Past & Present Secular Evolution in the Host Galaxies of NLS1s*

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“NLS1s represent a class of AGN in which the black hole growth is, and always has been, dominated by secular processes…”

*see also G. Orban de Xivry et al. 2011, almost submitted to MNRAS
Present
NLS1 galaxies are likely to be barred

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**Crenshaw+03, visual study HST survey (Malkan+98):**

- >90% of NLS1s and BLS1s are in spirals.
- ~65% of NLS1s spirals are barred
- ~25% of BLS1s spirals are barred
NLS1 galaxies are likely to be strongly barred

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- **Ohta+07, visual and ellipse fitting:**
  - Most NLS1s are in spirals galaxies.
  - ~85% of NLS1 spirals are barred.
  - SB (not SAB) show similar trend with FWHM(Hβ)
Present Secular Evolution & NLS1 Hosts
Morphological Properties - Circumnuclear

- Deo+ 2006, HST imaging survey from Malkan+ 98:
  - NLS1s likely have ‘grand-design’ nuclear spirals
- Nuclear grand design spirals are also characteristics of barred galaxies. Martini+03
  - Same trend with FWHM than bars fraction

But bars also drives gas inwards ...
Present Secular Evolution & NLS1 Hosts
Star Formation

- Sani+10, “Enhanced SF in NLS1 AGN revealed by Spitzer”
  - $R$ is ratio of star formation (PAH) to AGN luminosities at 6um
  - significant difference in $R$ between NLS1&BLS1 (checked for bias due to luminosity, distance, etc.)
Secular Processes All the Way Down

- “NLS1 host galaxies are likely to be strongly barred (much more than BLS1 ones) and their nuclear dust morphology is likely to be a grand-design spiral” (Crenshaw+03, Ohta+07, Deo+06)

- “NLS1 host bulges have a more intense star formation than BLS1s” (Sani+10)

- Also in line with the finding of Ho+97 that nuclear star formation is enhanced in barred galaxies.

- Secular processes are powerful on all scales
Past
Pseudo-bulges are secular phenomena (Kormendy & Kennicutt 2004)

- They are *bulges* because they are dense central components of galaxies (like classical bulges)
- They are *pseudo-* because they are made slowly by disks out of disk material. They are formed by internal secular processes (bars, spirals, etc.) > < galaxy mergers or external secular evolution

Fisher&Drory 2008

Fisher+09; larger disk makes larger bulges
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Pseudo- vs. Classical bulges

- Pseudo-bulge identification (e.g. KK04, Fisher&Drory08, Gadotti09, FD10)
  - Dynamics are rotation dominated (see later)
  - Structural properties:
    - low Sersic index (disk have n~1), bulge scaling relation, bulge morphology
  - Stellar population

Gadotti 09, SDSS data

Fisher&Drory 08, high resolution data
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Bulge-Disk decomposition - sample

- WFPC2 F606W images from HST survey of nearby AGNs by Malkan+98 (z<0.035)

- Classification is first taken from previous papers using these data and then verify based on spectra.

- Final sample: 10 genuine NLS1s (Veron et al. 2001); 18 BLS1s for comparison

- High resolution images: mean pixel scale ~ 20pc/px
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Bulge-Disk decomposition

Components:
1. Point source
2. Sersic profile (bulge), \( n \) index free (\( n \sim 4 \) elliptical, \( n \sim 1 \) disk)
3. Exponential profile (disk)

Additional features are masked

Doing this for 28 objects, we obtain…
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Sersic $n$ in the bulge of NLS1 and BLS1

NLS1 bulges $n$ is different than the one of BLS1s:

- $<n>(\text{NLS1}) \sim 1.59$
- $<n>(\text{BLS1}) \sim 2.54$
- FD08:
  - $<n>\text{(pb)} \sim 1.69$, $<n>\text{(cb)} \sim 3.49$
- Laurikainen+07: the mean bulge Sersic index is $\sim 2.5$ or less across the Hubble sequence
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- Lauikainen+07: the mean bulge Sersic index is $\sim$2.5 or less across the Hubble sequence
- Dispersion in $n$ 2X larger for BLS1 than NLS1
- NLS1 different from the average BLS1.
- BLS1 -> larger bulge range (pb and cb)
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- NLS1s bulges are less prominent (c)
- Not clearly offset from BLS1 in the FP projection but all on the fainter side (a)
NLS1 bulges are less prominent than BLS1 bulges as pb and cb.
NLS1 galaxies are later type than BLS1.
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NLS1s, pseudo-bulges and secular evolution

- Pseudo-bulges are secular phenomena
- NLS1 bulges have $n<2$. They are less prominent ($B/T<\sim0.2$).
- NLS1s have pseudo-bulges and are distinct from the average BLS1 bulges. NLS1s tend to be in later type galaxies than BLS1.

- Internal secular processes have dominated the past evolution of NLS1 hosts.

Evolutionary scenarios: BH growth is supported by secular processes

1. NLS1 would be young objects evolving into BLS1s (Mathur 2000, Mathur+ 2011)
2. NLS1 are not in any special phase of their evolution but are simply growing slower (Ric’s talk, Orban de Xivry+11)
NLS1 hosts have pseudo-bulges, distinct from the average BLS1s bulges

\[ <n>(\text{NLS1}) \sim 1.59 \quad <n>(\text{BLS1}) \sim 2.54 \]
NLS1 hosts have pseudo-bulges.

\(<n>(\text{NLS1}) \sim 1.59\quad <n>(\text{BLS1}) \sim 2.54\)

+ Ryan+07, 11 NLS1s AO CFHT data in J and K band:

\(<n_K> \sim 1.4\)

\(<n_J> \sim 1.5\)
NLS1 hosts have pseudo-bulges.

\[
\langle n \rangle_{\text{NLS1}} \approx 1.59 \quad \langle n \rangle_{\text{BLS1}} \approx 2.54
\]

- Ryan+07, 11 NLS1s AO CFHT data in J and K band:
  \[
  \langle n_K \rangle \approx 1.4 \\
  \langle n_J \rangle \approx 1.5
  \]

- Mathur+11 (updated), 10 NLS1s ACS F625W (6NLS1s have n<2)
  \[
  \langle n \rangle \approx 2.12
  \]
How to challenge this picture?

- Pseudo-bulges are more rotation dominated than classical bulges (KK04)
  - Can we detect it using an IFU?
  - Importance of angular momentum in the fueling of the NLS1 black holes growth?

Using the DYSMAL code, e.g. Davies+09
Conclusions

- NLS1s have strong bars, nuclear GD and enhanced SF,
- Secular evolution is powerful and on-going process on all scales,
- NLS1s host bulges are pseudo-bulges and distinct from BLS1s bulges
- Pseudo-bulges are driven by secular evolution therefore:
  - **NLS1 represent a class of AGN in which the BH growth has always been dominated by secular evolution**

- Ric will present the implications of this results and how it can fit in a cosmological context.

Thank you!