Evolution of the peaked-spectrum radio sources down to 54 MHz

Universiteit Leiden
Leiden Observatory

Sai Zhai (szhai@strw.leidenuniv.nl) at Leiden Observatory
Co-authors: Anniek Gloudemans, Huub Röttgering, et al.

LOFAR

Introduction:

1. What are Peaked-spectrum (PS) sources?

PS sources are distinguished by their peaked radio spectra. They can be classified into different types based on their peak frequency. We focus on the PS sources in the megahertz range, hereafter referred to as MPS.

2. Why MPS sources?

- They are likely represent early stages of radio loud active galactic nucleus (AGN), providing critical insights into AGN formation and evolution;
- High-sensitivity LOFAR surveys enable their study at frequencies below 100 MHz;
- Previous research has proposed and confirmed the effectiveness of using MPS sources to identify high-redshift candidates.

Sample:

- We selected **1,187 quasars** from the SDSS DR16 quasar catalog, ensuring data availability from LoLSS DR1 (54 MHz), LoTSS DR2 (144 MHz), and VLA FIRST (1.4 GHz).
- We differentiated optical and radio-selected quasars from the SDSS.
- We clasified the extended sources using the criteria: $\frac{S_{int}}{S_{peak}} > 1.25 + 3.1\times(\frac{S_{peak}}{rms})^{-0.53}$, where S_{int}, S_{peak}, and rms represent the integrated and peak flux density, and local noise of sources, respectively.
- By requiring the $\boldsymbol{\alpha_{54}^{144} \geq 0.1}$ **and** $\boldsymbol{\alpha_{144}^{1400} < 0}$, we identified **61 detected MPS sources**.

Fig. 1: The evolution of spectral index (α_{54}^{144}, α_{144}^{1400}) with redshift.

Left: Optical and radio selected quasars have nearly the same constant trend.
Right: Compared to compact sources, the **extended sources have slightly steeper spectral indices**.

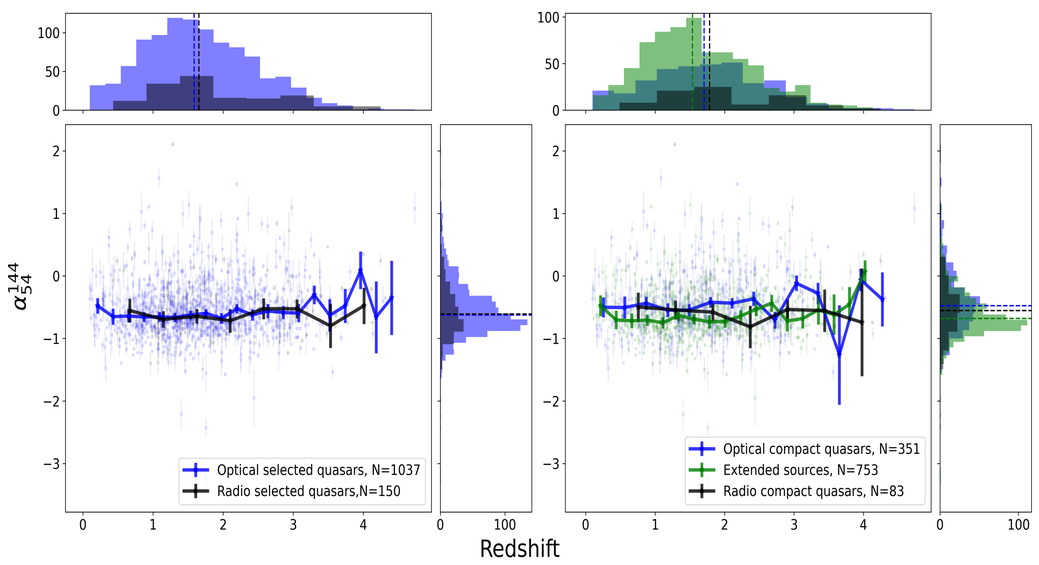


Fig. 2: The distribution of two spectral indices.

The red color show the distribution of MPS sources.

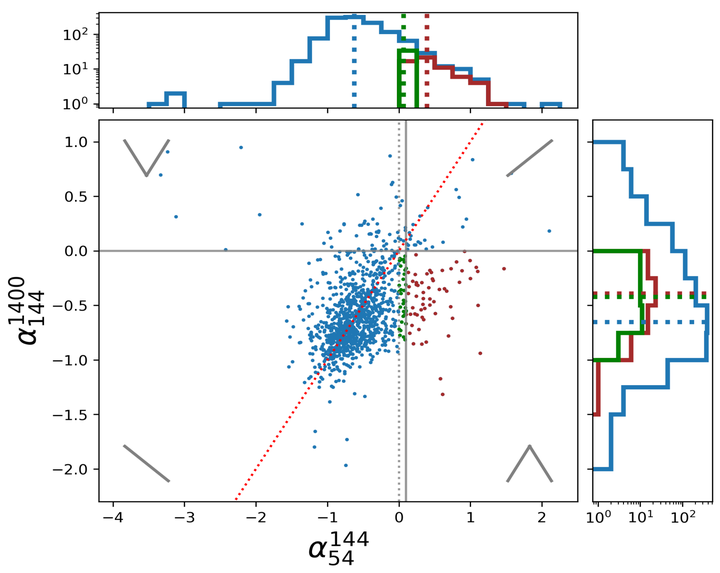
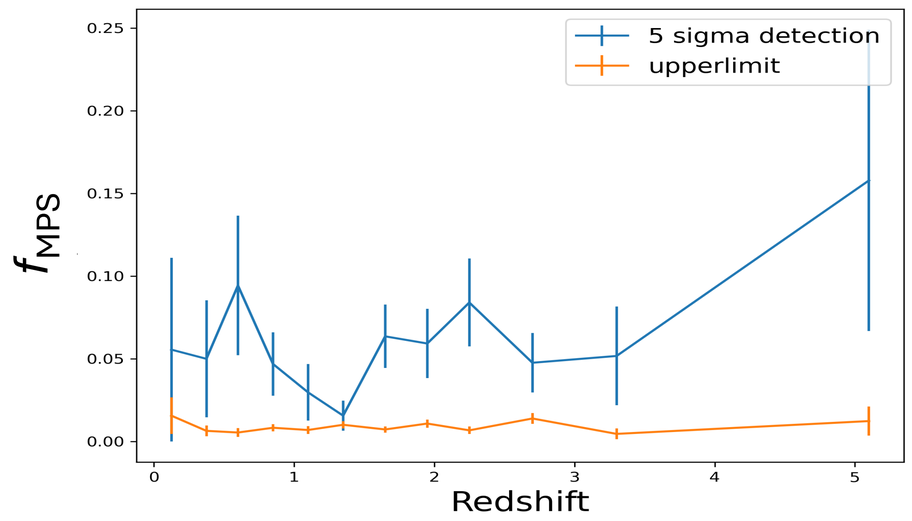


Fig. 3: The fraction of MPS sources VS redshift.

As LoTSS had the deepest observations, we expanded the sample using upper-limit data from LoLSS and FIRST. We found that **the fraction of MPS sources remains almost constant with increasing redshift.**



Take home message

1. What is the α-z relationship at low frequency band?

We find no significant evolution of the spectral index (α_{54}^{144}, α_{144}^{1400}) with redshift.

2. Will there be more MPS sources at high redshift?

For **MHz peaked-spectrum (MPS) sources**, their fraction remains nearly constant across varying redshifts ($0 < z <\approx 5$), bolometric luminosity, and SMBH mass, **indicating minimal changes relative to host galaxies' properties**.