Multi-band AGN and Starburst signatures

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in collaboration with
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S. Charlot, J. Gutkin & NEOGAL group - IAP

AGN11 - Where Black Hole and Galaxies Meet - 23-26 September - Trieste
AGN and SB co-exist in galaxies at all redshift
(e.g. Farrah et al. 2003, Alexander et al. 2005)

M-σ relation
(e.g. Magorrian et al. 1998, Ferrarese & Merritt 2000; Tremaine et al. 2002; Häring & Rix 2004; Gültekin et al. 2009)

quasar number density and SFH of the Universe
(e.g. Madau et al. 1998, Heavens et al. 2004, Boyle & Terlevich 1998; Heavens et al. 2004; Richards et al. 2006 etc)

feedback from AGN in cosmological simulations and semi-analytical models (e.g. Blandford & Rees 1974; Zanni et al. 2005; Di Matteo et al. 2005; Bower et al. 2006; Croton et al. 2006; Booth & Shaye 2009; Wagner & Bicknell 2011)

Molecular outflows
(e.g. Sturm et al. 2011; Brusa et al. 2014)
What is an AGN- or SB- dominated system when both phenomena are present?

Does the presence of an AGN have an impact on the properties of the host galaxy?
What is an AGN- or SB- dominated system when both phenomena are present?

AGN and SB co-exist in galaxies at all redshift (e.g. Farrah et al. 2003, Alexander et al. 2005)

method and wavelength range where to define such systems

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What is an AGN- or SB- dominated system when both phenomena are present?

method and wavelength range where to define such systems

Does the presence of an AGN have an impact on the properties of the host galaxy?

possible effects on the IR properties of the host galaxy
HerMES/IRS SAMPLE

- 375 sources
- detected >3\(\sigma\) at 250 \(\mu\)m
- in the northern HerMES fields (Bootes, FLS, Lockman, EN1)
- IRS spectra available
- reliable estimates of z (optical or IRS)

<table>
<thead>
<tr>
<th>BAND</th>
<th>DETECTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRAC 3.6 &amp; 4.5 nm</td>
<td>100%</td>
</tr>
<tr>
<td>IRAC 5.8 &amp; 8.0 nm</td>
<td>90%</td>
</tr>
<tr>
<td>MIPS 70 nm/MIPS 160</td>
<td>77%/43%</td>
</tr>
<tr>
<td>SPIRE 350</td>
<td>98%(72%)</td>
</tr>
<tr>
<td>SPIRE 500</td>
<td>84%(35%)</td>
</tr>
<tr>
<td>SDSS ugriz</td>
<td>73%</td>
</tr>
</tbody>
</table>

Feltre et al. 2013
CASSIS [http://cassis.astro.cornell.edu/atlas](http://cassis.astro.cornell.edu/atlas)
HerMES [http://hermes.sussex.ac.uk](http://hermes.sussex.ac.uk)
IRS SPECTRA DECOMPOSITION

AOR = 24156928.0 (2MASX_J10542172+5823445)

$z = 0.20453$

$\chi^2 = 0.4842$

$r_{cont} = 0.5624$ (AGN_CONT)

Hernán-Caballero et al. 2011, Hernán-Caballero et al. in prep.
* AGN and SB contribution to MIR (5-15µm)
* $EW_{PAH}$ (6.2µm, 11.3µm)
* $L_{PAH}$ $\Rightarrow$ $SFR_{PAH}$
IRS SPECTRA DECOMPOSITION

