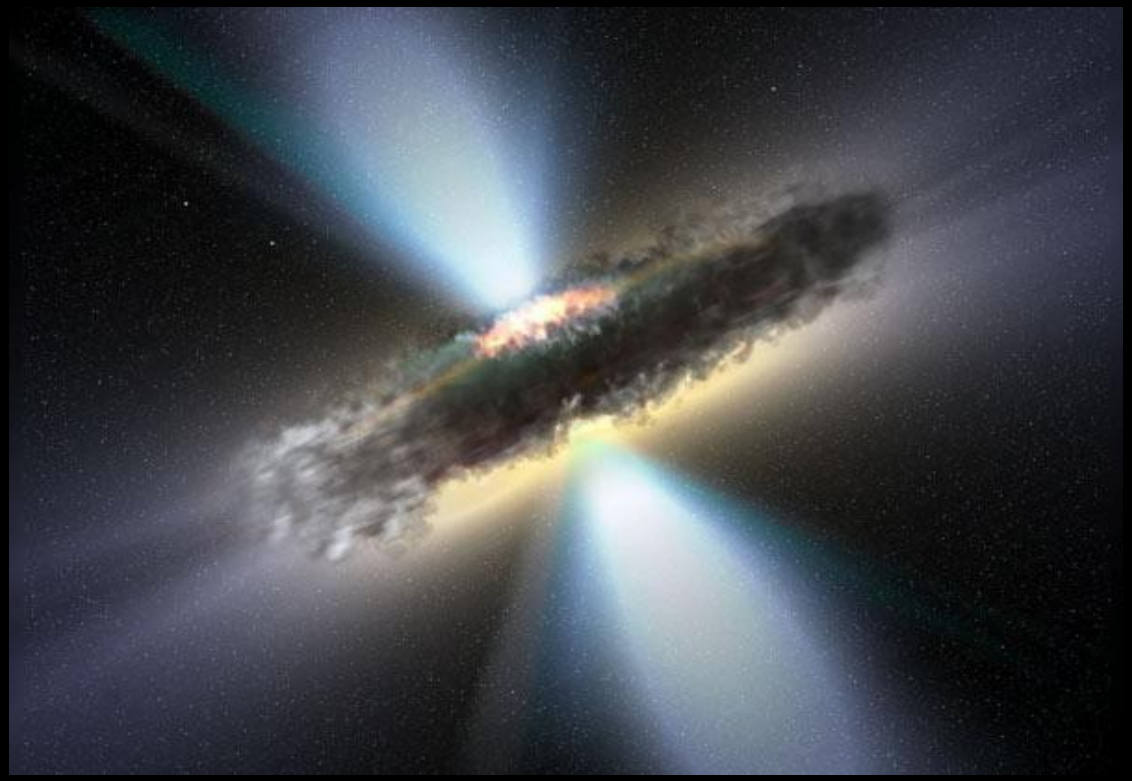
Probing AGN Unication with galaxy neighbours: pitfalls and prospects



Beatriz Villarroel (Department of Physics & Astronomy, Uppsala University)

– *Outline* –

nature physics

LETTERS

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The different neighbours around Type-1 and Type-2 active galactic nuclei

Beatriz Villarroel[1,2*] and Andreas J. Korn[1]

One of the most intriguing open issues in galaxy evolution is the structure and evolution of active galactic nuclei (AGN) that emit intense light believed to come from an accretion disk near a super massive black hole[1,2]. To understand the zoo of different AGN classes, it has been suggested that all AGN are the same type of object viewed from different angles[3]. This model—called AGN unification—has been successful in

So are Type-1 and Type-2 AGN truly representing the same kind of object?

The main idea of our hypothesis is that if Type-1 and Type-2 AGN are intrinsically the same objects, only viewed from different angles, their neighbours should, in a statistical sense, not differ systematically. On top of this, the AGN should interact in similar ways with them.

Why AGN environments?

