Exploring the connection between black holes, galaxies and AGNs:

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Image Credit: Space Engine

Outline

- 1. Introduction
- 2. Surveys: Astrogeo, DESI
- 3. VLBI jet PA vs Optical galaxy PA
- 4. Results
- 5. Future: SKA



Images Credit: Chandra X-ray Observatory

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Introduction

Is there any relationship between an AGN and its host galaxy? Big mystery in Astrophysics!



Figure 1: Artist's illustration of high-speed jets emitted from a supermassive black hole at the center of an active galaxy. [ESA/Hubble, L. Calçada (ESO)]

Slowly unraveling it!

Nature Astronomy paper: Detection of an orthogonal alignment between parsec scale AGN jets and their host galaxies (Nature accepted paper).

Authors: D. Fernández Gil, J. A. Hodgson, B. L'Huillier, J. Asorey, C. Saulder, K. Finner, M. J. Jee, D. Parkinson, and F. Combes.

Surveys: Astrogeo, DESI

Astrogeo VLBI Image Database:

- Contains 125,623 brightness distributions of 20,472 compact radio sources
- Focused on Active Galactic Nuclei (AGN)
- Data generated from VLBI surveys (Very Long Baseline Interferometry)
- Radio astronomy observations using networks of radio telescopes spread over thousands of kilometers

DESI LS:

- Inference model of the extragalactic sky in optical and infrared
- Covered ~14,000 square degrees of the extragalactic sky
- Northern hemisphere in three optical bands (g, r, z)



Figure 2: Optical surveys and the VLBI sample used.

Surveys: Astrogeo, DESI

Why DESI was chosen? Let's look at the distribution of the PAs.



Figure 3: Histogram of VLBI jet PAs. The PAs come from the Astrogeo catalogue and vary between -180° and 180°



Figure 4: PA distribution of the cross-matches with two of the optical surveys.

a) DESI LS shows the most uniform distribution.

b) SkyMapper shows the least uniform distribution.

VLBI jet PA vs Optical galaxy PA



 $\Delta PA = PA_{jet} - PA_{galaxy}$

If $\Delta PA = 0^{\circ}$: jet is **perpendicular** to the galaxy

If $\Delta PA = 90^{\circ}$: jet is **parallel** to the galaxy

Different scales: PA jet: pc-scale PA galaxy: kpc-scale Different range: PA jet = -180° to 180° PA galaxy = -90° to 90°

Results



VLBI Jet & Host Galaxy Morphology Connection

- Evidence of a connection between pc-scale VLBI jet and kpc-scale optical host galaxy morphology
- Jet direction tends to be perpendicular, with a p-value < 0.05 (galaxies with measured spectroscopic redshift or those well resolved)

Next Steps:

- Higher source counts and better optical resolution surveys (HST, JWST)
- Better resolution radio VLBI observations (e.g., Square Kilometer Array)
- Aim: Determine the **universality of the connection**

Figure 7: ΔPA for the DESI Legacy Survey sources, with various quality and redshift cuts.

Future: SKA?





Figure 8: Prototype SKA-Low antennas on site in Australia. Image credit: SKAO website.

Figure 9: Artist impression: an SKA-Mid dish in the foreground, with a MeerKAT dish on the left. Image credit: SKAO website.



Future me



What triggers AGNs?

- Look at the VLBI sources inside in the optical surveys
- Check if they are "special" or "different" from the rest of galaxies in the Universe (non-AGNs):
 - If they are, it could help to understand what triggers AGNs
 - If not, weirdos!



Q & A