* AGN and SB contribution to MIR (5-15µm)
* $\text{EW}_{\text{PAH}} (6.2\mu m, 11.3\mu m)$
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Hernán-Caballero et al. 2011, Hernán-Caballero et al. in prep.
A CUSTOMIZED TOOL

\[ f_{\text{AGN}}, f_{\text{SB}} \ (L_{\text{IR}}[8-1000] \mu m) \]
\[ L_{\text{acc}}, L_{\text{IR}}, L_{\text{SB}} \quad \Rightarrow SFR_{\text{FIR}} \]
\[ M_{\text{hot}}, M_{\text{cold}}, T_{\text{cold}} \]
ACUSTOMIZED TOOL

stellar emission

SSP models
Bertelli 1994

\[ f_{\text{AGN}}, f_{\text{SB}} (L_{\text{IR}}[8-1000]\mu\text{m}) \]
\[ L_{\text{acc}}, L_{\text{IR}}, L_{\text{SB}} \rightarrow SFR_{\text{FIR}} \]
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A CUSTOMIZED TOOL

SSP models
Bertelli 1994
Fritz et al. 2006
Feltre et al. 2012

stellar emission
AGN torus

f_{AGN}, f_{SB} (L_{IR}[8-1000]\mu m)
L_{acc}, L_{IR}, L_{SB} \rightarrow SFR_{FIR}
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A CUSTOMIZED TOOL

stellar emission

AGN torus

SB templates

SSP models
Bertelli 1994

Fritz et al. 2006

Feltre et al. 2012

\( f_{\text{AGN}}, f_{\text{SB}} (L_{\text{IR}}[8-1000] \mu m) \)

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A CUSTOMIZED TOOL

stellar emission

AGN torus

SB templates

modified black body

SSP models
Bertelli 1994

Fritz et al. 2006
Feltre et al. 2012

$f_{\text{AGN}}$, $f_{\text{SB}}$ ($L_{\text{IR}} [8-1000] \mu m$)

$L_{\text{acc}}$, $L_{\text{IR}}$, $L_{\text{SB}}$ $\Rightarrow SFR_{\text{FIR}}$

$M_{\text{hot}}$, $M_{\text{cold}}$, $T_{\text{cold}}$
AGN and SF in mid-IR

$\text{EW}_{\text{PAH} (11.3|6.2\mu m)} = 0.2$

- e.g. Spoon et al. 07, Smith et al. 2007,
- Hernan Caballero et al. 2009,
- Wu et al. 2010
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AGN-dominated (45%)
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**EW_{PAH}(11.3|6.2\mu m) = 0.2**

- AGN-dominated (45%)
- SB-dominated (55%)

- PAH 11.3 \mu m

- \frac{S_{8.0}}{S_{4.5}} vs \frac{S_{5.8}}{S_{3.6}}

- Number of Objects:
  - 0
  - 10
  - 20
  - 30
  - 40
AGN and SF in mid-IR

e.g. Spoon et al. 07, Smith et al. 2007, Hernan Caballero et al. 2009, Wu et al. 2010


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**AGN-dominated** (45%)

**SB-dominated** (55%)

PAH 11.3 µm

SB-dominated

un-obscured AGN
AGN and SF in mid-IR

\[ \text{EW}_{\text{PAH}}(11.3|6.2\mu m) = 0.2 \]

SB-dominated (55%)

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un-obscured AGN


e.g. Spoon et al. 07, Smith et al. 2007, Hernan Caballero et al. 2009, Wu et al. 2010
AGN and SF in mid-IR
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AGN-dominated

AGN fraction [MIR]

EW_{PAH}
AGN and SF in mid-IR

The diagram shows a scatter plot with two regions: AGN-dominated and SB-dominated. The x-axis represents EW_{PAH}, and the y-axis represents AGN fraction [MIR]. The data points are distributed across the plot, with a clear separation between the two regions, indicating a relationship between AGN activity and the PAH emission line strength.
AGN and SF in mid-IR
AGN and SF in mid-IR
AGN and SF in mid-IR
AGN and SF in mid- and far-IR

*SB component to account for FIR
*SB-dom. objects small contribution from AGN
AGN and SF in mid- and far- IR

- EW
- PAH
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\[ SFR_{\text{FIR}} \left[ M_\odot/\text{yr} \right] \]

\[ L_{\text{acc}} \left[ \text{erg/s} \right] \]

e.g. Serjeant & Hatziminaoglou 2009; Hatziminaoglou et al. 2010; Serjeant et al. 2010; Bonfield et al. 2011

