What triggers Kpc scale Radio Outflows in Seyfert Galaxies?

By

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‘Jet Triggering Mechanisms in Black Hole Sources’
Introduction

- Parent sample is Siding Spring Southern Seyfert Spectroscopic Snapshot Survey (S7) - 128 Seyferts observed with IFU on the Siding Spring 2.3m telescope in Australia (Dopita et al. 2014).

- S7 Giant Meterwave Radio Telescope (GMRT) sample - @ 610 and 1450 MHz - 17 Seyferts, \(0.004 \leq z \leq 0.02\).

- Larger aim: understand the origin of Kiloparsec - Scale radio structures (KSRs) whether they are AGN - driven (Colbert et al. 1996) or due to winds from the starbursts (Baum et al. 1993, Wilson et al. 1988).
Seyfert Galaxies and LINERs

- First identified by Carl Seyfert in 1943.
- Luminous ‘star-like’ nuclei superimposed on spiral or lenticular hosts.
- Strong narrow and broad emission lines.
- Both broad (1000-5000 km/s) and narrow (<500 km/s) emission lines - Type 1
- Only narrow lines - Type 2

- Low Ionization Nuclear Emission-line Regions (LINERs) - defined by its spectral line emission - weakly ionized or neutral atoms and strongly ionized atoms.

Active Galactic Nucleus

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Image courtesy: CALweb

Pavana M, IIA - JRF

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Selection criteria:

- To be accessible to GMRT - Dec range of $\pm 10\,\text{deg}$
- Flux density cutoff $\geq 25\,\text{mJy} @ 1450\,\text{MHz}$ (Veron catalog).
- 31 S7 Seyferts, 13 of which are Type 2 and the remaining 18 are Type 1 or LINER.
- 14 Seyferts have archival Very Large Array data @ 1450 MHz.
- GMRT observations @ 610 and 1450 MHz - 17 Seyferts (Project ID: 27_067) to look for the KSRs.

Data were reduced using the *NRAO Common Astronomy Software Application* (CASA) package.
Results: Images

Detection rate of marginally extended or extended sources in our sample: 55%.
Detection rate > previously observed in the literature (44% in Gallimore et al. 2006; Singh et al. 2014).
Comparison of the distribution of $q$ for KSR and non-KSR sources (Helou et al., 1985).

Far infrared (FIR) - radio continuum ratio, $q$ parameter is,

$$q = \log\left[\frac{FIR}{3.75 \times 10^{12} \text{ Hz}} / S(1.4 \text{ GHz})\right]$$ \hspace{1cm} (1)

S is flux density and

$$FIR = 1.26 \times 10^{-14} \left[2.58 \ S(60 \ \mu m) + S(100 \ \mu m)\right]$$ \hspace{1cm} (2)
Results: PA and luminosity distribution

1. $\Delta PA$ (degrees) between the KSR axis & host galaxy major axis for 9 KSR S7-Seyfert galaxies @ both frequencies.
   Similar results were found by Colbert et al. 1996 and Gallimore et al. 2006.

2. Distribution of luminosity of the radio source ($L$) @ 1450 MHz for non-KSR sources. $< \log(L) > = 41.87$.

3. Distribution of $L$ @1450 MHz for KSR sources. $< \log(L) > = 42.20$.
   Thus, KSR sources are more luminous on an average when compared to that of non-KSR sources.
Summary

1. Extended or marginally extended sources - 55%.
   - Observing @ low radio frequencies like 610 MHz - efficient @ detecting diffuse radio outflows.

2. Majority of ΔPA values : 40° - 50°
   - ⇒ KSR axis prefers to align at an oblique angle with the galaxy major axis.
   - Stellar winds align with the galaxy minor axes (Colbert et al. 1996).

3. KSR sources have excess radio continuum relative to the far-infrared continuum.

4. KSR Seyferts are more luminous than the non-KSR Seyferts @ 1450 MHz.

5. Overall, this study suggest that the radio outflows in S7-GMRT sample are related to AGN activity.