INTEGRAL view of the Extragalactic Sky

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T. Bird
Distribution of all AGN (~500) so far detected by INTEGRAL plotted on the sky (Malizia et al. 2012 + 2016 + extra AGN in Russian surveys).

mainly broad line or type 1 AGN, narrow line or type 2 AGN and blazars (QSO and BL Lac) but we can say that all type of AGN observed in soft X-rays now seen above 20 keV.

There are sources still of unknown optical class but they have been considered AGN since they have been associated with galaxies detected in the IR and/or in the Radio band.
All the INTEGRAL AGN have been undoubtedly identified through X-ray and optical follow-up observations and they have been fully characterized in terms of their spectral parameters in a broad energy band (2-100 keV).

<table>
<thead>
<tr>
<th>Name</th>
<th>RA</th>
<th>Dec</th>
<th>z</th>
<th>Class</th>
<th>$F_{2-100}$</th>
<th>$F_{2-10}$</th>
<th>Log N_{H}</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGR J00040+7020</td>
<td>00 04 01.92</td>
<td>+70 19 18.5</td>
<td>0.096</td>
<td>Sy2</td>
<td>1.47</td>
<td>0.35</td>
<td>22.52</td>
<td>De Rosa et al. 2012</td>
</tr>
<tr>
<td>IGR J00158+5605</td>
<td>00 15 54.19</td>
<td>+56 02 57.5</td>
<td>0.169</td>
<td>Sy1.5</td>
<td>&lt;0.66</td>
<td>0.31</td>
<td>21.50</td>
<td>Malizia et al. 2011</td>
</tr>
<tr>
<td>IGR J00256+6821</td>
<td>00 25 32.50</td>
<td>+68 21 44.0</td>
<td>0.012</td>
<td>Sy2</td>
<td>1.47</td>
<td>0.05</td>
<td>23.60</td>
<td>Landi et al. 2007a</td>
</tr>
<tr>
<td>IGR J00333+6122</td>
<td>00 33 18.34</td>
<td>+61 27 43.3</td>
<td>0.105</td>
<td>Sy1.5</td>
<td>1.38</td>
<td>0.68</td>
<td>21.03</td>
<td>Molina et al. 2009</td>
</tr>
<tr>
<td>1ES 0033+595</td>
<td>00 35 52.60</td>
<td>+59 50 05.0</td>
<td>0.080</td>
<td>BL Lac</td>
<td>1.83</td>
<td>5.90</td>
<td>21.55</td>
<td>Donato et al. 2005</td>
</tr>
<tr>
<td>IGR J00465-4005</td>
<td>00 46 20.68</td>
<td>-40 05 49.1</td>
<td>0.201</td>
<td>Sy2</td>
<td>3.56</td>
<td>0.12</td>
<td>23.38</td>
<td>Landi et al. 2010a</td>
</tr>
<tr>
<td>MKN 348</td>
<td>00 48 47.10</td>
<td>+31 57 26.0</td>
<td>0.015</td>
<td>Sy2</td>
<td>10.50</td>
<td>0.44</td>
<td>23.02</td>
<td>Tartarus Database</td>
</tr>
</tbody>
</table>

**Optical coordinates of counterpart and redshift**

**X-ray** [2-10 keV data]

**Most appropriate optical class: cross check NED and Veron-Cetty Veron 13th catalogue generally preferred the most recent!**

**In case of mismatch:** class criteria Veilleux & Osterbrock (‘87)

line ratio diagnostics of Ho et al. (‘93, ’97) and Kauffmann et al. (2003)

**For assigning Seyfert subclasses (1.2, 1.5, 1.8, 1.9):** Hα/O[III]λ5007 line flux ratio criteria (Winkler ‘92)
FIRST CUT OFF constrain in broad line Sey (Malizia+2014)

broadband (0.3–100 keV) spectral analysis by simultaneously fitting the soft and hard X-ray spectra obtained by XMM and INTEGRAL/IBIS–Swift/BAT on INTEGRAL complete sample of Sey 1

