Dual Frequency Analysis of Cygnus X-3 at the Time of Flare

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Aaahhh...those days!

Theoretical Background

Cygnus X-3: A high mass black hole candidate

Image courtesy of NRAO/AUI

Theoretical Background

- Located at a distance of about 10 kiloparsecs
- High mass X-ray binary system - compact object could be a black hole or a neutron star and the donor companion star is most probably a Wolf-Rayet (WN7 or 8)
- Classified as a microquasar due to its bipolar relativistic jet accompanied by radio flares.
- First observed in 1966 (Giacconi et al, 1967)
- Cygnus X-3 has been monitored across a wide range of frequencies, from radio, infrared, optical, X-ray to gamma-rays.

Radio Flares

- High Mass X-ray Binaries (HMXB) are known to exhibit flaring activities spanning from gamma ray to radio wavelengths.
- The typical pattern of the flares are such that it takes only 1-3 days to rise to its peak (sharp rise) and comparatively longer duration (1 month or so; slow decay) to return to its pre-flare state.
- Flares occur due to the instability of the accreting matter of the relativistic jet
- Brightness of several Janskys.

Radio Flares

- In May-June 2006, Cygnus X-3 was in one of the strongest flares in its recorded history
- Earlier strong fares occured in 1994, 2000 and 2001.

The GMRT

GMRT Observations

- Observed at 244 and 610 MHz, in rising and fading phase both (Pal et al, ATEL #809).
- The flux continued to rise till 13th May which saw it reach 7.5 Jy, after which it started fading.
- I have analyzed dual frequency data of 20th May, 2006 which records the flux in this fading phase.
- I calculated the flux densities and the spectral index of the source.

Data Analysis

- Preparing the data set for analysis
  - Loading FITS file into AIPS
  - Indexing the UV data
- Data editing/flagging on the UV domain
- Calibrating the data set
  - 3C286 and 3C48 were used for both flux and bandpass calibration
  - 2052+365 for phase calibration.
- Imaging
  - Fourier transforming and gridding
  - Cleaning and Self cal