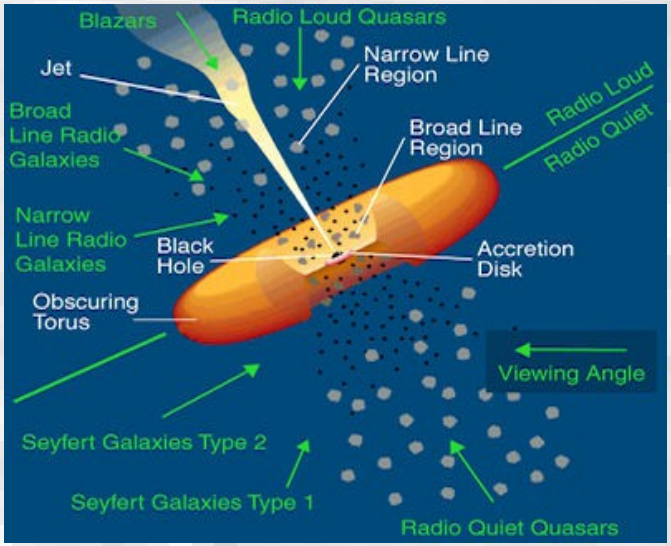
- **Large-scales** (10-1000 Mpc): cosmology, large-scale structure formation mechanisms
- **Small-scales** (< 1 Mpc): cosmology, large-scale structure formation mechanisms and AGN physics
- Should be an **isotropic parameter** in AGN Unification.
- So are Seyfert-1s and Seyfert-2s fueled the same way?

Past tests of Unification through AGN environments

The model is a widely accepted assumption but some issues remain:

- **Clustering** of satellites say the companion counts differ.
  - Dahari 1984: Seyferts have more companions than ordinary galaxies.
  - Laurikainen & Salo 1995: Sy-2s have more companions than Sy-1s.
  - Dultzin-Hacyan et al. 1999: Sy-2s have more companions than Sy-1s.
- -Seyfert-1s are **rare in pairs**. (Gonzalez et al. 2008)

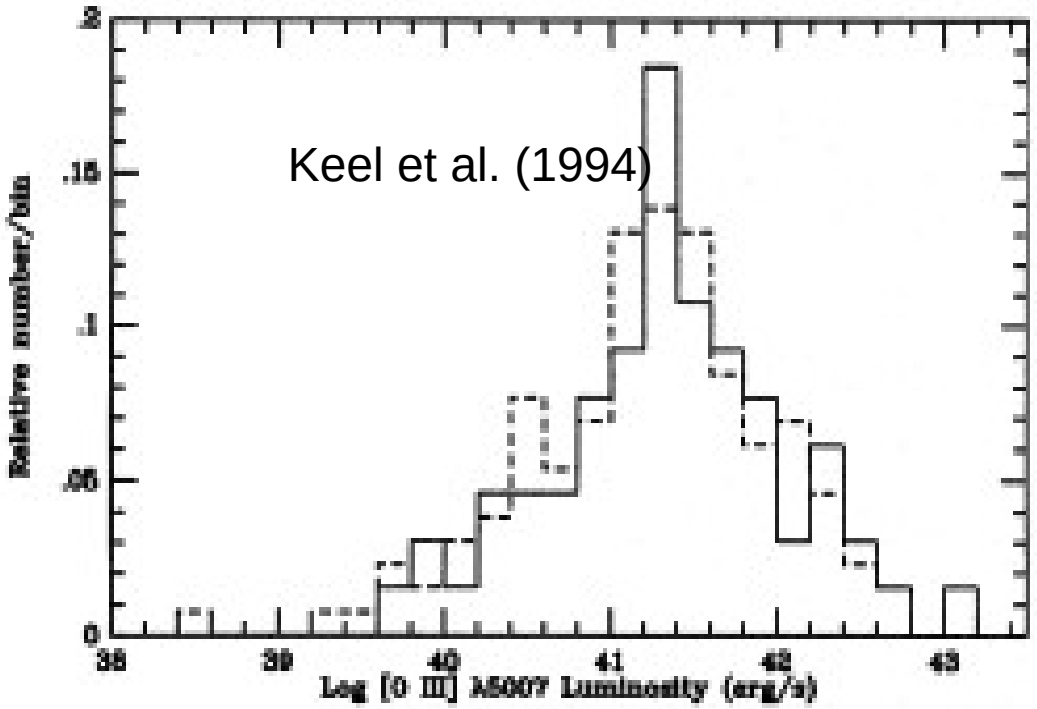
But before: what do YOU mean with AGN Unification?



- Version 1 predicts that L[OIII]5007 is isotropic.