NOT contemporaneous but cross correlations between instruments OK

photon index and cut-off well constrained

\[ \langle \Gamma \rangle = 1.73 \ (\sigma = 0.2) \]

\[ \langle E_c \rangle = 128 \text{ keV} \ (\sigma = 46 \text{ keV}) \]
High energy cut-off: confirmation by NuSTAR

Broad band (0.5-78 keV) spectral analysis of 18 Sey1 of the complete sample using simultaneous Swift-XRT and NuSTAR observations

Molina et al. 2019MNRAS.484.2735M

\[ \langle \Gamma \rangle = 1.74 \ (\sigma = 0.13) \]

\[ \langle R \rangle = 0.58 \ (\sigma = 0.41) \]

\[ \langle E_c \rangle = 111 \text{ keV} \ (\sigma = 45 \text{ keV}) \]
high energy cut-off: comparison with previous work

Molina+2018/Malizia+2014

Molina+2018/Ricci+2017

Molina et al. 2019MNRAS.484.2735M
### Table 4 - Previous Results

<table>
<thead>
<tr>
<th>Source</th>
<th>Malizia et al. 2014</th>
<th>Ricci et al. 2017</th>
<th>NuSTAR (Ref)</th>
</tr>
</thead>
<tbody>
<tr>
<td>QSO B0241+62</td>
<td>$&gt;138$</td>
<td>$177^{+66}_{-60}$</td>
<td>-</td>
</tr>
<tr>
<td>MCG+08-11-011</td>
<td>$171^{+44}_{-40}$</td>
<td>$252^{+131}_{-60}$</td>
<td>$175^{+110}_{-50}$ (1)</td>
</tr>
<tr>
<td>Mrk 6</td>
<td>$131^{+132}_{-48}$</td>
<td>$122^{+82}_{-15}$</td>
<td>-</td>
</tr>
<tr>
<td>FRL 1146</td>
<td>$84^{+79}_{-30}$</td>
<td>$&gt;72$</td>
<td>-</td>
</tr>
<tr>
<td>IGR J12415-5750</td>
<td>$175^{+296}_{-74}$</td>
<td>$&gt;229$</td>
<td>-</td>
</tr>
<tr>
<td>4U 1344-60</td>
<td>$&gt;110$</td>
<td>$45^{+7}$</td>
<td>-</td>
</tr>
<tr>
<td>IC 4329A</td>
<td>$152^{+51}_{-32}$</td>
<td>$236^{+42}_{-26}$</td>
<td>$185^{+15}_{-15}$ (1)</td>
</tr>
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<td>IGR J16119-6036</td>
<td>$&gt;100$</td>
<td>$127^{+333}_{-64}$</td>
<td>-</td>
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<td>IGR J16482-3036</td>
<td>$163^{+220}_{-60}$</td>
<td>$&gt;90$</td>
<td>-</td>
</tr>
<tr>
<td>GRS 1734-292</td>
<td>$58^{+24}_{-7}$</td>
<td>$84^{+38}_{-26}$</td>
<td>$53^{+10}_{-10}$ (1)</td>
</tr>
<tr>
<td>2E 1739.1-1210</td>
<td>-</td>
<td>$&gt;230$</td>
<td>-</td>
</tr>
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<td>IGR J18027-1455</td>
<td>$&gt;86$</td>
<td>$&gt;74$</td>
<td>-</td>
</tr>
<tr>
<td>3C 390.3</td>
<td>$97^{+20}_{-11}$</td>
<td>$166^{+64}_{-37}$</td>
<td>$120^{+20}_{-20}$ (1)</td>
</tr>
<tr>
<td>2E 1853.7+1534</td>
<td>$89^{+30}_{-26}$</td>
<td>$152^{+41}_{-38}$</td>
<td>-</td>
</tr>
<tr>
<td>NGC 6814</td>
<td>$190^{+185}_{-65}$</td>
<td>$&gt;210$</td>
<td>$135^{+70}_{-35}$ (1)</td>
</tr>
<tr>
<td>4C 74.26 (tot)</td>
<td>$189^{+171}_{-66}$</td>
<td>$&gt;119$</td>
<td>$183^{+51}_{-35}$ (2)</td>
</tr>
<tr>
<td>S5 2116+81</td>
<td>$&gt;180$</td>
<td>$&gt;175$</td>
<td>-</td>
</tr>
<tr>
<td>IGR J21247+5058</td>
<td>$79^{+23}_{-15}$</td>
<td>$206^{+111}_{-27}$</td>
<td>$100^{+90}_{-30}$ (3)</td>
</tr>
</tbody>
</table>