Image at 244 MHz

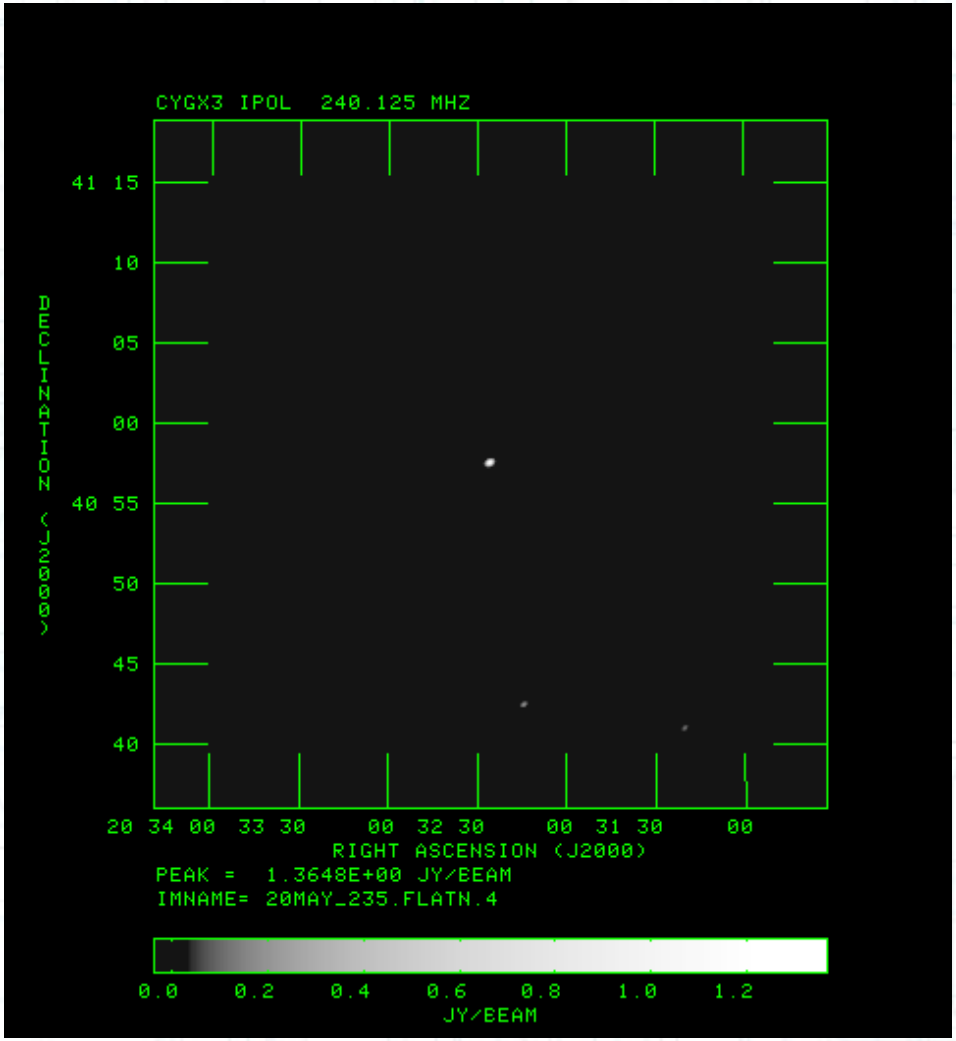
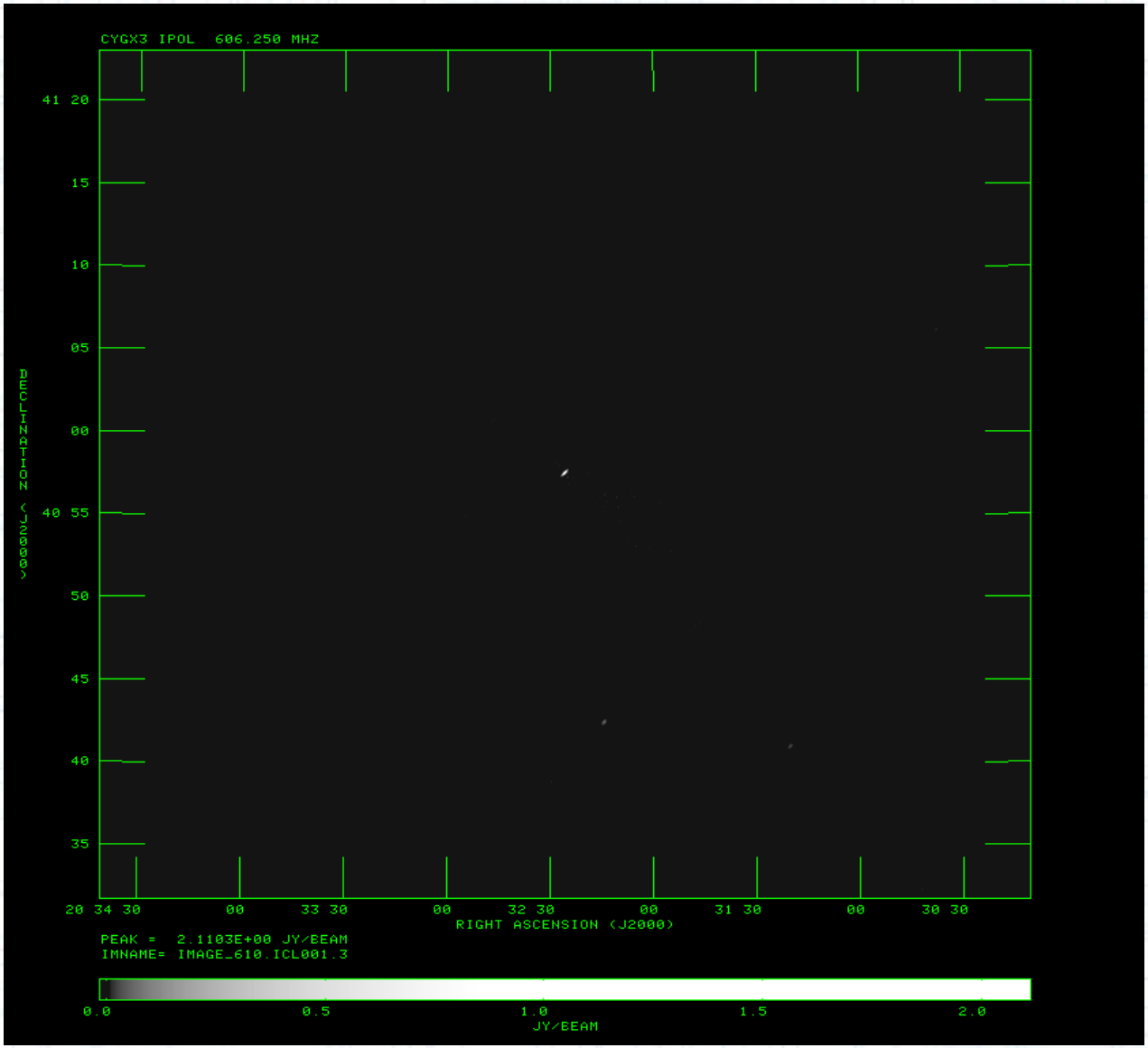


Image at 614 MHz



Results

	244 MHz	614 MHz
Flux density	1.64 Jy	2.28 Jy
RMS Noise	5.31 mJy	1.23 mJy
Signal to Noise	309	1854

Results

Spectral Index

- Power Law : $F_\nu \propto \nu^\alpha$
- Spectral Index : $\alpha = \frac{log\left(\frac{614}{244}\right)}{log\left(\frac{F_{614}}{F_{244}}\right)}$

The calculated spectral index for Cyg X-3 at the time of this flare was 0.359.