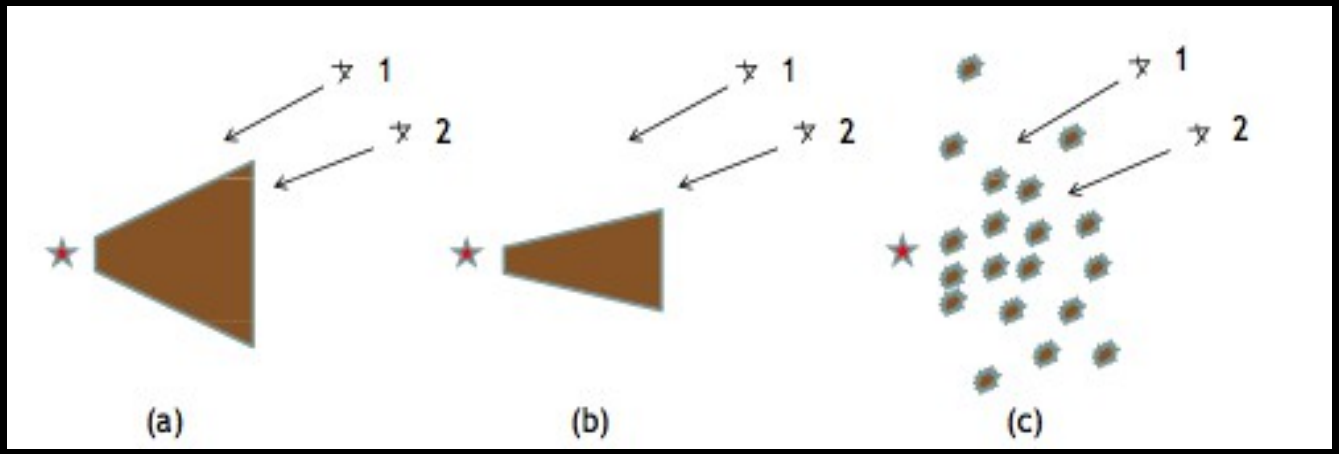
Version 1: "All Type-1 and Type-2 AGN are the same type of object just viewed from different angles through the dust torus."

Version 2: "A Type-2 AGN is a Type-1 AGN viewed through some dust."



Complications of statistical tests

Clumpy torus. (e.g. Tristram et al. 2007)
Individual covering factors > selection biases in intrinsic properties.



Ramos-Almeida et al. 2011, Ricci et al 2011, Elitzur (2012)

See also review by Antonucci 1993, 2012

– The Three Commandments –
for statistical tests of the Straw Person Model

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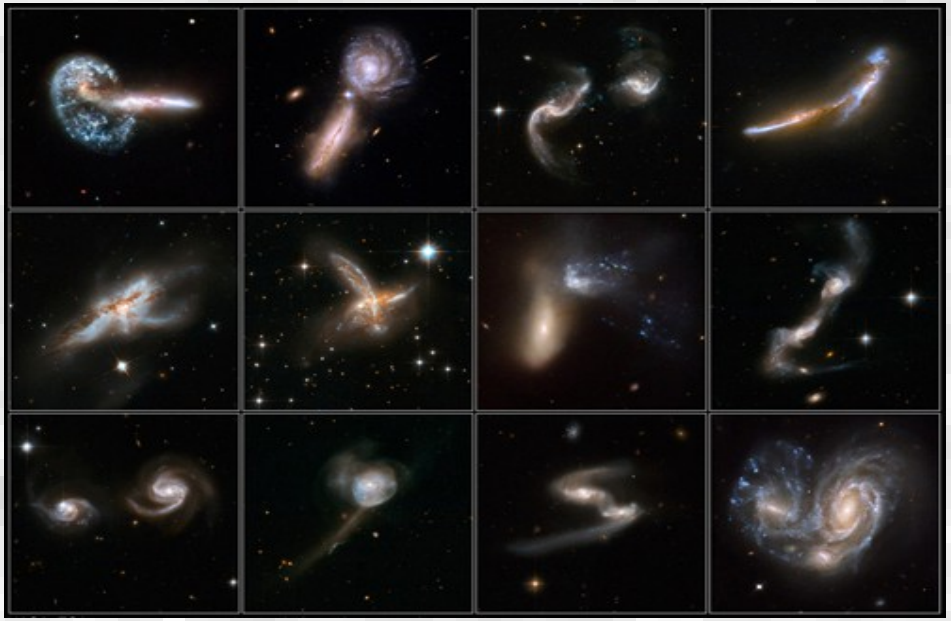
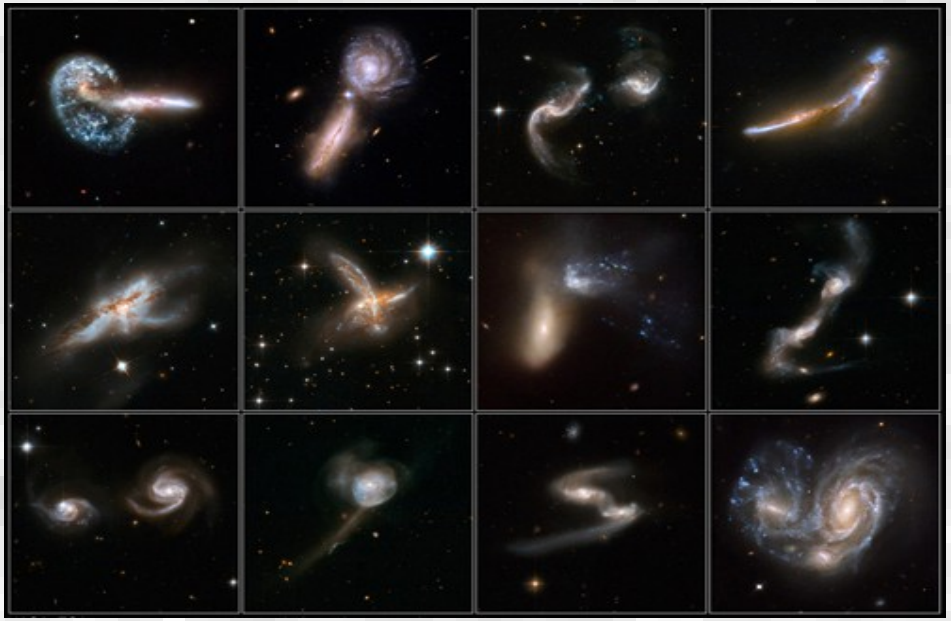
3. *"Remember the predicted L[OIII]5007 isotropy, to keep the narrow-line region holy."*



