The physics of the radio emission in the quiet side of the AGN population

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Radio-quiet AGN

The majority of AGN are radio-quiet, not radio-silent

Small fraction in mJy radio surveys

\[ L_{1.4 \, \text{GHz}} < 10^{20-23} \, \text{W/Hz}; \]

Dominant AGN population < 100 μJy @ 1.4 GHz
Radio-quiet AGN

Large fraction from stellar-related processes

Tight radio-FIR correlation

Luminosity evolution similar to SFG

Core: \( L_{2\text{cm}} \sim 10^{18-22} \text{ W/Hz}; \)

No core radio-FIR correlation
The host galaxy contribution

Usually in late-type galaxies → Loads of gas and stars

AGN emission hidden by stellar contribution

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AASKA - Giardini Naxos
11/06/2014
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Radio-quiet AGN

What is the origin of the nuclear emission?

• Thermal emission from AGN wind/hot corona
  
  NGC 1068, Gallimore+04

• ADAF/ADIOS
  
  Narayan&Yi 94; Blandford&Begelman 99

• Non-thermal jet emission
  
  Jet morphology similar to radio-loud AGN,
  GeV emission exceeding the star-forming contribution,
  Circinus, Hayashida+13

• Combination of jet and disk emission
  
  NGC 4151, Ulvestad+98
Observational requirements

High angular resolution (sub-arcsecond scale)
Separate AGN and stellar emission in the central kpc region

High sensitivity (μJy or better)
Pick up the faint contribution from the AGN
Study the high-z AGN population

Polarization (0.1% level or better)
Disentangling thermal and non-thermal contribution
Resolve regions with well ordered H

Continuous frequency coverage (~100 MHz resolution)
Disentangling thermal and non-thermal emission by the spectrum
**Stellar vs AGN emission**

High angular resolution to go into the central kpc region

SKA1-mid 100 km

0.4'' @ 21cm

0.07'' @ 3.6 cm < 0.6kpc @ z=1.5

Large angular scale to detect low-surface brightness extended features

VLBI picks up 100% down to 10-20% of VLA-A flux or non detection at all
Thermal vs non-thermal

Good frequency converage for characterizing the spectral shape
Continuous coverage ~1 to 10 GHz (bands 2, 4 and 5)

Convex

Flat

JVLA

Cont. rms ~1.0 μJy  5rms = 5 μJy

10^{23} \text{ W/Hz @} z=2
10^{22} \text{ W/Hz @} z=1
5 \times 10^{21} \text{ W/Hz @} z=0.5
10^{20} \text{ W/Hz @} z=0.1
10^{18} \text{ W/Hz @} z=0.01
Thermal vs non-thermal

Good frequency coverage for characterizing the spectral shape
Continuous coverage ~1 to 10 GHz

100-MHz rms ~5.0 μJy  5rms = 25 μJy  \( \Rightarrow \)  \( 10^{20} \) W/Hz @z=0.1

\( 10^{18} \) W/Hz @z=0.01

DEEP STUDIES OF LOCAL OBJECTS

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Thermal vs non-thermal

- Information on the magnetic field
  
  Linear polarization → Synchrotron + ordered B
  
  No-polarization → Thermal
  Synchrotron + depolarization

- Multi-frequency dependence
  
  Circular polarization (0.4 – 1%, e.g. M81*)

- Spectral peak
  
  \[ H_{SSA} = \frac{\theta_{max}^2 \theta_{min}^2 \nu_p^5}{f(\alpha)^5 S_p^2 (1+z)} \]
Summary

• Disentangling the contribution of star-forming activity from the nuclear emission and detecting jet-like structures from the AGN

  Sub-arcsec resolution  $\rightarrow$ 100 km baseline

• Determining the nature of radio emission from the central AGN:
  
  Broad-band observations  1-10 GHz
  Sensitivity  $\text{rms} \leq 1 \mu Jy$
  Polarization  Accuracy $\sim 0.1\%$

• The advent of the full SKA2 will be crucial for studying the high-z radio-quiet AGN population