Black Hole Scaling Relations:

Improved data and new results for M_{BH}-L_K

Ronald Läsker[1,2], Laura Ferrarese[2], Glenn van de Ven[1]

[1]MPIA Heidelberg, Germany; [2]HIA Victoria, Canada

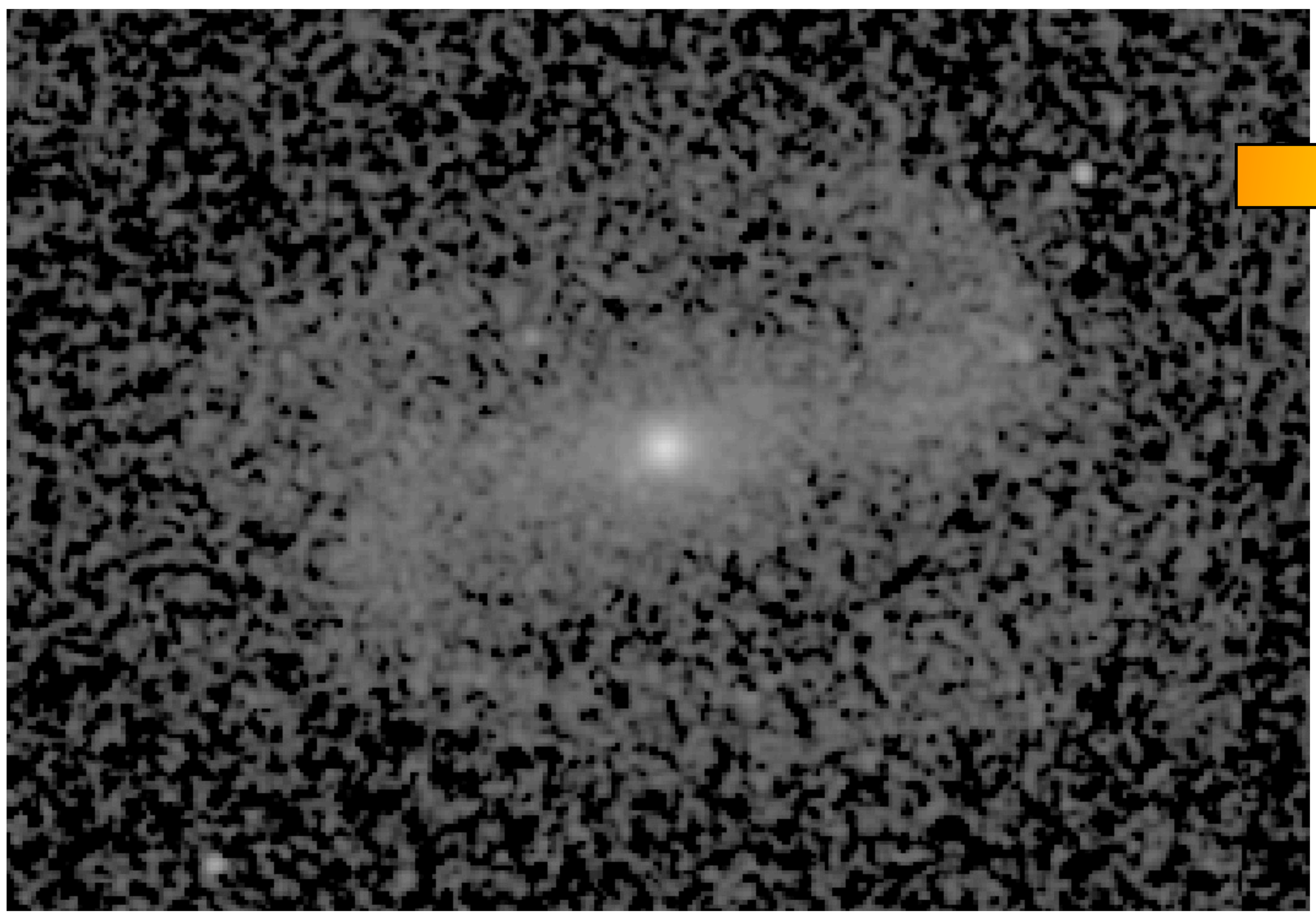
Abstract

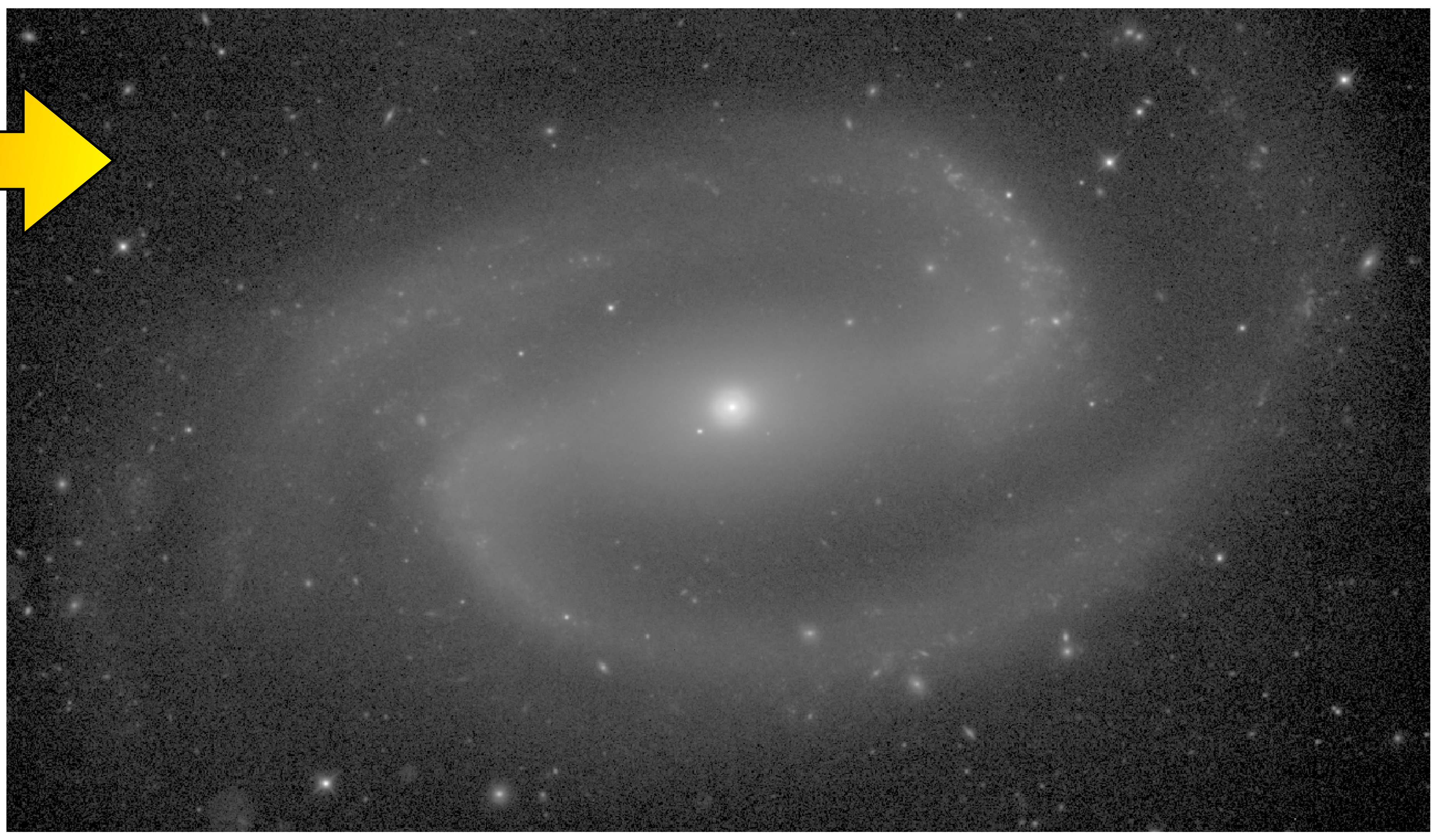
The correlation between masses (M_{BH}) of central Supermassive Black Holes (BH) and host galaxy bulge luminosities (L_{bul}) has been widely used as a fundamental scaling relation, even though its characterization is far from secure. At near-infrared (NIR) wavelengths, where dust extinction is negligible, it is based on 2MASS data (Marconi & Hunt, 2003), where limited depth and spatial resolution compromise reliable disentanglement of bulge, disk, and other frequently occurring structures (e.g.: nuclei, bars, spiral arms, rings).

