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CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

Discordant optical and X-ray classification of AGN

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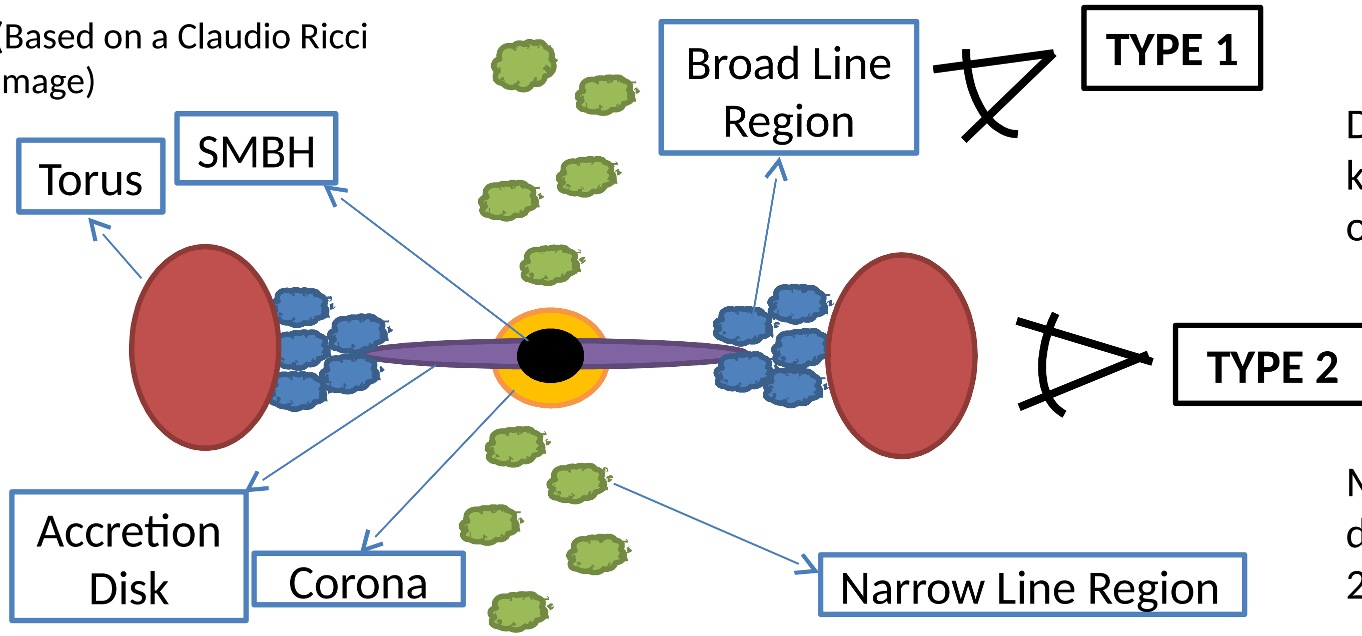
Introduction

Unified model of AGN

(Based on a Claudio Ricci image)



OPTICAL

Detection of >1000-1500 km/s broad lines (type-1) or not (type-2).

X-RAY

Modelling X-ray spectra to detect absorption (in type-2) or not (in type-1).

- 10-23% of type-1 AGN X-ray absorbed
- 3-17% of type-2 AGN X-ray unabsorbed

(e.g. Mateos et al. 2005, Corral et al. 2013, Merloni et al. 2013)

Aims

Determine the origin of the apparent mismatch between X-ray and optical properties:

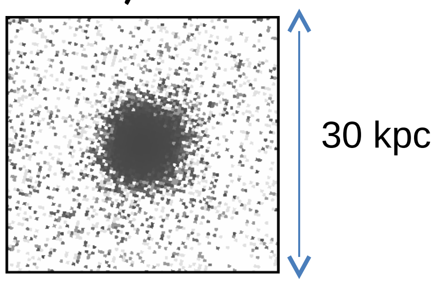
- **Compton-thick scenario:** If $N_H > 1.5 \cdot 10^{24}$ cm^{-2} we only detect the reflected spectrum <10 keV (flat broad band continuum; strong Fe reflection line).

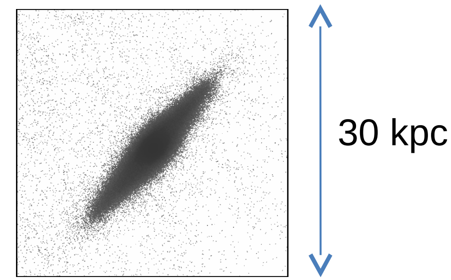
- **Host dilution:** emission from the host galaxies dilutes AGN signatures (e.g. broad UV/optical lines).

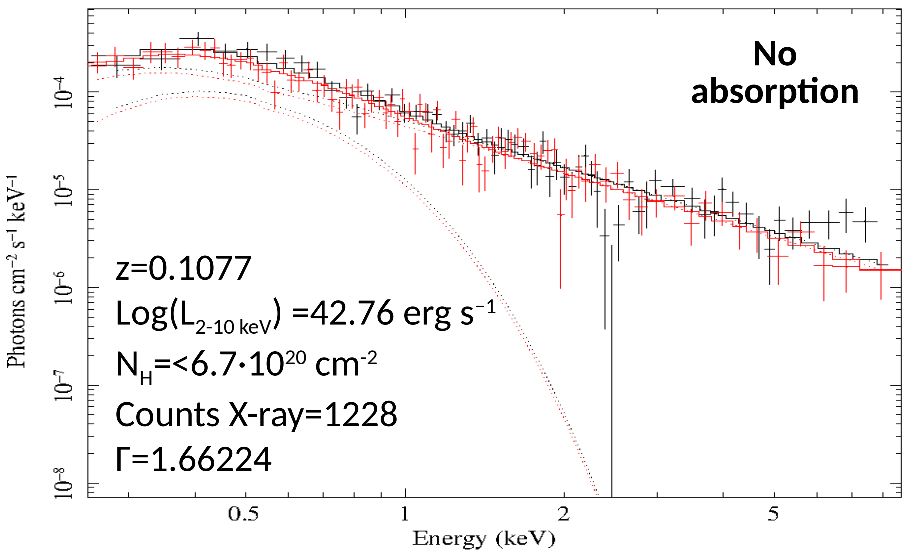
- **Intrinsic properties of the AGN:** such as intrinsically weak broad line regions (BLR) or different dust-to-gas ratio.