Feltre et al. 2013
AGN and SF in mid- and far-IR

- e.g. Serjeant & Hatziminaoglou 2009; Hatziminaoglou et al. 2010; Serjeant et al. 2010; Bonfield et al. 2011
- Schweitzer et al. 2006; Netzer et al. 2007; Lutz et al. 2008; Armus et al. 2007; Brandl et al. 2006; Smith et al. 2007; Pope et al. 2008; Fadda et al. 2010

Feltre et al. 2013
Lutz et al. 2008 report a constant $L_{\text{PAH}}/L_{\text{SB}}$ ratio over > 4 orders of magnitude in $L_{\text{SB}}$ on a sample of local ULIRGs.

Wu et al. 2010 observe a slight decrease.
Lutz et al. 2008 report a constant $L_{\text{PAH}}/L_{\text{SB}}$ ratio over > 4 orders of magnitude in LSB on a sample of local ULIRGs.

Wu et al. 2010 observe a slight decrease.

Feltre et al. 2013

PAH features not affected by $L_{\text{acc}}$
Single-T modified BB (Fritz et al. 2012) but range of temperatures consistent with multi-T approach (e.g. Kirkpatrick et al. 2012)
Hot and Cold dust components

<table>
<thead>
<tr>
<th>L_{acc} [erg/s]</th>
<th>&lt;T&gt; [K]</th>
</tr>
</thead>
<tbody>
<tr>
<td>total</td>
<td>28.5</td>
</tr>
<tr>
<td>(&lt;10^)</td>
<td>27.1</td>
</tr>
<tr>
<td>(10^)</td>
<td>27.7</td>
</tr>
<tr>
<td>(&gt;10^)</td>
<td>30.9</td>
</tr>
</tbody>
</table>

Single-T modified BB (Fritz et al. 2012) but range of temperatures consistent with multi-T approach (e.g. Kirkpatrick et al. 2012)

\(T\) of the cold dust does not depend on \(L_{acc}\)
**CONCLUSIONS**

- Definition of AGN (SB)-dominated system is method and wavelength dependent.
- AGN rarely contribute >50% to L_{IR}.
- Lacc does not affect SFR estimates.
- SFR_{FIR} and SFR_{PAH} correlate differently for AGN- and SB- dom. sources.
- L_{PAH}/L_{SB} not constant for SB-dominated objects.
- No robust evidence that the temperature of the cold dust is affected by the AGN.
- Non-constant fraction of gas driven by the gravitational effects to the AGN while the starburst is ongoing.

**NO EVIDENCE THAT THE PRESENCE OF AN AGN AFFECTS THE STAR FORMATION PROCESS**

**TWO PHENOMENA OCCUR SIMULTANEOUSLY OVER A WIDE RANGE OF LUMINOSITIES**
NEOGAL
NEw frOntiers in GALaxy spectral modeling

Members

Stéphane Charlot (PI)
Aida Wofford, Jacopo Chevallard, Julia Gutkin, Alba Vidal,
Anna Feltre, Michaela Hirschmann

GOAL

explore the early star formation and chemical
evolution of galaxies through the development and
exploitation of innovative spectral models and
spectral analysis tools
modeling emission lines from AGN using photoionisation code CLOUDY

looking for diagnostics through comparison with emission lines models of galaxies
(Gutkin et al., in prep)
(e.g. calibrating the models starting from the BPT diagram and exploring other emission lines)

to create grids of models in preparation for NIRspec-JWST high quality observations of the early Universe
THANKS FOR THE ATTENTION
TAKE AWAY POINTS

✧ Definition of AGN (SB)-dominated system is method and wavelength dependent
✧ AGN rarely contribute >50% to LIR
✧ Lacc does not affect SFR estimates
✧ $SFR_{\text{FIR}}$ and $SFR_{\text{PAH}}$ correlate differently for AGN- and SB- dom. sources
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