Sloan Digital Sky Survey:

- AGN with at least one neighbour within projected distance of 350 kpc.
- Low redshift: $0.03 < z < 0.2$
- $|\Delta z|<0.001$, 0.006, 0.012 (spectroscopic-z) and $|\Delta z| < 0.03$ (photometric-z)



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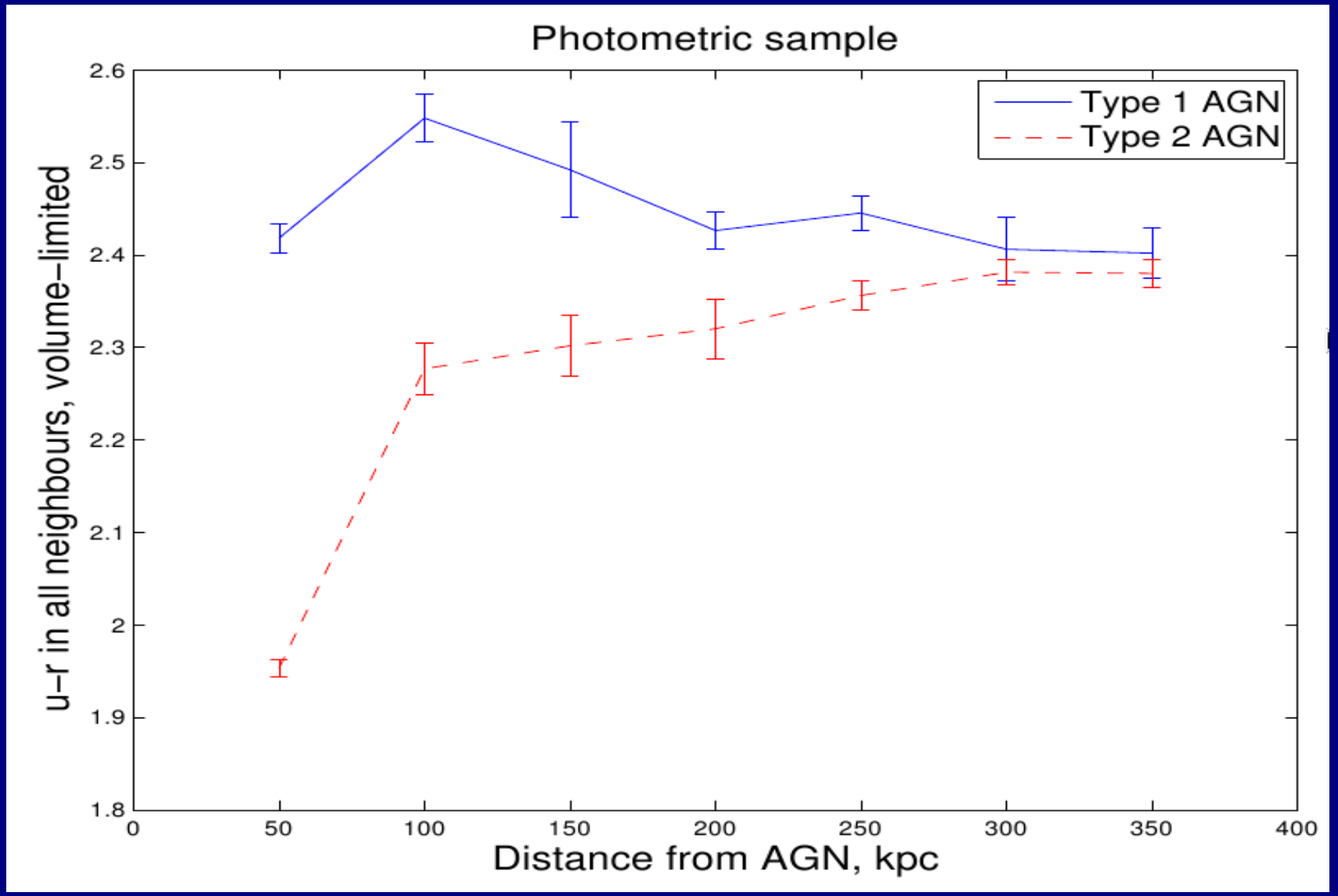
Spectroscopic pairs: 1658 Type 1 AGN-galaxy pairs; 5698 Type 2 AGN-galaxy pairs.