Therefore, we have obtained deep high-resolution NIR (K-band) imaging for galaxies with measured BH mass. By means of a dedicated NIR-sky subtraction procedure and detailed 2D-image decomposition, we extract bulge and total luminosities (L_{tot}) from galaxies spanning all morphological types. We show that the intrinsic scatter of the M_{BH}-L_{bul} relation is equal to that of M_{BH}-L_{tot}. We further find that most bulges cannot be reliably extracted via a "standard" bulge+disk decomposition, and that even if all structures are accounted for, ambiguity in determining L_{bul} often remains.

While here we focus on scaling relations from NIR photometry, we also observed the same targets in near-ultraviolet and optical bands, and utilize the results to make a transition from luminosity measurements to stellar mass distributions. Finally, we began to combine these with integral-field (IFU) spectroscopic data to model the total (including dark) matter distributions and relate those to BH masses as well.

Below: K_S-image of NGC1300 from our WIRCam data (left: 2MASS image drawn to scale for comparison)





NIR imaging (K-band)

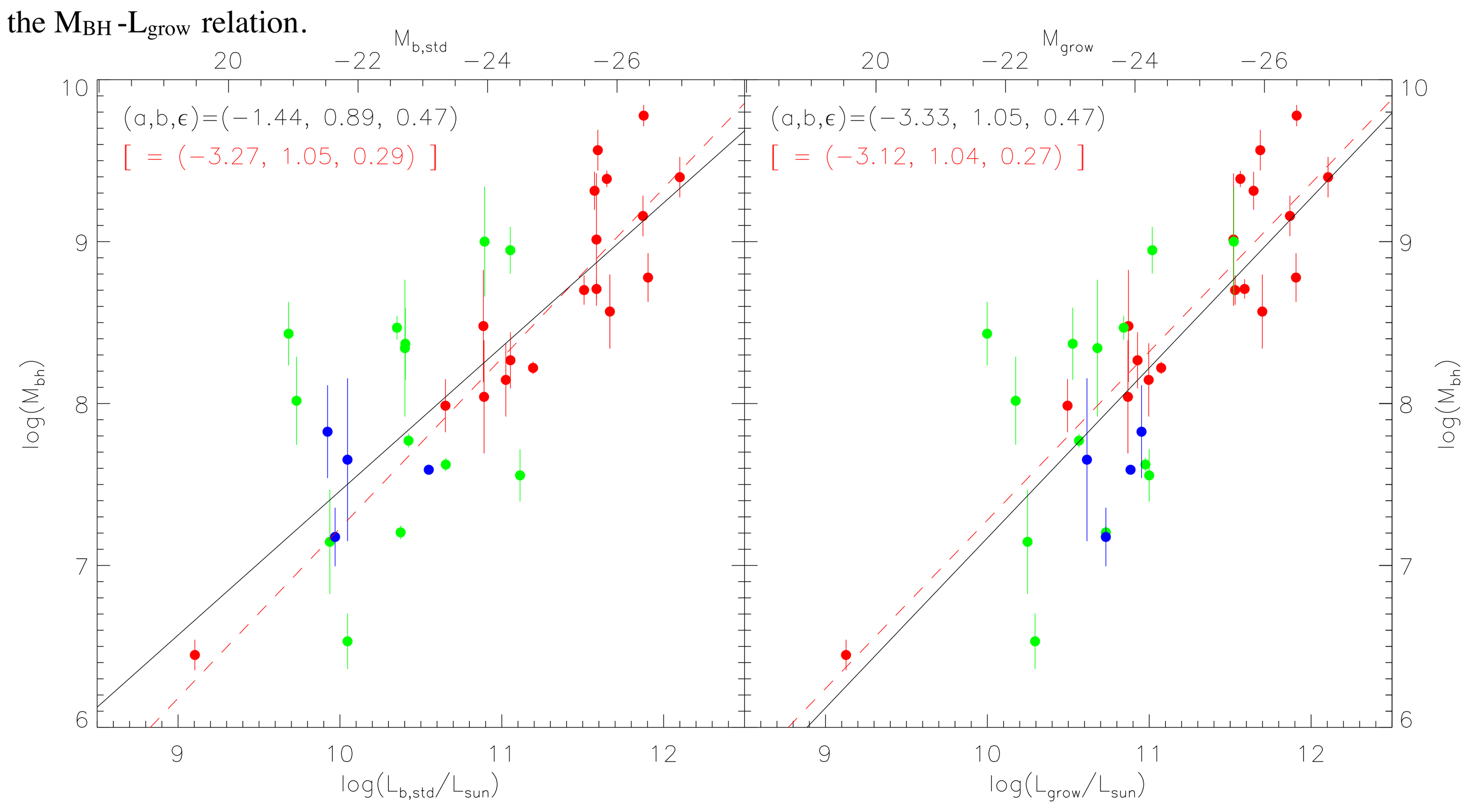
- sample: 35 galaxies with reliable[1] BH mass
- NIR data vs. optical: reduced effects of dust
- our CFHT WIRCam observations improve on previously used 2MASS data:
  → 3x higher resolution, 4mag deeper
  → to discern components, reduce degeneracies, detect "wings"
- large coverage: 30x30 arcmin per target
- we devised a dedicated data reduction pipeline with special emphasis on NIR background ("sky")

