Hunting for feeding and feedback signatures in a sample of hard X-ray selected NLS1

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Feeding & Feedback in AGN

Tight correlation between BH mass and mass of host galaxy bulge

Self-regulating mechanism linking SMBH accretion-powered growth to star formation

**FEEDING**
Luminous AGN phases: cold and dense molecular gas which forms stars inflows towards the nucleus, feeding the growth of the SMBH.

**FEEDBACK**
AGN-powered winds and outflows can modify the physics and geometry of the ISM, altering further star-formation and nuclear gas accretion.

SMBH growth, nuclear activity and winds come to a halt, until new cold gas accretes toward the nucleus, starting a new AGN phase.
Fundamental Elements of Feeding & Feedback cycle:

Molecular gas content of galaxies

Preceding phase in which the AGN-driven winds expel gas quenching star formation

How can we study these two fundamental topics?

CO measurements —> molecular gas reservoirs + ALMA high resolution mapping

Deep X-ray spectroscopy

XMM+NuSTAR
Observational Evidence

- Molecular gas detected and mapped in several AGN (e.g. Feruglio et al. 2015; Fiore et al. 2017).

- WA and UFOs (X-rays; Piconcelli et al. 2005; Tombesi et al. 2010).

**HOWEVER**

Information about cold gas in AGN is from far infrared selected samples which are biased toward star-forming host galaxies. Therefore, results are mainly based on heterogeneous and biased AGN samples.
The IBISCO Sample

- 60 hard X-ray selected (20-100 keV) AGN at z<0.05, Dec>-20° from the Malizia et al. (2012; 2016) samples all with black hole mass estimates.

- Broad ranges of luminosity, BH mass, Eddington luminosity and obscuration.

- Entire sample observed in the CO(1-0) and (2-1) lines (see talk by Chiara Feruglio).

- Goal: study feeding and feedback cycle in a well-controlled sample of AGN.

Sub-Sample of 8 Narrow Line Seyfert 1 Galaxies
Why Narrow Line Seyfert 1 Galaxies?

- Peculiar sub-class of type 1 AGN.
- Full width at half-maximum (FWHM) of the Hβ line lower than 2000 km s\(^{-1}\).
- Permitted lines only slightly broader than forbidden lines.
- \([\text{OIII}] \lambda 5007 / \text{Hβ} < 3\).
- Unusually strong FeII and other high ionisation emission line complexes.
- X-rays: strong variability (also on short timescales), steep power-law spectra.
Why Narrow Line Seyfert 1 Galaxies?

Smaller black hole masses than their broad line analogues.

Comparable luminosity to that of the BLS1s (Pounds, Done & Osborne 1995): highly efficient accreting systems with higher fractional accretion rates ($\dot{m}=\dot{M}/\dot{M}_{\text{Edd}}$).

NLS1 could be in an early phase of black hole evolution, making them key targets for studying formation and evolution of AGN

Within the IBISCO sample, NLS1 are the most peculiar sources where to investigate possible correlations between fractional accretion rates and molecular gas fraction in the host galaxies.
# NLS1 in the IBISCO Sample

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<thead>
<tr>
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<th>Obs date</th>
<th>z</th>
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Spectral Analysis

Sources are complex and variable

Baseline model has been used to homegeneously fit all the broad band spectra

\[ \text{wag}*\text{zxipcf}*(\text{nthComp}+\text{pexrav}+\text{zga}+\ldots) \]

Once the broad band spectrum is properly fitted, we investigate the presence of absorption features between 5 and 9 keV, which are indicative of winds/outflows
### Preliminary X-ray Spectral Analysis

Baseline model: wag*zxipcf*(nthcomp+pexrav+zga)

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<th>$N_H$</th>
<th>cf</th>
<th>Log$\xi$</th>
<th>$\Gamma$</th>
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<tr>
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</table>
Emission line @0.55 keV due to O VII. XMM RGS analysis also shows presence of O VIII emission line (see Cardaci et al. 2011).