The Sample

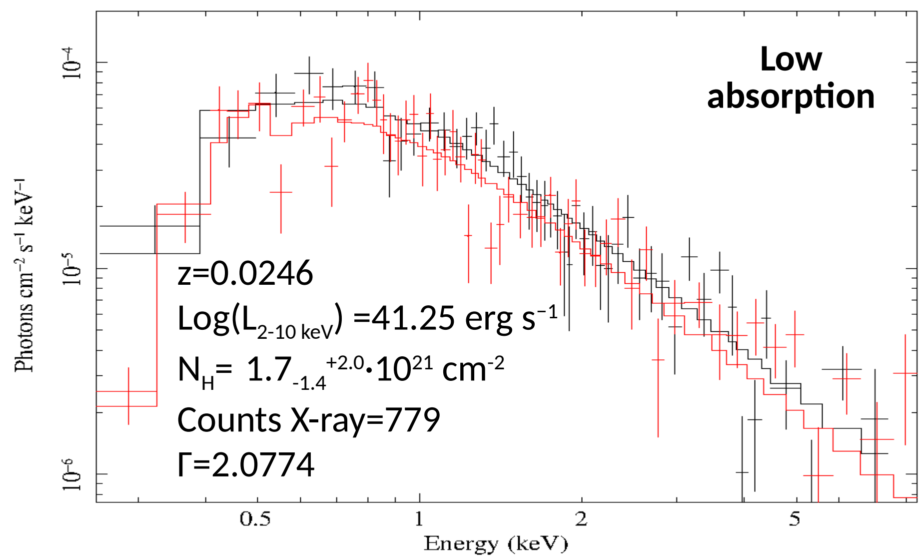
Two type 1.9-2 AGN with low X-ray absorption drawn from the Bright Ultra Hard XMM-Newton Survey (BUXS; Mateos et al. 2012). **None of this sources is Compton-thick (N_H<1.5·10^{24} cm^{-2}, no strong Fe reflexion line).**