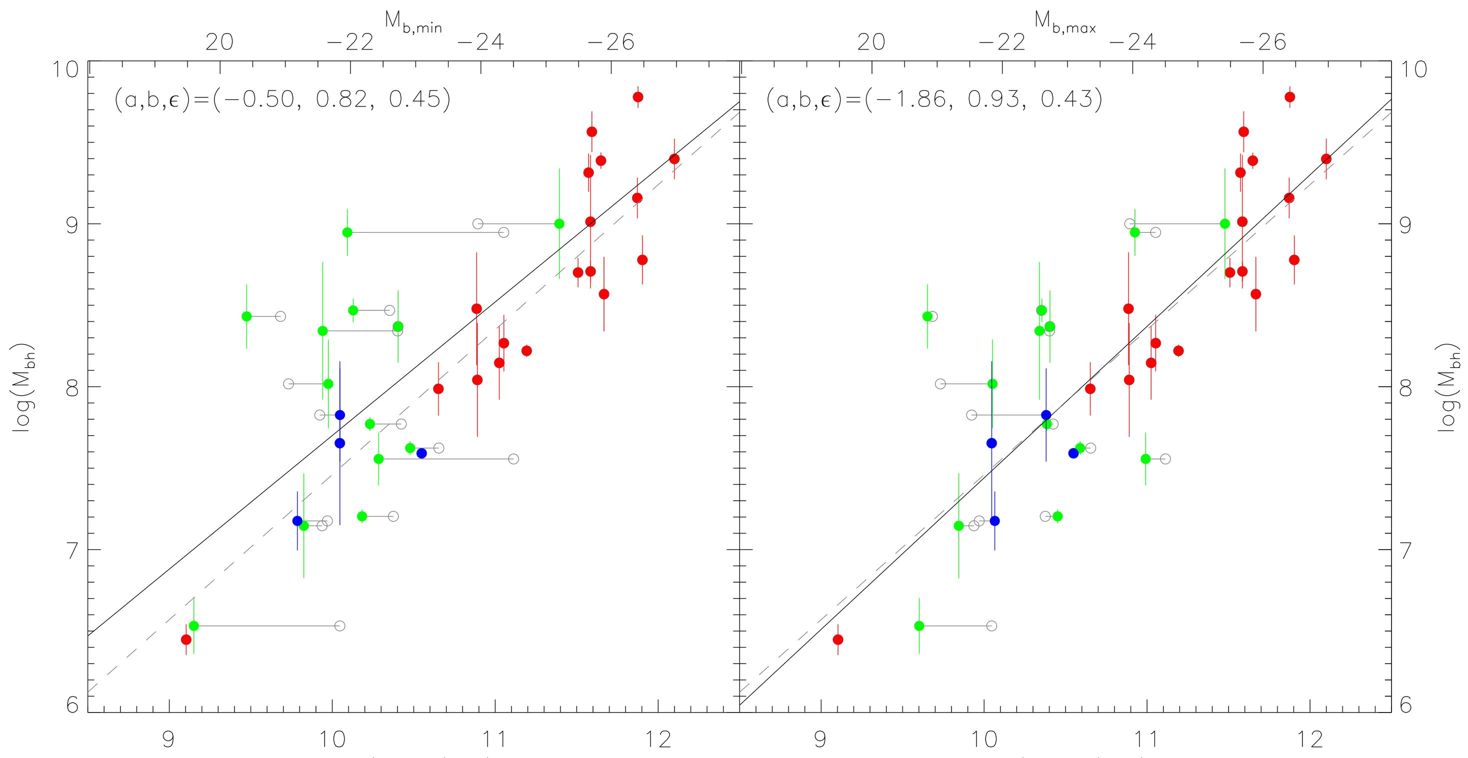
[1] at the time of observing proposal, after exclusion of upper limits and some problematic cases

