Introduction

Gigahertz peaked spectrum (GPS) sources have a sharply peaked radio spectrum and possess one or more compact components that are physically small (<100pc), highly luminous ($P > 10^{27} W\ Hz^{-1}\ sr^{-1}$) and contain the bulk of the total flux density. The incidence of extended structure in GPS sources is small, at around 20% of all the objects examined (O'dea et al, 1991, ApJ, 380, 66). It is not unusual for GPS sources to possess two compact components with very similar sizes, brightness and spectra.

There is little evidence in these objects, either from the VLBI morphology or polarization, for the existence of jets or other energy transfer mechanisms to power the luminous components. Flux density monitoring surveys of these objects at centimetre wavelengths indicate that the incidence of variability is systematically low (King, 1994, PhD thesis). In the absence of variability as an indicator of scale sizes, high angular resolution is the only means to examine source structures in detail.

The overall morphological similarity of the sources within the GPS class has lead to attempts to incorporate them in a unified scheme with other radio sources based not on orientation, but on evolutionary processes. On the one hand it is argued that GPS sources are young objects that have not been "turned on" long; hence the absence of extended structure and small size. An alternative point of view is that they are like other powerful AGN, only engulfed by a dense medium which confines them so they are physically small, but bright nonetheless. Neither of these hypotheses explain the existence of the extended emission referred to above, so a third suggestion advanced is that GPS objects have episodes of outbursts, and we recognise them as GPS only when they are in a quiescent state.

Absorption Processes

It has long been thought that the low frequency spectral turnover characteristic of GPS sources is because of synchrotron self-absorption (SSA). Recently, this hypothesis has been subject to renewed competition from the suggestion that this turnover is due to free-free absorption (Bicknell, Dopita & O'Dea, 1997, ApJ, 485, 112). One of the principal criticisms of the SSA hypothesis is that the magnetic fields in GPS radio sources calculated from SSA theory are in poor agreement with those derived from energy equipartition arguments (corresponding almost to the minimum energy condition). The possibility of free-free absorption leading to the turnover had earlier been discounted as requiring unreasonably high electron column densities and magnetic fields lower than are consistent with minimum energy conditions in order for free-free to dominate over SSA (eg Hodges et al 1984, AJ, 89, 1327). Part of the impetus for the rejuvenation of the free-free hypothesis has come from arguments, based on radio depolarisation and optical emission line diagnostics, that thermal electron densities may be higher in GPS sources than are typical in other AGN (O'dea et al, 1991, ApJ, 380, 66).

We propose to distinguish between these two competing hypotheses by making hitherto impossible high-resolution observations of strong GPS sources with the VSOP spacecraft. The magnetic field strength estimated from SSA depends on the fourth power of the source sizes at the frequency of the peak so it is very important to establish accurate source sizes. The equipartition field also depends on the source size (though only to the $-4/7$ power) so accurate imaging will permit a direct test of the compatibility of SSA with equipartition. The extra resolution afforded by VSOP is essential to this project as it is not possible to resolve these sources *at the frequency of the spectral peak* using ground based arrays alone. A knowledge of the emission processes present in these objects is essential to understand how they are related to the broader population of AGN.

Source Sample

Our sample has been chosen to include GPS sources with a flux density greater than 5.0 Jy at the frequency of the peak, peak flux densities in the frequency range 1.0–5.0 GHz, and known VLBI structure on intercontinental baselines. The sources meeting these criteria are PKS0237−233, 1127−145, 1718−649, 1934−638 and 2134+004. We have included one additional source, PKS0022−423, which we know possesses sufficient flux density on intercontinental baselines, although it does not meet the peak flux density greater than 5 Jy criterion. Each of these six objects have two strong components which dominate the contributions to the total flux density.

With the exception of PKS1127−145 and 2134+004, all the sources have been the subject of Southern Hemisphere VLBI imaging observations at 2.3 or 5 GHz. Each source was detected on the baselines between Australia and South Africa. Images of the four objects from these observations are provided on the attached page. Five of the sources in the sample have a total angular extent less than 30mas. However 1934−638 consists of two components separated by about 41 mas. Since component sizes, which are the primary goal of this proposal, depend most sensitively on the amplitudes of the longest baselines, it will be necessary to correlate either at two phase centres, or else to keep the integration time short. The latter approach is more likely to be used since integration times will need to be short for a source for which the correlated amplitudes beat so fast.

Calculations of field strengths based on the presently available observational data indicate that the SSA magnetic fields are typically between 1 and 100 times smaller than those calculated from equipartition theory. However, because the calculations require estimation of the source sizes at the frequency of the spectral peak, away from those of the observations, these results are equivocal. To remove this uncertainty, the components must be observed at the frequency of the spectral turnover.

All six objects in this sample peak either in the range 1–2 GHz, or close to 5 GHz respectively. Thus by selecting observations at either 1.6 or 4.8 GHz it will be possible to measure the source parameters at the peak frequency, where not only is each source strongest, but also where SSA begins to dominate. This is exactly as is required to estimate the SSA magnetic field accurately. Matching the observation frequency to the frequency of the peak flux density is very important to achieve the goal of this proposal. The spread in peak frequencies means it will be possible to assess to what extent the competing absorption mechanism hypotheses apply with varying source conditions.

To achieve the accurate imaging necessary, we request 4-orbit observations, as the image quality depends crucially on adequate space-ground uv-coverage. Four orbits are needed for the equatorial sources in order to pick up all the baselines from the VLBA through to South Africa. Simulations demonstrate that satisfactory uv-coverage can be achieved for all sources at particular times during the second AO. For the three southern-most sources, all ground and spacecraft data will be recorded with S-2 recorders, and will be correlated on the Canadian S-2 correlator, thus relieving the load on the Mitaka correlator. Simulations also show that the observations of the equatorial sources benefit from the north-south baselines between the western VLBA antennas, Asia-Pacific antennas and the Australian array.

Some of these objects have been observed or scheduled with HALCA (2-orbits) in the AO1 period but data are not yet available. We request the completion of this AO1 program and, whenever possible, second observations in AO2 to complete the 4 orbits needed for good uv-coverage. The second epoch observations also permits checking for any unexpected changes in structure.