Photometric pairs: 13519 Type 1 AGN- galaxy pairs; 58743 Type 2 AGN-galaxy pairs.

Morphology of AGN host galaxies from the Galaxy Zoo project (Lintott et al. 2008, 2009, 2010, etc)



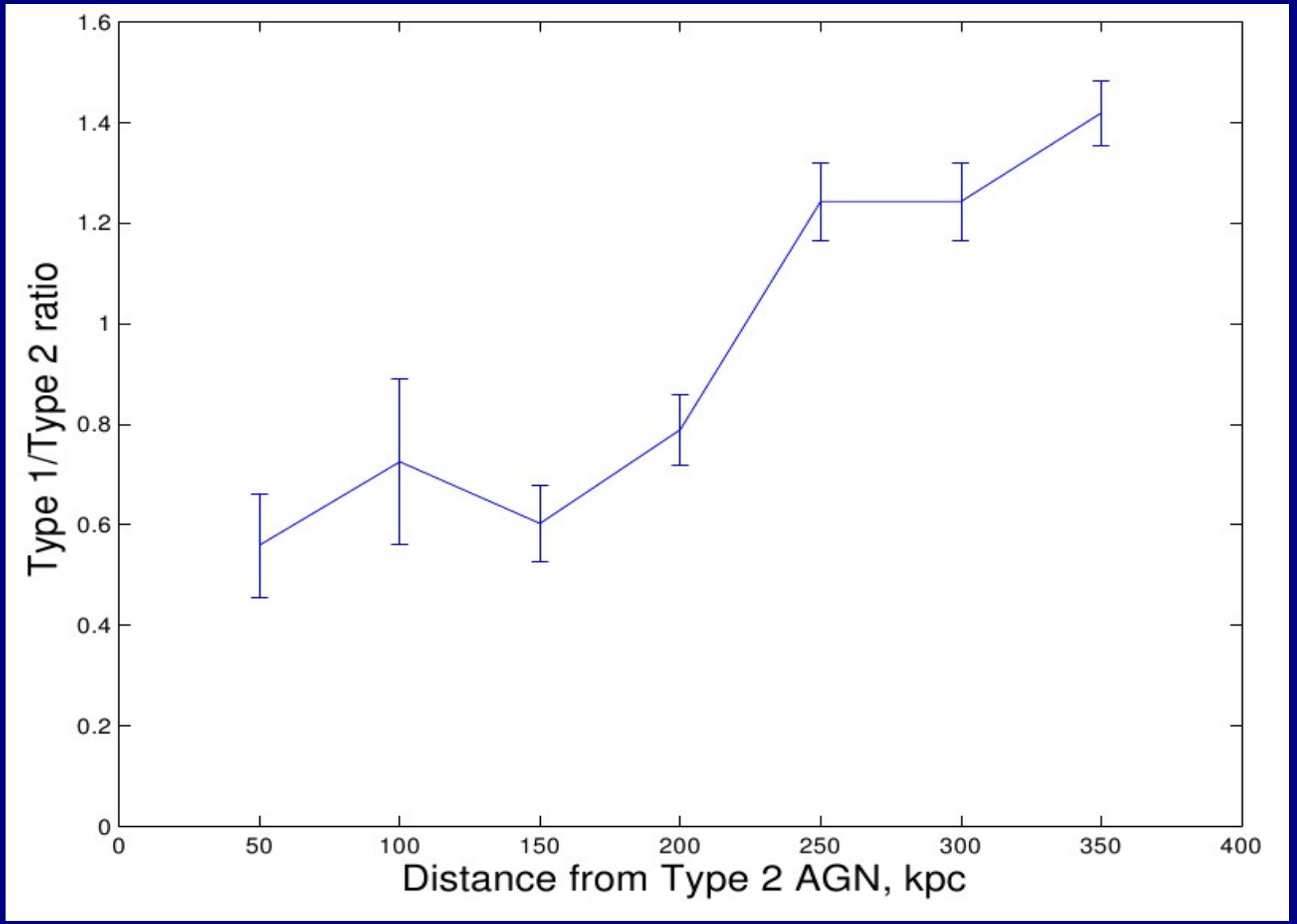
Type-2s have more star-forming neighbours.