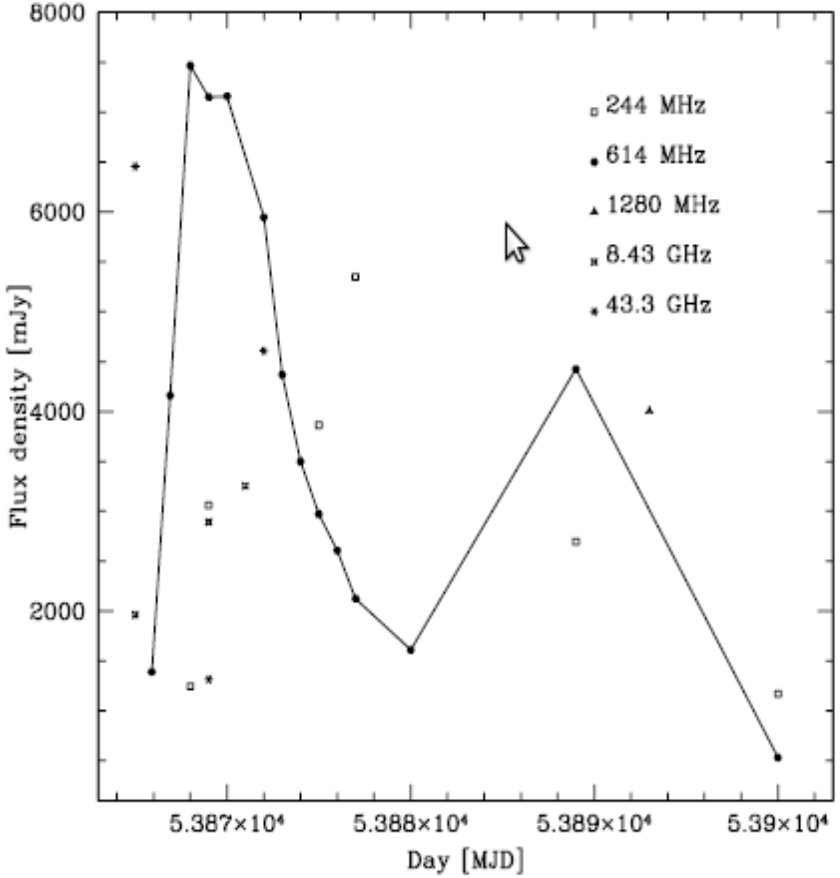
Conclusion

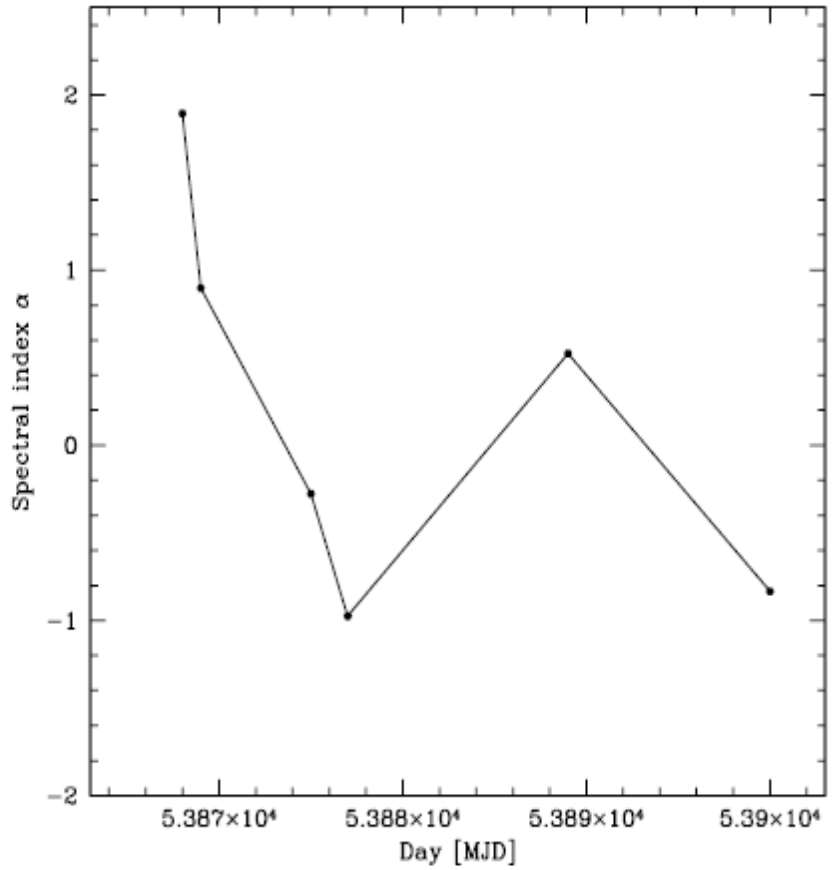
- Using the synchrotron self-absorption model, it can be said that since the value of the 2 point spectral index is positive, the emitting region is compact and self-absorbed in these frequencies (radio spectrum is optically thick)
- The observed spectral index of Cygnus X-3 is 0.359 which implies that we were at the transition part of the spectrum just before the turnover frequency.

