The Black Hole Mass - Bulge Luminosity Relation in Nearby Type I AGNs

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Introduction

Motivation & Questions

The **strong correlations** between the mass of super massive black holes (BHs) and properties (bulge luminosity and velocity dispersion) of host galaxies implies that BHs and galaxies are closely linked in their evolution.
Questions:
1. How the relation originates?
2. Which (BH & Galaxy) comes first?
3. AGN feedback or merging plays important role?

Method

We probe the low-z M_{BH} - L_{bulge} relation in Type I AGNs by
1. **accurately** determining the **slope** and **zero-point**
2. investigating the origin of intrinsic **scatter**

using *Hubble Space Telescope* archival images.

Why do we use **AGNs**?
- Ease of measuring BH mass with single epoch optical spectrum based on the virial method.
  $M_{BH} = 1/G \times f \times v$ [FWHM of broad lines]$^2 \times R$ [L_{5100}]
  we assume a spherically symmetry broad line region
  f=0.75

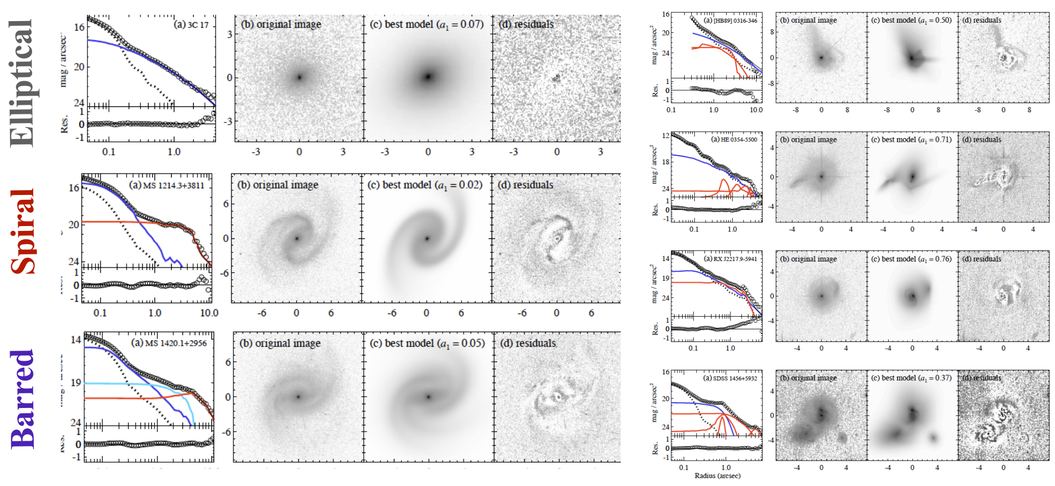
Why do we use the M_{BH}-L_{bulge} **relation**?
- Relative ease of measuring L_{bulge} with HST images.

Sample

237 local Type I AGNs that have reasonably deep HST images and measurements of FWHM of broad lines
- $10^{5.5}$ $M_\odot$ < M_{BH} < $10^{9.3}$ $M_\odot$

Image Analysis

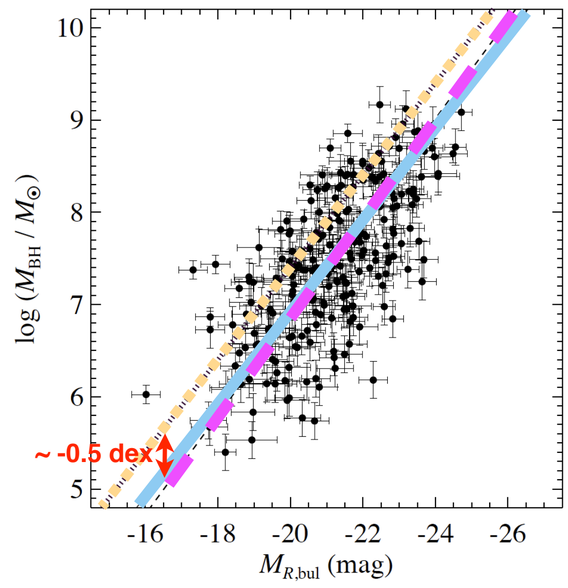
We use the new version of GALFIT 3.0 which allows us
- to fit images with **multi-component models**
- to quantify the degree of **asymmetry (a_1) with Fourier mode**
- to generate **spiral arms**
- to model **a truncated profile.**



examples of 2-d image fits

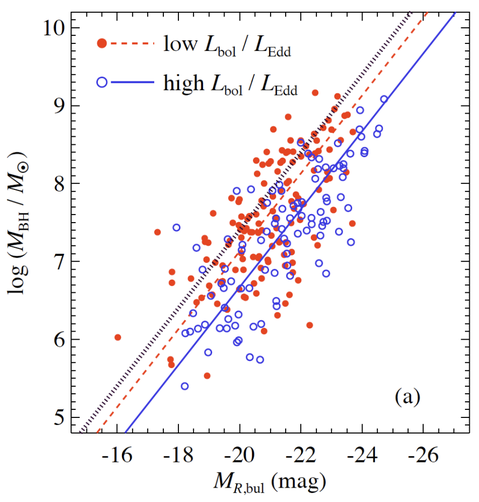
examples of fits with Fourier mode

Result 1 - Active Galaxies vs. Normal Galaxies



$\log M_{BH} = \alpha + \beta M_{R,bul}$
- Normal Galaxies
  α = **-2.60**; β = **-0.50**
  ε_y ~ **0.4 dex**
- Active Galaxies
  α = **-3.08**; β = -0.50
- Active Galaxies
  α = -3.88; β = **-0.54**
  ε_y ~ **0.6 dex**

Result 2 - Dependence on accretion rate



- How to explain the offsets?

  $M_{BH} = 1/G \times f \times v^2 \times R$

- BH mass might be **underestimated**, if the broad line region
  i) has disk-like structure (e.g., Wu & Han 2002)
  ii) is dominated by radiation pressure. (e.g., Marconi et al. 2008)

***f* should be larger than expected and proportional to the accretion rate.**

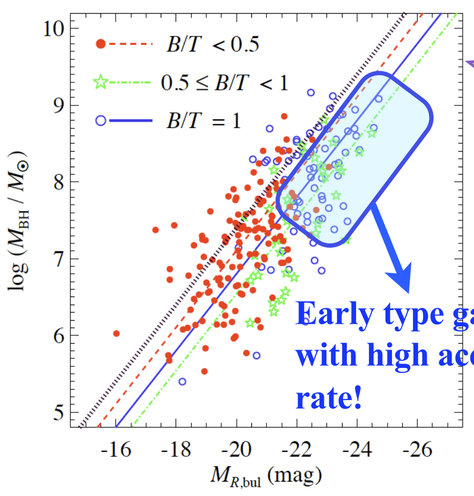
- **BH is growing** during AGN phase? (by a factor of 2~4)

Degeneracy between BH Growth vs. underestimation of M_{BH}.
The independent M_{BH} measurement is required!

★ X-ray variability method based on very limited sample yields
f = **1.12 ± 0.54** (Nikolajuk et al. 2006)
(c.f. f=1.5 ~ 2.3 to explain the zero-point offset).

10 ~ 40% of BH Growth during AGN PHASE.

Question - Gas Contents in AGNs



Is there enough gas to support BH Growth? Or is gas blown out by AGN feedback?

CO or submm observation with ALMA will shed light on this issue!