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ALOFT: A Potential Low Frequency Space VLBI Mission

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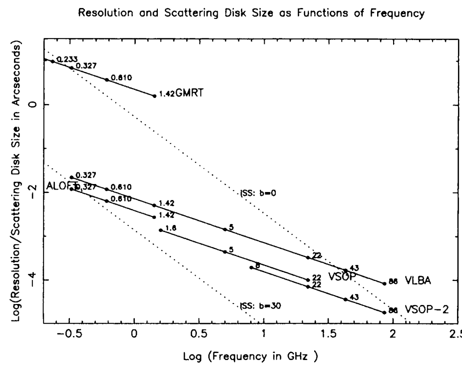
Abstract. We present a preliminary study of A LOw Frequency Orbiting Telescope (ALOFT) which co-observes with ground radio telescopes, in a similar fashion to the current VSOP mission. Our current strawman ALOFT mission has a spacecraft operating at three frequency bands (0.33, 0.6, and 1.4–1.6 GHz) in an orbit with a 10,000 km apogee height. It should be relatively low cost as the lower frequencies less stringently constrain the design, for example uncooled receivers, narrower bandwidth, and simple antennae. The major science goal to be addressed by this mission is to examine scattering phenomena through the technique of space VLBI, although other problems, such as AGN physics, can of course also be addressed.

The first dedicated space-VLBI mission is the VSOP project, in operation since 1997. The HALCA spacecraft observes at 1.6, 5, and 22 GHz. The follow-up mission will be at higher frequencies (likely to 43 GHz), bandwidth, and aperture. However, there is strong trend in radio astronomy toward lower frequencies, with the completion of the GMRT, the low-frequency upgrade to the VLA, and the proposed SKA. In the Figure we show the resolution of various telescopes (GMRT, VLA, VLBA, VSOP and VSOP-2) as well as that of the potential ALOFT mission along with the scattering disk sizes from both Interstellar Scattering (ISS) for Galactic longitude b = 0°, 5°, 30°, 90°and Interplanetary Scattering (IPS) for solar elongations of 90°and 180°. It's clear that space VLBI will not be possible below about 327 MHz as the resolution at these frequencies is much smaller than the scattering disk sizes; nearly all sources will be heavily resolved. Thus, for the ALOFT orbiting radio telescope we consider 0.33, 0.61, and 1.4–1.6 GHz.

The primary ALOFT science will be the study of scattering: are images consistent with a smooth pseudo-Gaussians or do they demonstrate refractive effects such as ellipticity, wander, or multiple sub-images? Can we characterize the turbulence power spectrum by measuring the scattering strength C_n^2, spectral index α, and inner and outer scales? What are the scattering properties of intra-day variables, low frequency variables, and extreme-scattering event sources?



Apart from scattering a variety of other observations are possibles with the ALOFT mission such as AGN physics at low frequencies (synchrotron self-absorption, free-free absorption, HI absorption, spectral aging, ...).

Considering arrays with the GMRT, VLBA, and VLA, we have found that an orbit with a perigee height of ≈ 500 km, apogee height of ≈ 10,000 km and a 30 degree inclination has some nice properties: it allows scattering studies but doesn't resolve all sources; an orbital period of 3.5 hr allows for rapid imaging; nodal and perigee precession periods of 7.9 and 5.0 months mean no long periods of poor *uv* coverage; overlapping Earth-Earth and Earth-space baselines provide good antenna calibration.

The current VSOP 5-station tracking network could provide ALOFT 70% time coverage. A tracking station co-located with the GMRT is attractive, as it would allow near-real-time fringe verification using a suitable single-baseline correlator.

Relatively simple and inexpensive wire antennae can provide the necessary sensitivity at 1420 MHz, but not very easily at lower frequencies. Adhering to the low-cost goal suggests two observing modes: imaging experiments at 1420 MHz with ground arrays such as the GMRT or VLBA, and single-baseline experiments at 330 MHz and 610 MHz with the phased GMRT or VLA. For the orbit described, *uv*-coverage is good in both modes. It should be possible to adequately measure the source visibility function to allow scattering physics studies. For some experiments, it may be possible to use second large telescope, providing closure phase information to see if the images depart from symmetrical pseudo-Gaussians.

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