Further on...

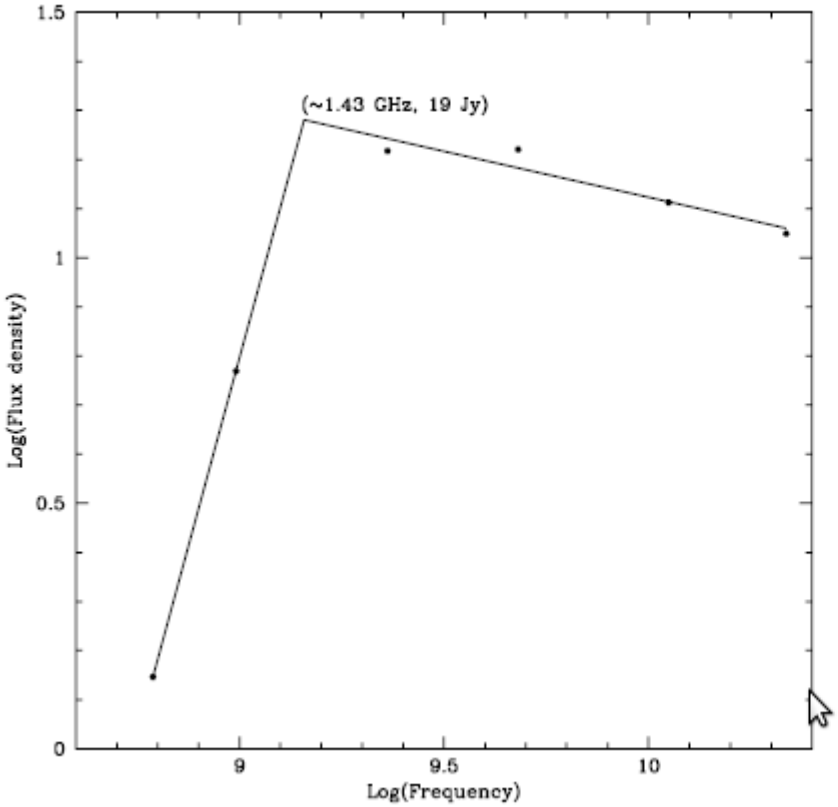
- ”*Multi wavelength radio observations of Cygnus X-3 during the giant flare of May-June 2006*” - Pal et al, CP1053, Observational Evidence for Black Holes in the Universe, Proceedings of the 2nd Kolkata Conference, 2008
- GMRT data at 244 and 614 MHz, VLA at 8.43 and 43.3 Ghz, published results from RATAN at higher frequencies
- Spectral evolution studied and speed of expansion of the synchrotron blob estimated