Spectra & light curves

MCG+08-11-11

GRS 1734-292

\( \Gamma_{\text{NuSTAR}} - \Lambda = 1.94 \ [1.90772, 1.98356] \)
\( F_{20-100 \text{ keV}} = 1.78 \times 10^{-10} \text{ ergs/cm}^2/\text{s} \)
\( \Gamma_{\text{cat1500}} = 1.95 \ [1.88934, 2.01904] \)
\( F_{20-100 \text{ keV}} = 2.02 \times 10^{-10} \text{ ergs/cm}^2/\text{s} \)

\( \Gamma_{\text{NuSTAR}} - \Lambda = 2.10 \ [1.87659, 2.34096] \)
\( F_{20-100 \text{ keV}} = 1.0 \times 10^{-10} \text{ ergs/cm}^2/\text{s} \)
\( \Gamma_{\text{cat1500}} = 2.16 \ [2.12103, 2.20531] \)
\( F_{20-100 \text{ keV}} = 9.5 \times 10^{-11} \text{ ergs/cm}^2/\text{s} \)

for all AGN!!

CEN A

Circinus Galaxy

MCG +08-11-11 - 20-100 keV

2002 -2015
**X-ray absorption and large scale structure**

**host galaxy & galactic structures**

- Inclination of host galaxy (axial ratio $b/a$)
- Presence of bars in the host galaxy

**Example Images**:
- SWIFT J0601.9-8636: $b/a = 0.2$, Edge-on
- ESO 323-G77: $b/a = 0.92$, Face-on

**Statistics**:
- Collected 301 $b/a$ measurements
- 229 morphological info out of 378 Seyferts
Maiolino et al. (1999): strong correlation between the gaseous absorbing column density in type 2 AGN and the presence of bars in their host galaxies, i.e. strongly barred objects have on average column densities two order of magnitudes higher than non barred sources.

percentage of barred/unbarred galaxies seems to increase/decrease with column density but with large errors

overall trend: gas in bar of host galaxy can contribute to the X-ray absorption especially in CT AGN
Host galaxy inclination

Inclination of host galaxy (axial ratio b/a) can have a role in the X-ray absorption

- if absorber/torus aligned with galaxy: Sy1 face-on and Sy2 edge-on
- if not, no correlation between Sy type and axial ratio expected

neither works:

Sy 2 uncorrelated with a/b
Sy 1 correlated with a/b

need for dual absorbers
(proposed by Maiolino & Rieke 95)

deficit of type 1 in edge-on galaxies looks like these are recovered going to higher energies but still present in the INTEGRAL hard X selected sample

type 2 are distributed over the whole range of b/a
where are the missing type 1 AGN hosted in edge-on galaxies?

conclusions

- Torus misaligned with the galaxy
- Second absorber located in and aligned with host galaxy

Thick enough to hide the BLR

Mis-classified type 2 AGN

Contribution also to CT AGN

Malizia et al. in preparation
Future work

MIR the most suitable band to study the host galaxy

Silicate feature strength (9.7 micron)
index of dust presence

torus models are not able to reproduce deep silicate absorption features ($S_{Sil} < -1$)

extra dust structures on larger scales should be considered

A NEAR INFRARED VIEW OF NEARBY GALAXIES: THE CASE OF NGC 6300
(GASPAR et al. astro-ph 1902.02373)

‘An analysis of the Ks-band continuum slope shows an IR excess outside the nucleus and up to ~ 27 pc probably associated with hot dust and not related to the putative dusty torus of the UM. We propose that this hot dust must be contributing to the AGN obscuration and it could be partially responsible for its Sy2 classification.’

Dust-lanes – bars – galaxies