A statistical study of continuum radio and optical properties of quasars using wide area surveys

Mandar Gokhale
(Guide: Dr. Yogesh G. Wadadekar)

July 2, 2008
A statistical study of continuum radio and optical properties of quasars using wide area surveys

Mandar Gokhale (Guide: Dr. Yogesh G. Wadadekar)
Quasars : Characteristics

Some characteristics of quasars are:

- Very high redshift sources
- Point-like rather than extended sources
- Luminosity across a wide range of frequencies
Figure: 3C273, the first quasar discovered
Quasar Categories

According to their activity in the radio spectrum, quasars are generally classified as -

- Radio-quiet
- Radio-loud

The basis for this classification is varied, and will be explained in more detail later.
The FIRST survey

FIRST: Faint Images of the Radio Sky at Twenty-centimeters

- The radio equivalent of the Palomar Observatory Sky Survey over 10,000 square degrees of the North Galactic Cap
- B-configuration of the NRAO Very Large Array (VLA)
- 3-minute snapshots covering a hexagonal grid using 27 3-MHz frequency channels centered at 1365 and 1435 MHz
The FIRST survey

FIRST survey details

- 90 sources per square degree at the 1 mJy source detection threshold
- 35% of these have resolved structures on scales from 2-30".
- Peak and integrated flux densities and sizes are derived from fitting a two-dimensional Gaussian to each source
- Individual sources have 90% confidence error circles of radius < 0.5" at the 3 mJy level and 1" at the survey threshold

Mandar Gokhale (Guide: Dr. Yogesh G. Wadadekar)
A statistical study of continuum radio and optical properties of quasars using wide area surveys
The FIRST survey

FIRST Survey Northern Sky Coverage, 2003 April 11

Figure: Coverage of FIRST survey
The Sloan Digital Sky Survey has mapped one-quarter of the entire sky and performed a redshift survey of galaxies, quasars and stars. The DR6 is the sixth major data release of this survey and provides images, imaging catalogs, spectra, and redshifts for download. It covers 9583 square degrees of the sky.
**The Sloan Digital Sky Survey**

### Overview

- Uses a dedicated, 2.5-meter telescope on Apache Point, NM
- A 120-megapixel camera images 1.5 square degrees of sky at a time
- Imaging done in five bands - $u,g,r,i,z$

**Figure:** The SDSS camera

---

Mandar Gokhale (Guide: Dr. Yogesh G. Wadadekar)

A statistical study of continuum radio and optical properties of quasars using wide area surveys
A statistical study of continuum radio and optical properties of quasars using wide area surveys

Figure: SDSS DR6 Sky coverage
The FIRST Survey contains a large number of radio sources
\[ \sim 811,000 \]

Optical surveys document spectra and several other properties

These are essential for determining the redshift, distance, structure, type of the radio source

Hence the idea of examining optical properties of known radio sources
The data interface to the Sloan Digital Sky Survey is through the site http://casjobs.sdss.org/casjobs. By running SQL queries on the server through the interface provided, one can get data across a number of fields. Users can also upload their own catalogs on the server and match them with SDSS data.
A sample SQL query (Quasar selection by Fan et al)

```
SELECT run, camCol, rerun, field, objID, 
u, g, r, i, z, 
ra, dec
FROM Star
WHERE (u - g > 2.0 or u > 22.3)
and (i < 19)
and (i > 0)
and (g - r > 1.0)
and (r - i < (0.08 + 0.42 * (g - r - 0.96)) or g - r > 2.26)
and (i - z < 0.25)
```
We have a catalog of quasar candidates created by Gordon Richards et al from the SDSS Data Release 4. Spectra are available only for a small fraction of sources.

The FIRST sources are also available in a compatible format.

We run queries to find FIRST sources within a radius of 2” from the SDSS sources which are also in the catalog of identified quasars.

Also, a Perl script is written to automatically download images of the objects identified by the search.
Parameters

- Object should be a part of Richards’ Quasar Catalog (DR4)
- Object should be within 2” of a FIRST source
- The object should not be a composite object that has been further deblended
- The redshift of the object should be accurate to a probability of 85%
Methodology I

- Using this procedure, a total of around 4099 quasars with usable data (total objects number ~ 10000) are obtained.
- Thus, the data set is not too large, and there are uncertainties involved, as the sources are not known quasars but quasar candidates.
- Thus, due to technical difficulties using the sample, another approach (described hereafter) was adopted.
DR5 Quasar Catalog

- A catalog of known quasars, with spectra, from Data Release 5, matched with radio sources from FIRST, is already available.
- However, the set of quasars in this catalog is not as extensive (only \( \sim 70000 \) objects as opposed to \( \sim 300000 \)).
- This was the set of quasars used for the analysis.

Mandar Gokhale (Guide: Dr. Yogesh G. Wadadekar)

A statistical study of continuum radio and optical properties of quasars using wide area surveys
The entire set of 77249 quasars with key parameters was downloaded.

Various plots, most of which have been made with a far smaller catalog earlier (Wadadekar and Kembhavi, 1999), were made.

These were interpreted to draw certain conclusions regarding the distribution of quasars with regard to various parameters.
Steps - K Corrections

A K-correction is correction to an astronomical object’s magnitude/flux that allows a measurement of a quantity of light from an object at a redshift $z$ to be converted to an equivalent measurement in the rest frame of the object. $\alpha = 0.5$ for our calculation.
Steps - Conversion to standard frequencies

The radio flux and the optical magnitudes of the object given is at certain wavelengths. These have to be converted to fluxes at standard wavelengths for comparison with previously obtained results.

<table>
<thead>
<tr>
<th>Type</th>
<th>Original</th>
<th>Final (with K-correction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio</td>
<td>1.42 GHz</td>
<td>5 GHz</td>
</tr>
<tr>
<td>Optical</td>
<td>4800Å</td>
<td>2500Å</td>
</tr>
</tbody>
</table>
The data obtained from the Sloan Survey was corrected and processed as indicated earlier in MATLAB, and then plots of various parameters were made. These are shown in the following slides.
A statistical study of continuum radio and optical properties of quasars using wide area surveys

Figure: Absolute magnitude v/s redshift
Figure: Absolute magnitude v/s redshift (Wadadekar and Kembhavi, 1999)
Figure: $\log(\text{Radio luminosity})$ v/s Redshift

Mandar Gokhale (Guide: Dr. Yogesh G. Wadadekar)
A statistical study of continuum radio and optical properties of quasars using wide area surveys
Figure: \( \log(\text{Radio luminosity}) \) v/s Absolute Magnitude

Mandar Gokhale (Guide: Dr. Yogesh G. Wadadekar)
A statistical study of continuum radio and optical properties of quasars using wide area surveys
Figure: Distribution of log(R) (Ratio of radio and optical luminosities)
Figure: Radio-loud fraction as a function of absolute magnitude
Figure: Radio-loud fraction as a function of absolute magnitude (Wadadekar and Kembhavi, 1999)
A statistical study of continuum radio and optical properties of quasars using wide area surveys

**Figure:** Radio-loud fraction as a function of redshift
A statistical study of continuum radio and optical properties of quasars using wide area surveys

**Figure:** Radio-loud fraction as a redshift (Wadadekar and Kembhavi, 1999)
A statistical study of continuum radio and optical properties of quasars using wide area surveys

**Figure:** Separation of SDSS sources from FIRST