J000441.24+000711.3=J00



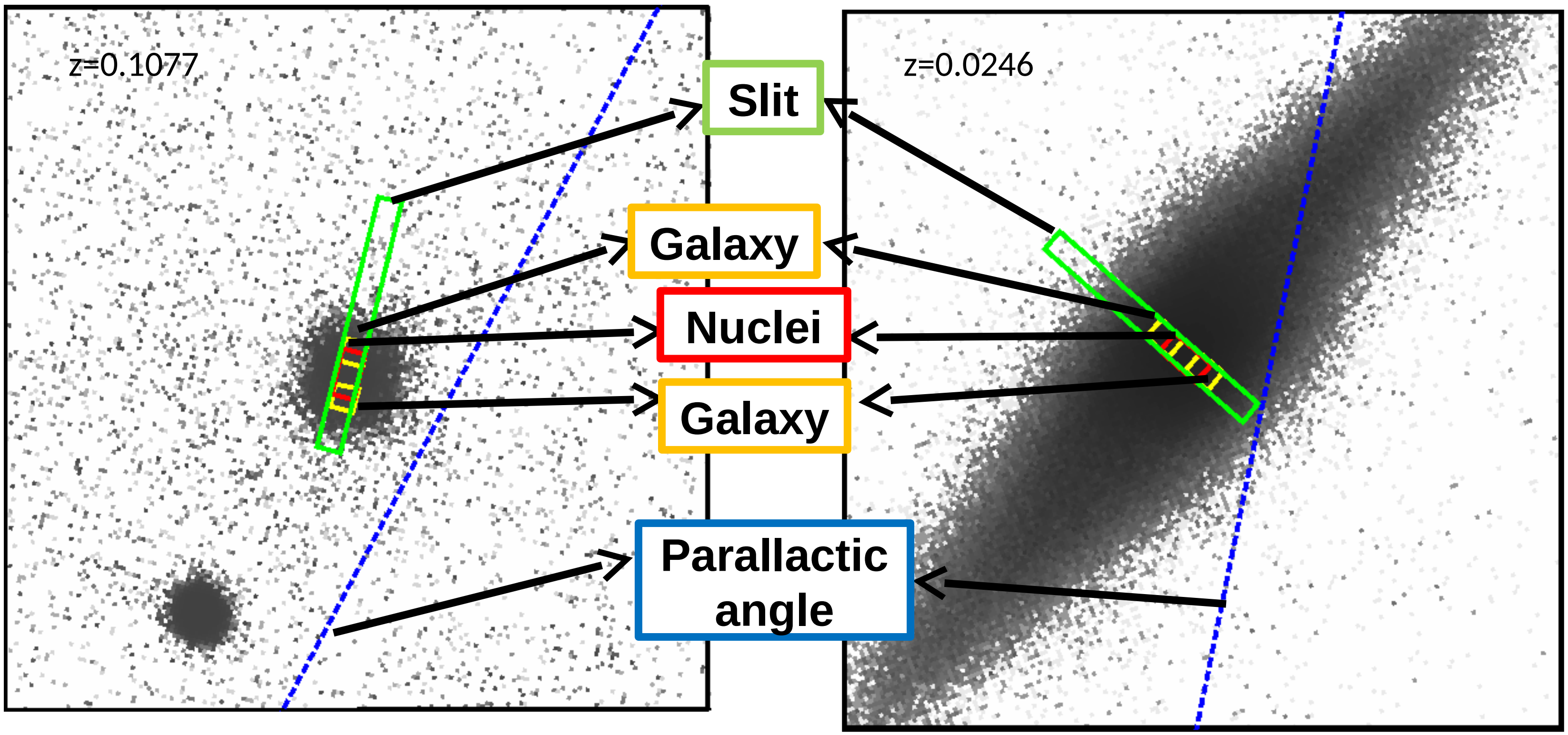
J025218.60-011746.3=J02

Lx,J00 30 times brighter than Lx,J02

VLT-XSHOOTER data

Extraction of the **central zone** spectrum (AGN+Galaxy) and extraction of the **host galaxy** spectrum. In J00, through the slit enters more galaxy than in J02. J00 is at higher z, then more galaxy light in the slit.

Exposure time (for both objects): For UVB and VIS, 1420 s. For NIR, 480 s.



J00 (0.5’x0.5’)

J02 (0.5’x0.5’)

AGN-host decomposition

We decompose the galactic-extinction-corrected spectrum of the central zone in:

Host Galaxy + **Nuclei** × **Extinction Model**

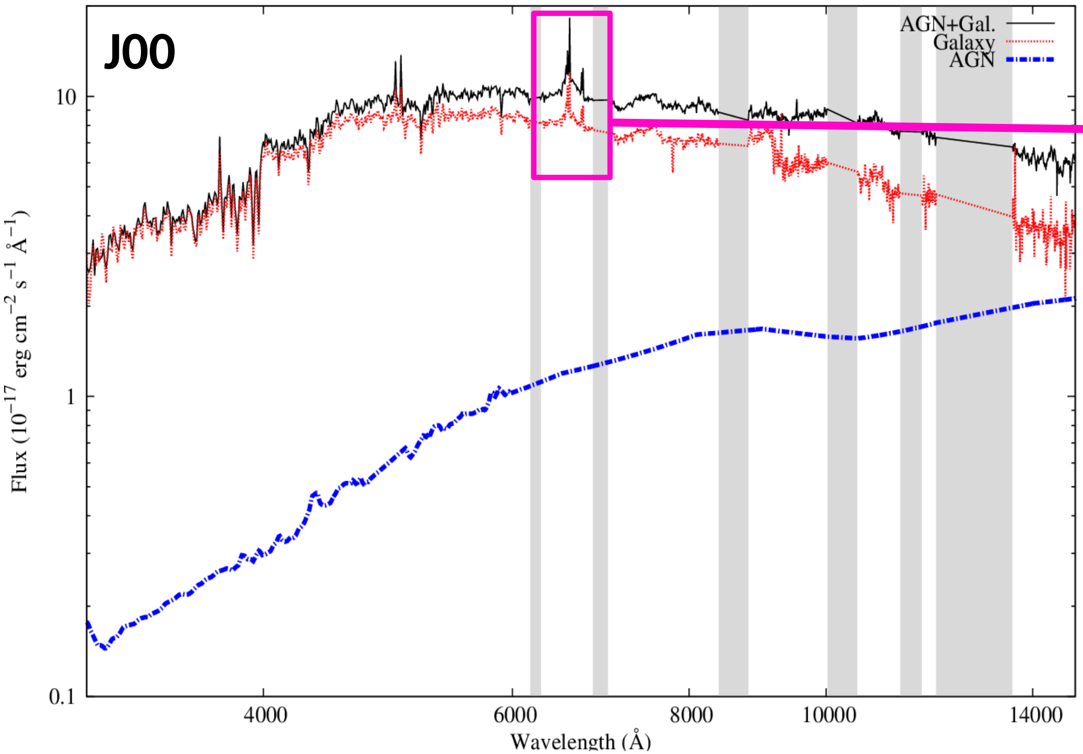
<u>Three components:</u>

-QSO1 template from the **SWIRE Template Library** (Polletta et al. 2007), corrected for slit losses.

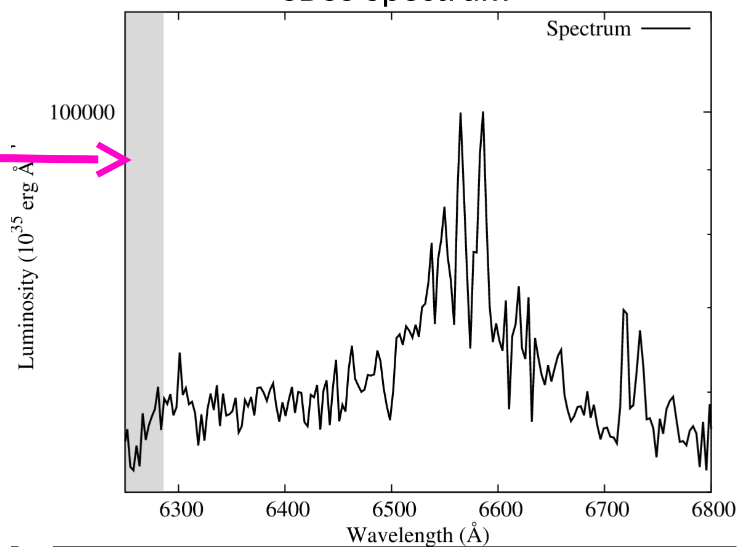
-Extinction law model of SMC (Gordon et al. 2003).
N(HI)/A(V) = $(13.18 \pm 1.02) \cdot 10^{21}$ HI atoms/mag

-Host galaxy spectrum from XSHOOTER. Rescaled to match the Ca II galactic absorption lines at 3800-3900 Å.

