–500 Mλ) flux density plotted as a function of short baseline (0–50 Mλ) flux density is shown in Figure 2. This figure clearly shows that nearly all survey sources are resolved significantly. It is also apparent that there is some division between source types, with the BL Lac objects (albeit few in number) generally more compact than the quasars at the 1% significance level.

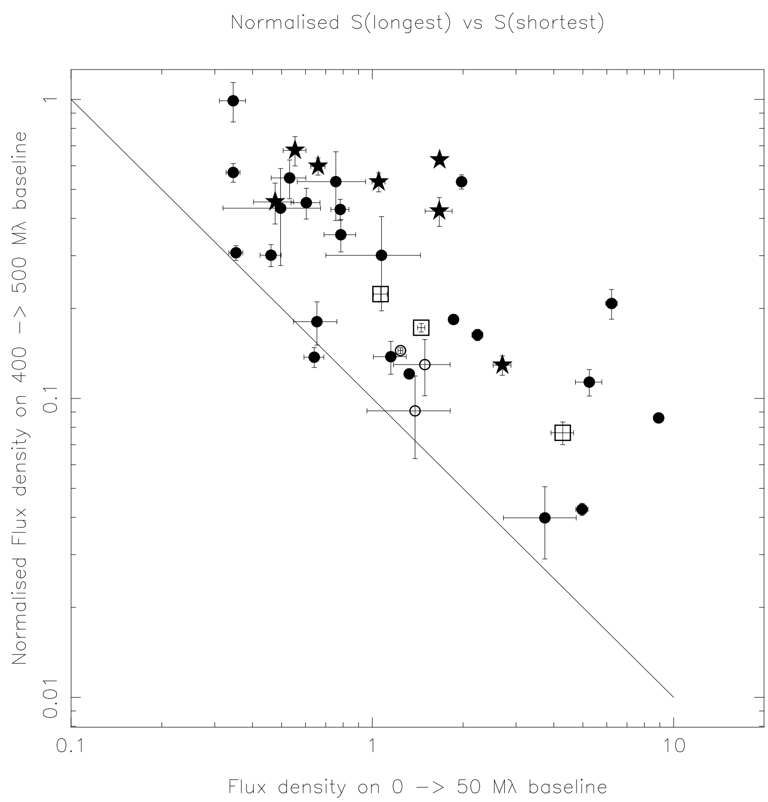

Figure 2: Normalised long baseline flux density plotted against short baseline flux density. The star-shaped symbols represent BL-Lacs, filled circles represent quasars, open circles represent galaxies and open boxes represent unidentified sources. The solid lines indicates the nominal detection limit on ground-space baselines of 0.1 Jy.

3 Brightness Temperature Measurements

As described in Paper II, the angular size of the components in all sources is determined using the Difmap software package (Shepherd et al. 1994) which fits one or several Gaussian components directly to the measured visibility data. However, whether a component is consistent with a point source, within the data errors, can not be ascertained from the algorithm because no errors are estimated and the algorithm rarely converges on a point source. This problem is exacerbated by the elliptical (u, v)-coverage for most survey observations.

A estimate of the minimum detectable angular size, A, that can be measured for an isolated small-diameter component of flux density S, with observations with an integrated rms noise N, and the maximum baseline length U is

$$A < \frac{2.4\sqrt{\frac{N}{S}}}{U}$$

where A is in milliarcsec and U is in units of 100 Mλ. The constant 2.4 depends on the details of the (u, v)-coverage and weighting of the data and was chosen to represent that used for the typical survey dataset. For $S = 0.5$, $N = 0.005$ and $U = 5$, the expected minimum detectable angular size is 0.05 mas. Using the above algorithm we determined the angular size limit in the major and minor axis direction of the (u, v)-coverage and compared these limits to the angular sizes produced by Difmap. If the modelfit size was more than 50% greater than the derived limits, it was taken as a robust measurement of the angular size. Otherwise, the limiting size was adopted and used as a lower limit to the brightness temperature.

Figure 3 shows the brightness temperatures measured with VSOP for the Survey, in the observers' frame and in the source frame (at source emitted frequency) respectively. Each plot is divided into sources for which only a lower limit was possible (which accounts for $\sim 2/3$ of the sources so far analysed) and those for which a core size could be reliably measured.

The highest observer-frame brightness temperature so far measured in the survey is 2.8×10^{12} K and the highest lower-limit brightness temperatures observed is 6×10^{12} K. We find that 30% of the 67 sources have observers'-frame brightness temperatures in excess of 10^{12} K and of the 59 sources for which redshifts are available, 51% have source-frame brightness temperatures greater than 10^{12} K.

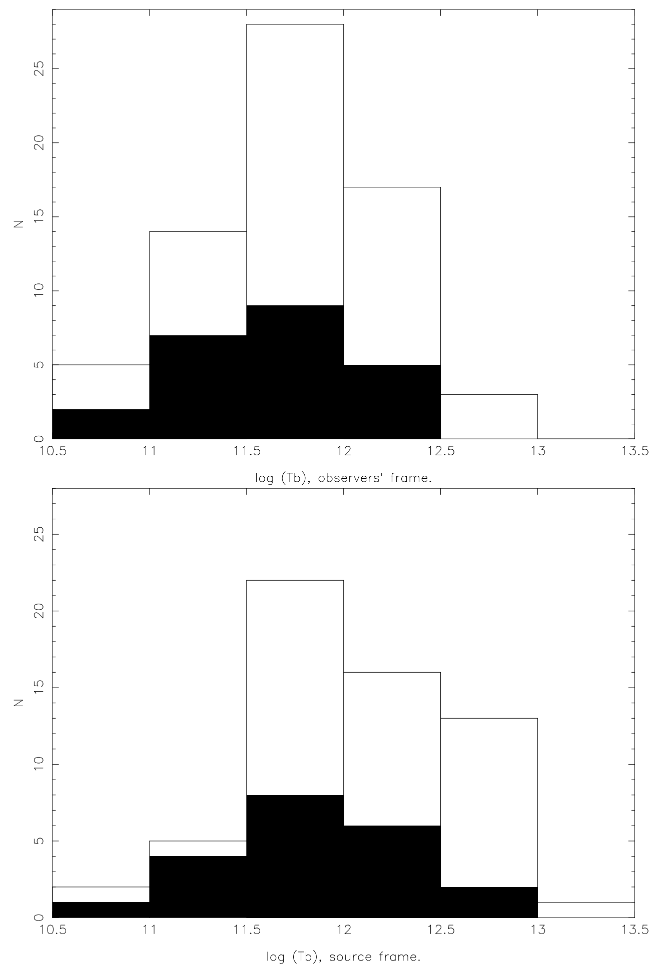

Figure 3: Brightness temperature distributions in the observers' frame (top) and in the source frame at the source emitted frequency (bottom). The filled blocks represent sources where a compact component size was measured while open blocks represent sources where only an upper limit on size and hence a lower limit on brightness temperature was possible.

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References

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