$E_Fe = 6.39 (+0.08/-0.10) \text{ keV}$

$EW = 46 (+20/-21) \text{ eV}$

Consistent with Boller et al. 2007

No evidence of WA or UFOs
**NGC 4051** - Swift XRT+NuSTAR

$E_{Fe} = 6.4 \text{ keV}$

$E_{Fe} = 6.80 \text{ keV}$

$E_{Fe} = 7.01 \text{ keV}$

Consistent with Turner et al. 2017

NGC 4051 has been found to have both WA and UFOs

Ref: Tombesi et al. 2010, 2013
Mrk 766 - XMM pn+NuSTAR

$E_{Fe} = 6.4 \text{ keV}$
$E_{Fe} = 6.81 \text{ keV}$

Consistent with Turner et al. 2006

Tombesi et al. (2010, 2013) detected evidence of the presence of WA and UFOs

BUT

source is very variable...

No evidence of UFOs in our observation (but we do find the WA!)
NGC 4748 - XMM pn+IBIS/ISGRI+Swift/BAT

Little studied source
No evidence of WA
No evidence of outflows

$E_{\text{Fe}} = 6.4 \text{ keV}$

$E_{\text{Fe}} = 6.69 \text{ keV}$
NGC 5506 - XMM pn+NuSTAR

Consistent with Matt et al. 2001; 2017

$E_{Fe} = 6.38$ keV
$E_{Fe} = 6.93$ keV

Patrick et al. (2012) found evidence of WA and possibly of an outflow.

In our observation we do not detect these features... BUT source is variable (in flux, spectral shape, absorption...)

```
wabs(nthComp+wabs(pexrav+zga+zga))
```
Swift J2127.4+5654 - XMM pn+NuSTAR

- `E_{Fe} = 6.4` keV
- `E_{Fe} = 6.80` keV
- `E_{Fe} = 7.0` keV

No evidence of WA.
No evidence of outflows.

*Consistent with Marinucci et al. 2014*
**KAZ 320 - Swift XRT+ Swift BAT**

- Poorly studied source
- X-ray data from Swift (XRT+BAT) do not allow an in-depth study due to the poor statistical quality

More data needed!!

Combined XMM/NuSTAR observation has been requested in latest XMM AO.
IGR J19378-0617 is a very interesting source. Light curves show strong variability on relatively short timescales.

- Spectral analysis in three different epochs.
<table>
<thead>
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<th>$N_H$ ($10^{22}$ cm$^{-2}$)</th>
<th>Log$\xi$</th>
<th>cf</th>
<th>$\Gamma_s$</th>
<th>kTe</th>
<th>$\Gamma$</th>
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<td>2.36</td>
<td>94</td>
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IGR J19378-0617

Energy (keV)

wabs*zxipcf*(nthComp+pexrav+zga+zga+zga)

IGR J19378–0617 – Epoch 1

Energy (keV)

wabs*(nthComp+pexrav+zga+zga+zga)

IGR J19378 – Epoch 2

Energy (keV)

wabs*(nthComp+pexrav+zga+zga+zga)

IGR J19378–0617 – Epoch 3

Energy (keV)
## Accretion Parameters

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<th>Source</th>
<th>z</th>
<th>(L_{2-10}) (erg/s)</th>
<th>(L_{bol}) (erg/s)</th>
<th>(L_{Edd}) (erg/s)</th>
<th>(\text{Log}(M_{\text{BH}}/M_\odot))</th>
<th>(\lambda=L_{bol}/L_{Edd})</th>
<th>(\dot{M} (\varepsilon=0.1)) (M_\odot/yr)</th>
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CO Observations of NLSY 1 (IRAM)

75% CO detection rate

+ NGC4051 and NGC5506  CO detections from Maiolino+1998
Molecular Gas Fraction of NLSy1

**COLDGASS**: inactive galaxies (Saintonge+2011)
**IBISCO**: active galaxies

NLSY 1 are hosted in low stellar mass galaxies but have high gas fraction
NLSy1: BOLOMETRIC LUMINOSITY scaling

NLSY 1 are in the UPPER ENVELOPE of Eddington Ratio distribution

High Eddington Ratio

High Gas Fraction

PRELIMINARY
Conclusions

- Peculiar, complex and highly variable objects.
- WA found in 30% of the sample, cold absorber in one object BUT from comparison with previous observations we know that also absorption is variable.
- Winds/outflows in one source BUT detected in most of our NLS1 in previous observations (VARIABILITY).
- As expected NLS1 are efficiently accreting systems BUT variations also in the optical band can lead to quite different estimates of BH masses, therefore large scatter in \( \lambda \) values.
- CO detected in 75% of the sample.
- NLS1 show higher molecular gas fractions.