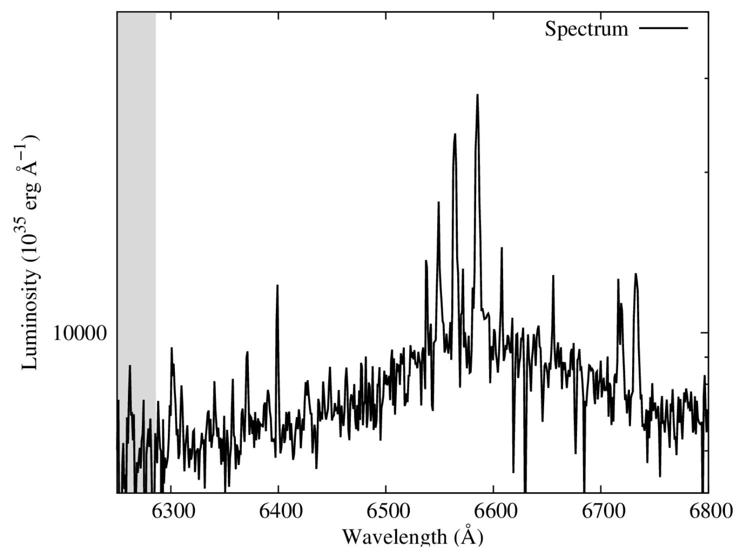
Host Dilution



SDSS Spectrum



XSHOOTER – spectrum



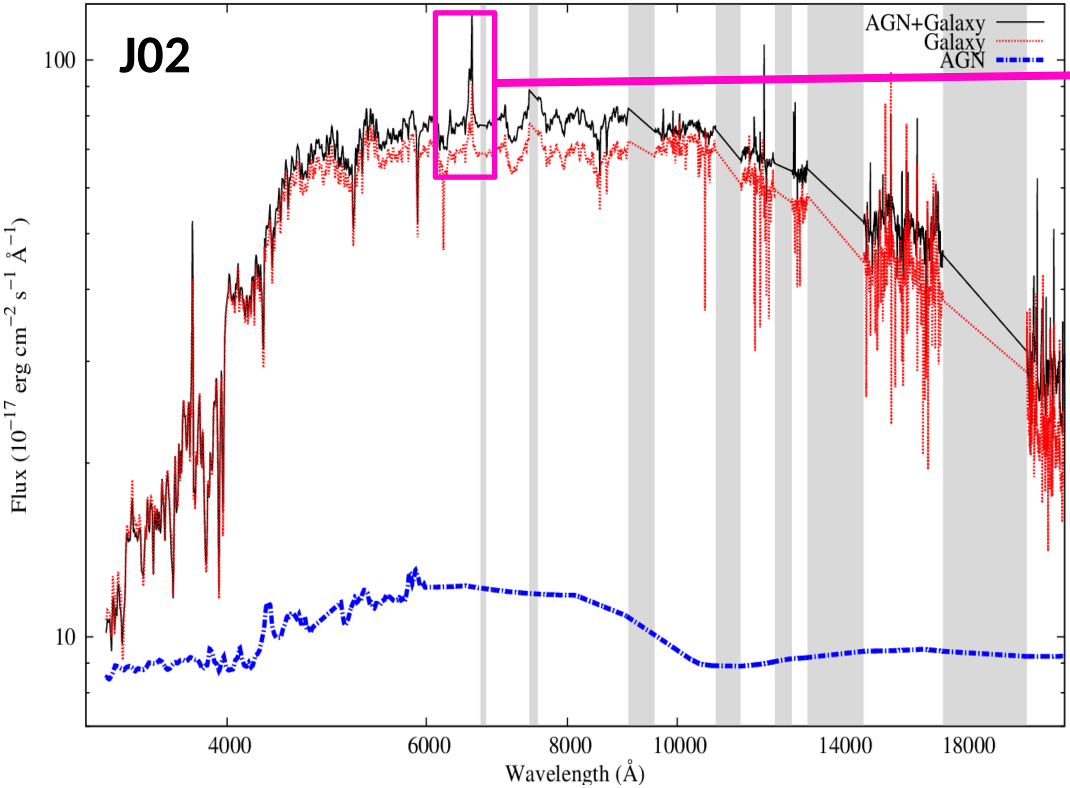
N_H from X-rays: $<6.7 \cdot 10^{20}$ cm^{-2}