But hey!! Where the isotropy?

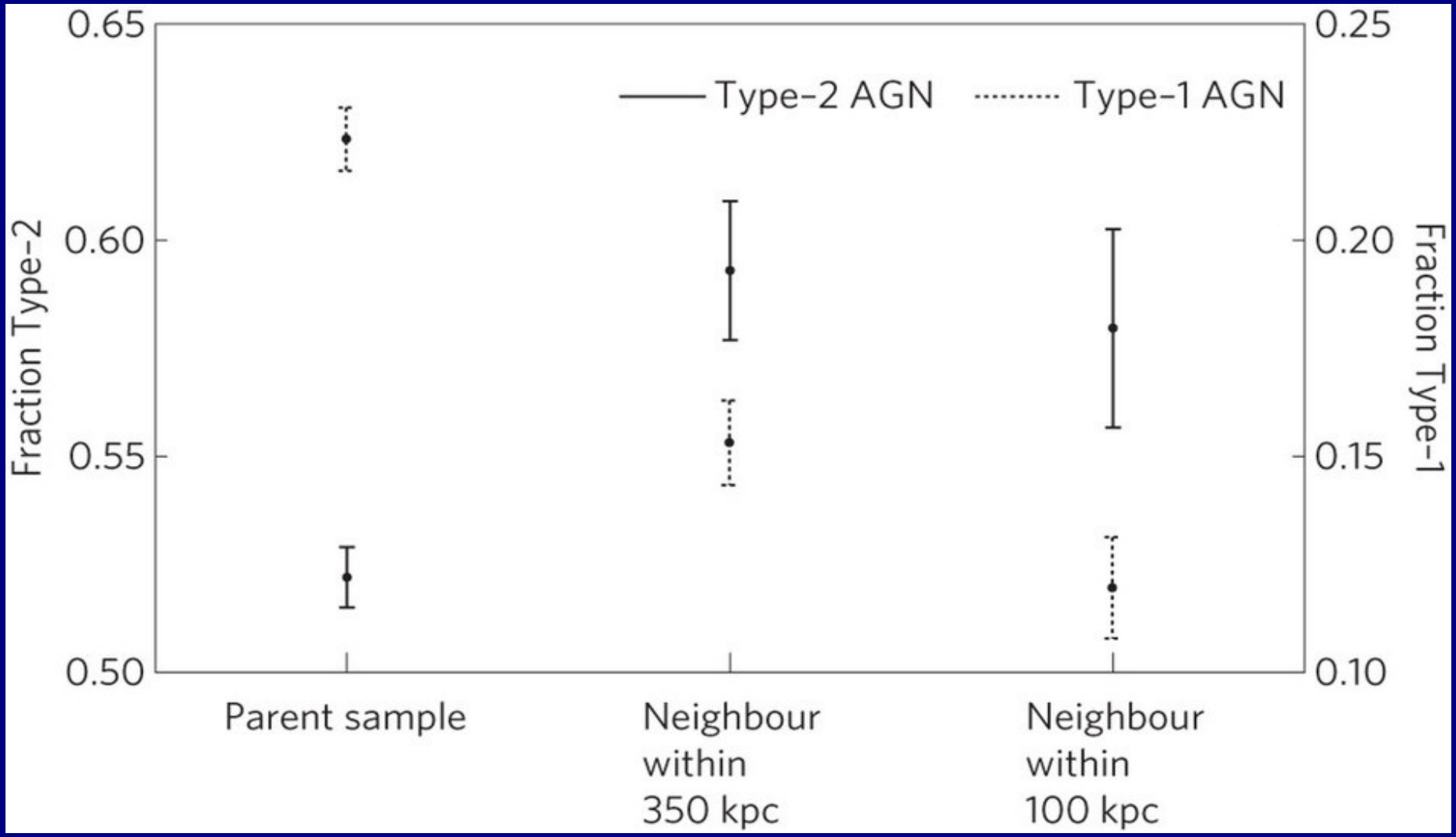
A Type-1 and Type-2 AGN at the same z, same host galaxy type and same L[OIII]5007 must have the same mass.

