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Evidence for Self-Similar Evolution of Gigahertz-Peaked–Spectrum Sources

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Abstract. A sample of gigahertz-peaked–spectrum (GPS) sources has been selected from the Westerbork Northern Sky Survey (WENSS) at flux densities one to two orders of magnitude lower than bright GPS sources studied until now. VLBI observations on our faint sample and other brighter samples provide evidence that GPS sources evolve in a self-similar way.

1. VLBI Observations of a Faint Sample of GPS Sources

Gigahertz-peaked–spectrum (GPS) sources are a class of extragalactic radio source characterized by a convex radio spectrum peaking at about 1 GHz in frequency. They are compact luminous radio sources, and it has been proposed that they may evolve into compact steep-spectrum (CSS) sources and then into FR I and/or FR II sources (Fanti et al. 1995, Readhead et al. 1996). We have selected a sample of 47 faint GPS sources from the Westerbork Northern Sky Survey. By comparing this new faint GPS sample with bright samples from the literature, we aim to investigate the properties of GPS sources as a function of radio luminosity, redshift and rest frame peak frequency. The sample is being studied as intensively as possible in the radio, infrared and optical wavelength regimes. For a general overview of the project see Snellen et al. (1996). The WENSS sample of GPS sources has been observed at 5 GHz with a global array (6 EVN and 10 VLBA stations), and part of the sample at 15 GHz using the VLBA only.

2. Self-Similar Evolution

The correlation found between peak frequency and projected linear size in the bright samples (e. g., Fanti et al. 1990)—the higher the peak frequency, the smaller the source—is also found in our faint sample. In addition, we find a correlation between projected linear size and the luminosity at the spectral peak: the higher the peak luminosity, the larger the source. We have investigated whether these two correlations are actually related via a correlation between projected linear size and the diameter of the dominant individual component. The motivation for this comes from the realization that the peak frequency ν_{max} and the peak luminosity S_{max} are related in synchrotron theory to the

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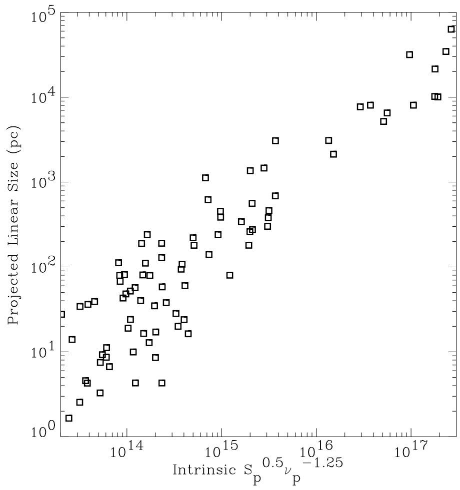

Figure 1. The projected linear size as function of $S_p^{0.5}\nu_p^{-5/4}$, where S_p is the peak luminosity and ν_p the intrinsic peak frequency, for GPS and CSS sources. The correlation found indicates a constant ratio of overall source size to size of the dominant radio components in GPS and CSS sources. Assuming that GPS sources evolve into CSS sources this implies a self-similar evolution.

linear size L of an individual component by $L \propto S_{max}^{0.5}\nu_{max}^{-5/4}$. In figure 1 the projected overall linear size is shown as a function of the intrinsic $S_{max}^{0.5}/\nu_{max}^{-1.25}$. Included are our faint GPS sources from WENSS, GPS sources from a sample at intermediate flux densities from Snellen et al. (1995), bright GPS sources from Stanghellini et al (1996) and the CSS sources from Fanti et al. (1990). Indeed a clear linear correlation is found, indicating that the ratio between the projected overall linear size to the size of the dominant radio component (producing the spectral peak) is constant for GPS and CSS sources.

What does this mean? Assuming that GPS sources evolve into CSS sources, they have to evolve from small into larger sources following the correlation found, which means that the ratio between the total size and the size of the individual radio components is constant. This indicates a self-similar evolution of young radio sources.

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