N_H from Av=$(4.11 \pm 0.10) \cdot 10^{22}$ cm^{-2}

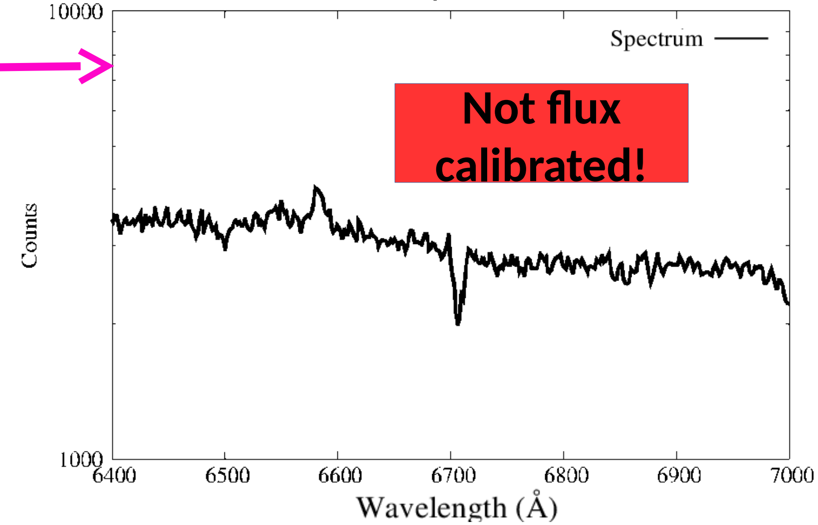
Av=3.08±0.08 mag

More broad line gained

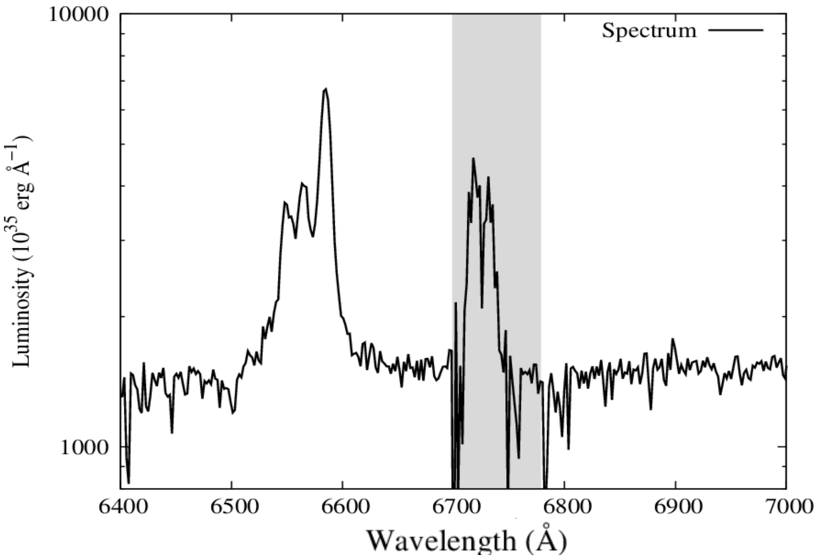
Host Dilution



6dF Spectrum



XSHOOTER – AGN spectrum



N_H from X-rays= $1.7_{-1.4}^{+2.0} \cdot 10^{21}$ cm^{-2}

N_H from Av=$(2.0033\pm0.0013)\cdot10^{22}$ cm^{-2}

Av=1.124±0. 029 mag

From type 2 to type 1.9

Dust-to-gas ratio

The galactic $E(B-V)/N_H$ relation is:

$E(B-V)/N_H = 1.7 \cdot 10^{22}\ cm^{-2}$ (Maiolino et al. 2001)

J00:

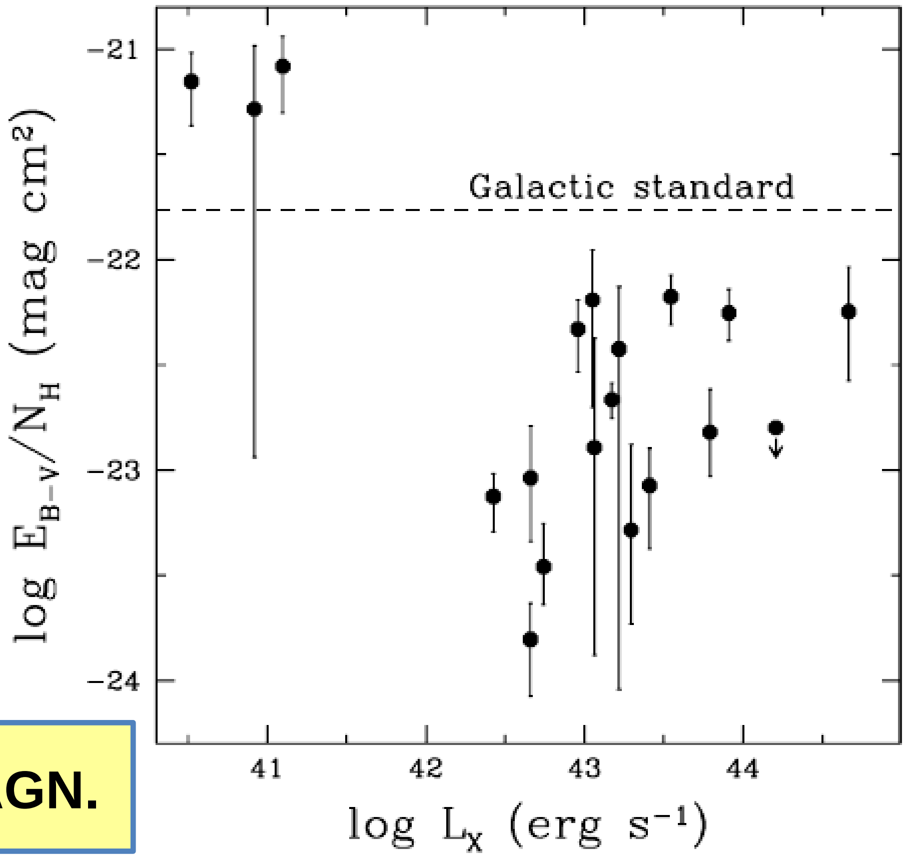
$E(B-V)/N_H >$ **11.09 times** the galactic relation

J02:

$E(B-V)/N_H =$ **2.5 times** the galactic relation

AGN population normaly ranges between 0.3-0.01 times the galactic relation.

Higher dust-to-gas relation in both AGN.



SMBH masses

We fit the AGN spectrum after subtracting the host starlight, focusing on the H_α region.

The fit is performed using **gaussian functions for broad and narrow lines**, plus a **power law for the continuum**.