Image Decomposition

- 2D-decomposition with GALFIT
- fit "standard" Sersic bulge (+exponential disk) models first & determine magnitudes
- supplement, wherever applicable, by extended/"improved" models (additional components, disk modifications)
- improved models yield lower ($L_{b,min}$) and upper ($L_{b,max}$) estimates of bulge luminosities
- supplement by growthcurve-based total magnitude (L_{grow})

Below: Correlations of M_{BH} with bulge ($L_{b,std}$, left panel) and total (L_{grow}, right panel) luminosity. Colors distinguish elliptical (red), S0 (green) and spiral (blue) galaxies. Vertical solid bars indicate the 1σ-uncertainties in M_{BH}, while magnitude errors (typically < 0.1mag) are omitted for clarity. Solid lines are the best-fit linear relations of the form $\log(M_{BH}) = a+b*\log(L)$. The intrinsic scatter ε is the same for both relations. Moreover, when only elliptical galaxies are fitted (red dashed lines), the resulting offset (a) and slope (b) are much closer to the M_{BH}-L_{grow} relation.





Above: Correlations of M_{BH} with minimal ($L_{b,min}$, left panel) and maximal ($L_{b,max}$, right panel) bulge luminosity. Filled circles, vertical bars and solid lines are defined analogous to the previous figure. The intrinsic scatter ε is nearly same for both relations. Overplotted in grey are the "standard" bulge luminosities (open circles) and the dashed line for the corresponding M_{BH}-$L_{b,std}$ relation, illustrating the effect incurred by unaccounted-for structures and components.

Preliminary Results

- identifying and modeling of additional structures (beyond bulge+disk) required to extract bulges properly
- otherwise, bulge parameters are biased in most cases
- while slopes and offsets differ, intrinsic scatter of all M_{BH}-L_{bul} and M_{BH}-L_{tot} relations is equivalent (~0.45dex)
- when fitted to ellipticals only: M_{BH}-L_{ell} agrees well with M_{BH}-L_{tot}
- accounting for cores and pseudobulges does not alter the above findings

Conclusions

- intrinsic scatter is virtually independent of the type (bulge vs. total) and method of luminosity measurement
- but M_{BH}-L_{tot} more robust (definition, method of measurement, required data quality, dependence on sample selection)
- given the complications, usage of total magnitude is likely superior to bulge magnitude as BH mass predictor