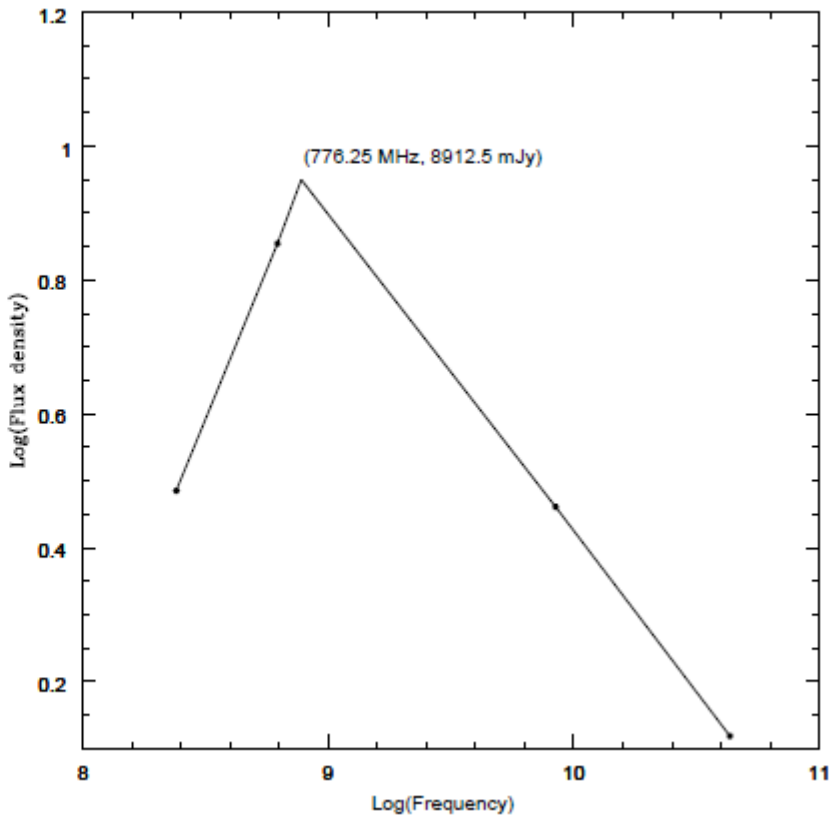
Radio Light Curve and Spectral Evolution



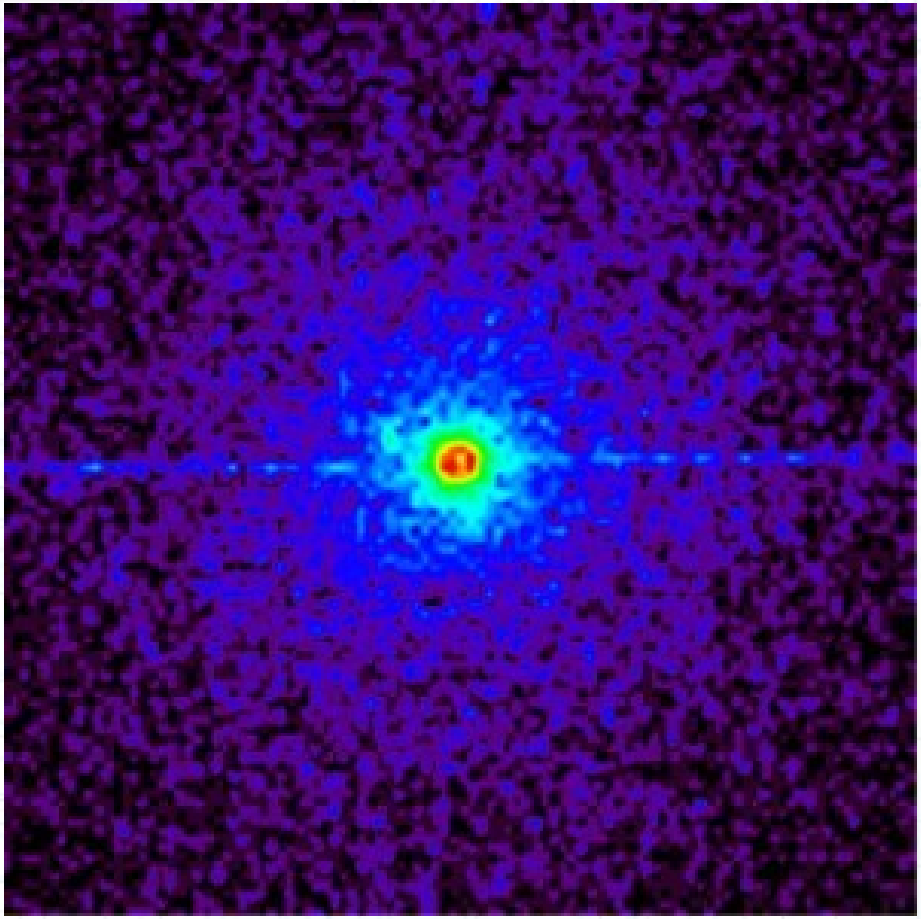


Radio Spectrum and Jet Expansion Speed





The initial velocity of the expansion of the jet was found to be in the range 0.02c to 0.17c, assuming magnetic field strength to be 0.1 to 1 Gauss.



Thank you!