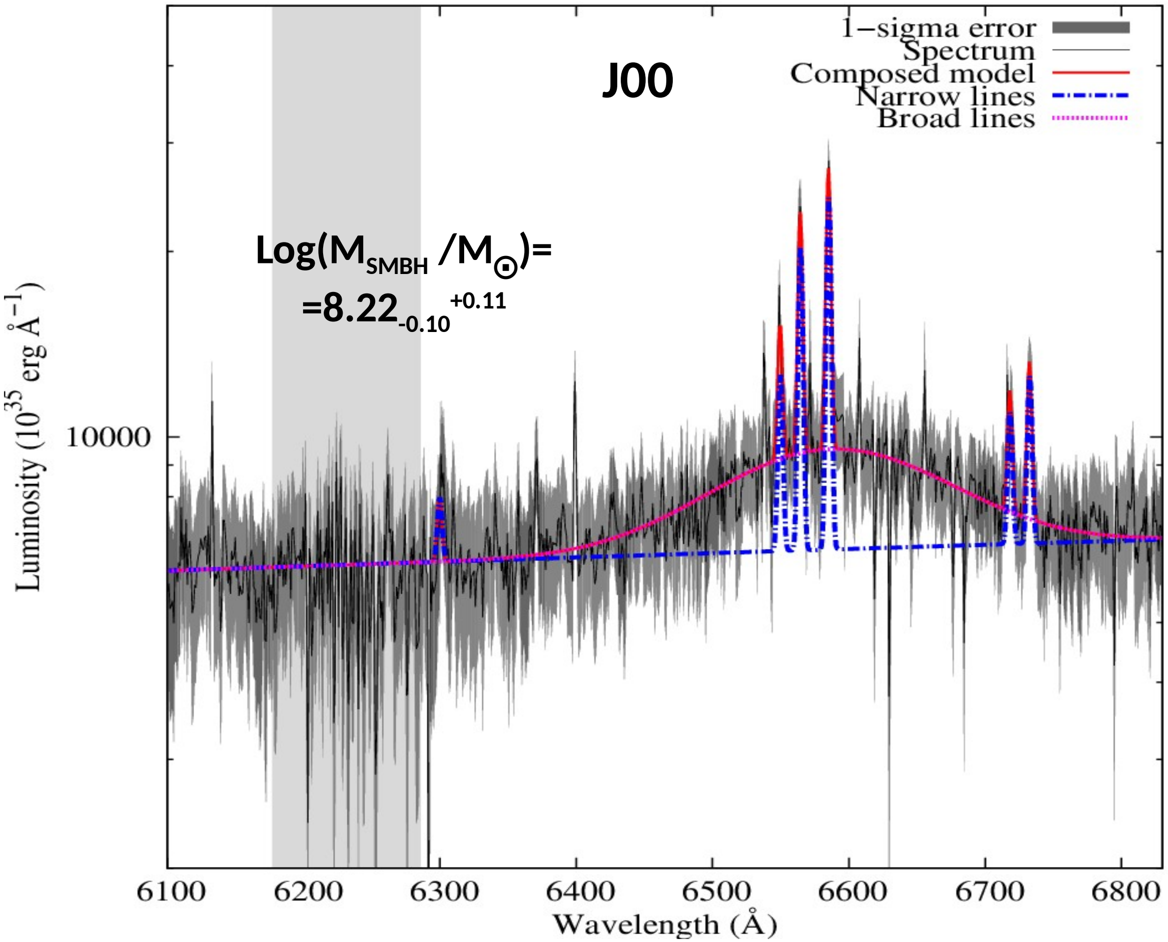
Same width for narrow lines.

To compute the SMBH mass we use the following expression :

$$M_{SMBH} = (2.0^{+0.4}_{-0.3}) \times 10^6 \left(\frac{L_{H\alpha}}{10^{41} ergs \cdot s^{-1}}\right)^{0.55 \pm 0.02} \left(\frac{FWHM_{H\alpha}}{10^3 km \cdot s^{-1}}\right)^{2.06 \pm 0.06} M_\odot$$

(Greene & Ho 2005)

SMBH masses



SMBH mass typical of the overall SMBH population at these redshifts (z~0.1).

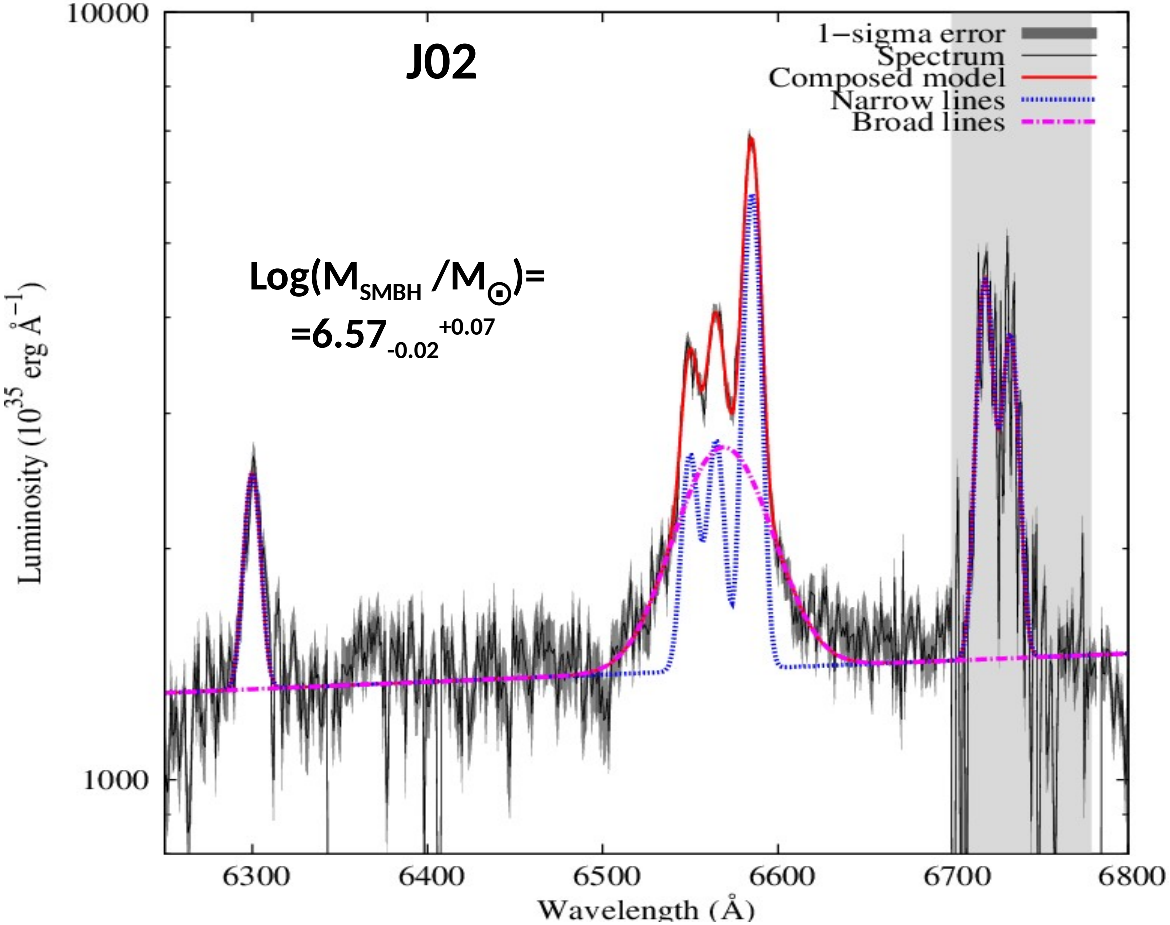
(Feoli et al. 2010).

