Black Holes from Stars to Galaxies – Across the Range of Masses
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The VSOP Survey: final aggregate results

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Abstract. In February 1997 the Japanese radio astronomy satellite HALCA was launched to provide the space-borne element for the VSOP mission. HALCA provided linear baselines three-times greater than that of ground arrays, thus providing higher resolution and higher AGN brightness temperature measurements and limits. Twenty-five percent of the scientific time of the mission was devoted to the "VSOP survey" of bright, compact, extra-galactic radio sources at 5 GHz. A complete list of 294 survey targets were selected from pre-launch surveys, 91% of which were observed during the satellite's lifetime.

The major goals of the VSOP Survey are statistical in nature: to determine the brightness temperature and approximate structure, to provide a source list for use with future space VLBI missions, and to compare radio properties with other data throughout the electro-magnetic spectrum. All the data collected have now been analysed and is being prepared for the final image Survey paper. In this paper we present details of the mission, and some statistics of the images and brightness temperatures.

Keywords. Surveys – galaxies: active

1. Introduction

The VLBI Space Observing Program (VSOP) satellite HALCA provided the space baseline for the observation of a complete sample of bright compact Active Galactic Nuclei (AGN) at 5 GHz; the VSOP survey (Hirabayashi *et al.* 2000). Of this set of 294 AGNs: 102 were presented in Scott *et al.* (2004, hereafter P1), 140 will be presented in Dodson *et al.* (2007, hereafter P2), and 29 were not observed. The remaining 23 did not produce space fringes, where we expected to find them. Some of these may be correct, however we have erred on the side of caution and consider them to be failures.

The HALCA downlink had a bandwidth of 128 Mbps, or 32 MHz at Nyquist, two bit, sampling. A typical VSOP Survey experiment would consist of three Ground Radio Telescopes (GRTs) and a single tracking pass of HALCA; normally several hours. This leads to a nomimal fringe sensitivity of 100 mJy, and a image noise level of 10 mJy, for the space baselines. Figure 1a) shows the number of antennae in each experiment.

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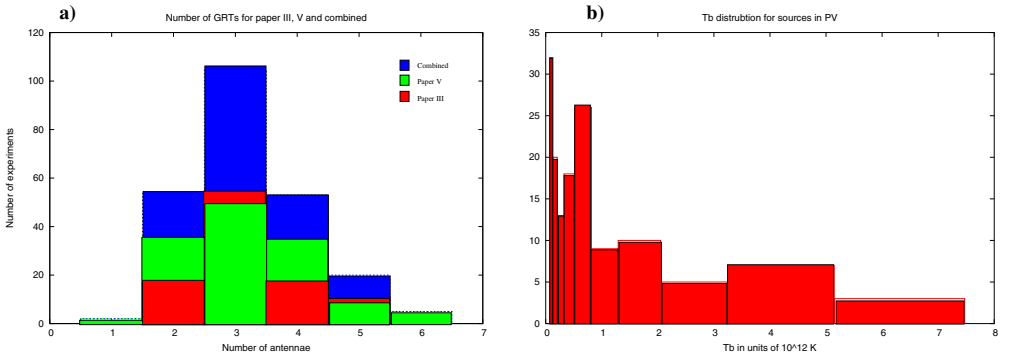

Figure 1. a) A histogram of the number of antennae for experiments in P1,2. b) A histogram of the upper limits to the source rest frame brightness temperatures from the imaged data in P2, in logarithmic bins.

One of the core goals of the VSOP Survey imaging program was to measure lower limits to the brightness temperatures (T_b) directly from the data (c.f. Horiuchi *et al.* 2004). The determined T_b (from VLBI) depends only on the physical baseline length, independent of frequency, so space baselines will always provide the highest possible limits. Figure 1b) plots the lower limits to T_b for the sources in P2, binned logarithmically. These are the source frame T_b values, unless the redshift is unknown. In which case the observer frame values are used, as a lower limit. Lower limits were estimated from the lowest brightness temperature model compatible with the data.

2. Conclusions

We have completed the VSOP survey imaging data reduction. The paper covering 140 sources is in preparation, and when it is published the imaging portion of the VSOP Survey Project will be completed. We have directly measured the source brightness temperatures, and produce a distribution of the lower limits to directly measured T_b.

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