-FWHM (Hα,B)=8836±1152 km/s
-L(Hα,B)=(4.09±0.61)· 10^{41} erg s^{-1}

-FWHM (Hα,N)=179.8±5.4 km/s
-L(Hα,N)=(2.22±0.21)· 10^{40} erg s^{-1}

More luminous and broader lines than J02

SMBH masses



SMBH at the low end of the SMBH mass distribution at these redshifts (z~0.02).

(Feoli et al. 2010).

-FWHM (Hα,B)=2681 ± 73 km/s
-L(Hα,B)=(2.348 ± 0.082)·10^{40} erg s^{-1}

-FWHM (Hα,N)=475.1 ± 5.5 km/s
-L(Hα,N)=(1.521 ± 0.098)·10^{39} erg s^{-1}

Less luminous and narrower lines than J00

Masses of the AGN hosts

The relation of the BH mass and its host galaxy spheroidal mass is:

$<M_{SMBH}/H_{stell}>=-2.9\pm0.5$ Merritt & Ferrarese (2001)

The stellar mass is calculated through the $M/L_K=0.8$ (Bell & de Jong 2002).

Object	**$Log(M_{SMBH}/M_{\odot})$**	**$Log(M_{stell}/M_{\odot})$**	**$Log(M_{SMBH}/M_{stell})$**
J00044124+0007113	8.22 [8.02,8.33]	10.47 [10.37,10.67]	-2.33
J025218.60-011746.3	6.57 [6.55,6.63]	10.32 [10,12,10.52]	-3.59

The SMBH in J02 is smaller than expected in this relation. The one in J00 is higher.

Conclusions

J00

- No Compton-thick.
- We gained more signal in Broad H-alpha subtracting the host galaxy contribution.
- Significantly higher gas-to-dust ratio than both the Galactic value & AGN population.
- Its M_{SMBH}/M_{host} don't deviate significantly from the standard relation.

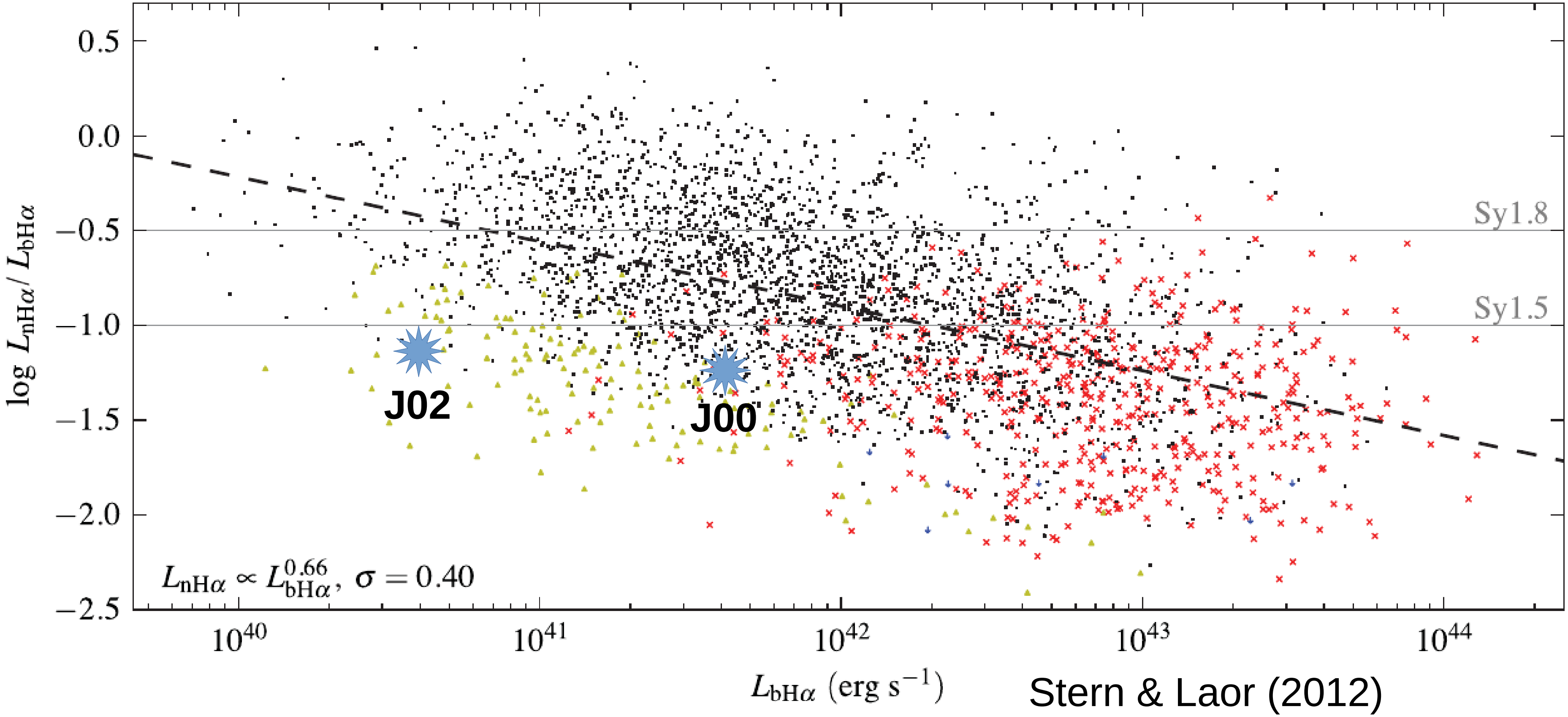
J02

- No Compton-thick.
- The broad H-alpha contribution appears when the galaxy is subtracted.
- Significantly higher gas-to-dust ratio than both the Galactic value & AGN population.
- Its M_{SMBH}/M_{host} don't deviate significantly from the standard relation.

General conclusions

- None of our sources is Compton-thick.
- The mismatch can not be explained only by host galaxy dilution.
- An instinsically high dust-to-gas ratio is the most likely explanation to the mismatch.

Ln/Lb vs Lb



Stern & Laor (2012)

Objects do not deviate significantly from Ln/Lb vs Lb trend.

Masses of the AGN hosts

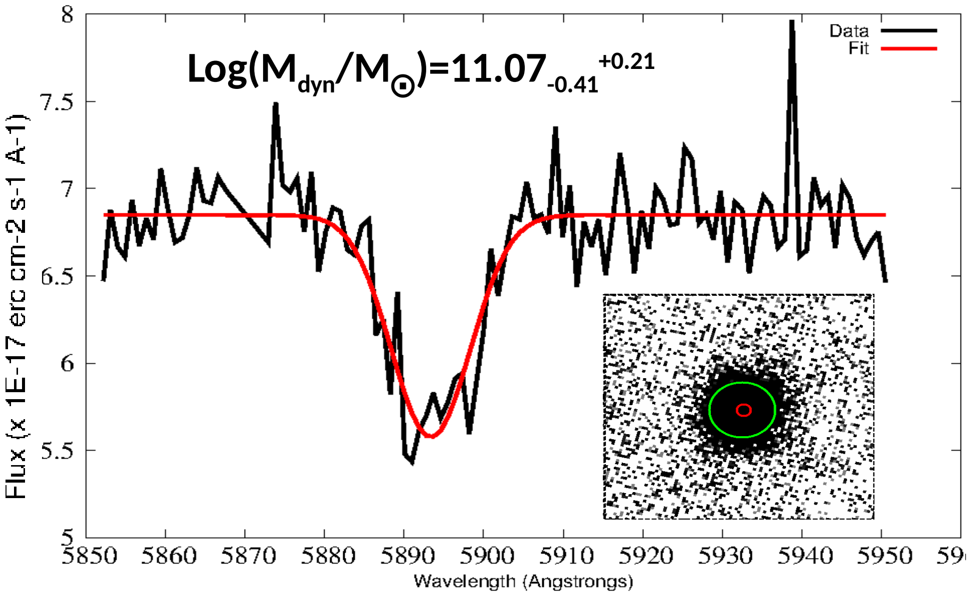
$$M_{dyn} = (5.0 \pm 0.1) \cdot \frac{r_e \cdot {\sigma_e}^2}{G}$$

(Cappellari et al. 2006)

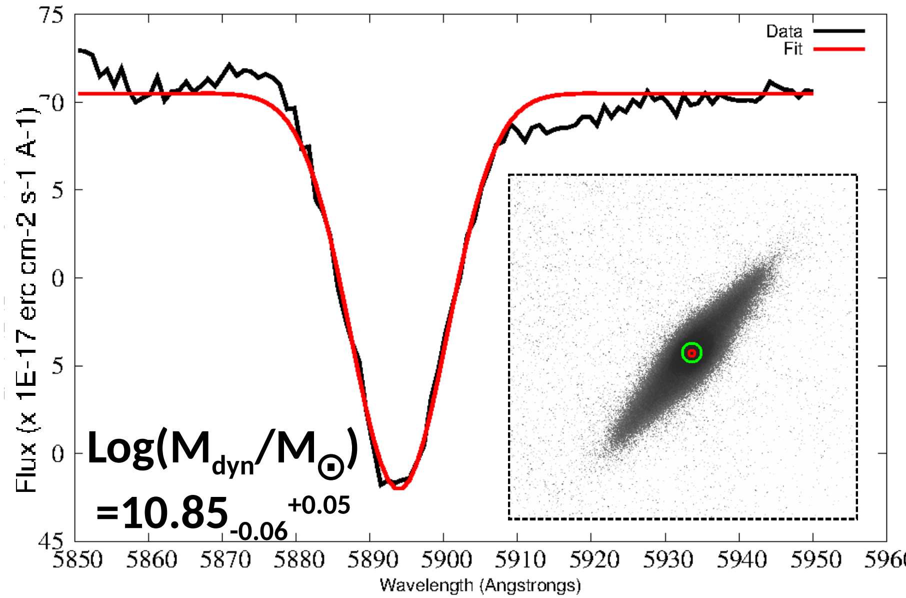
-Effective **radius** from Imfit.

-**Stellar velocity dispersion** from **Na Id,** corrected for both the intrinsic width (Bruzual & Charlot 2003) and instrumental resolution.

J00 – Na Id



J02 – Na Id



Both AGN reside in very massive hosts (Vitale et al. 2013).