1. Spiral (radio-quiet), face-on Type-1s and Type-2s.
2. For each Type-1, select the Type-2 with most similar redshift z and L[OIII]5007.
3. How are the neighbours now?

Type-1s and Type-2s have different neighbours – like before.



Few Type-1s in close pairs.
See also: Gonzales et al. 2008, Kocevski et al. (in press)

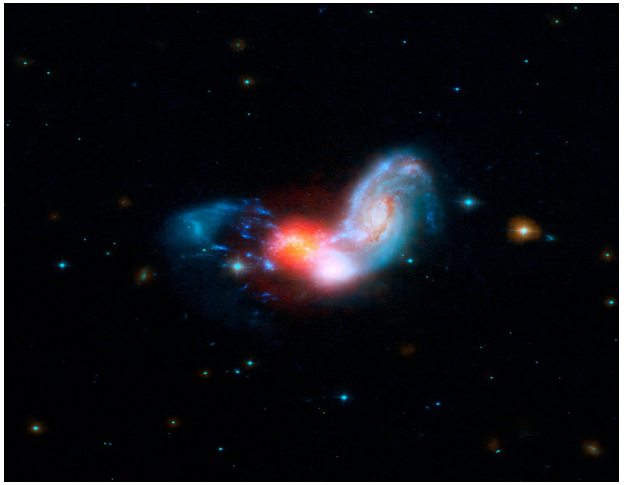


Reverse morphology-density relation for Type-1s and Type-2s??????????

Alternative: the Krongold-Dultzin model

(~ with a slight modification)

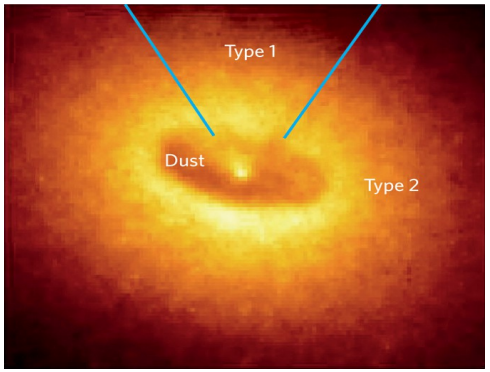
The Krongold – Dultzin model



2. Gasflows towards center: starburst ignition

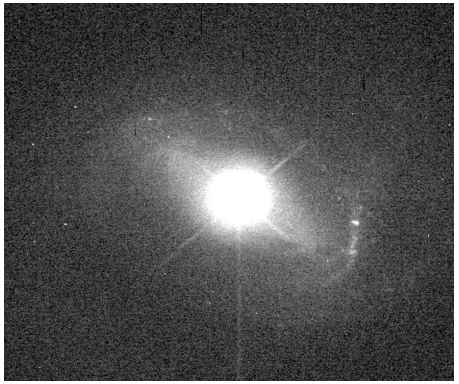
1. Pair of interacting/merging galaxies

3. More gas flows; formation of accretion disk, dust torus & relaxation of starburst

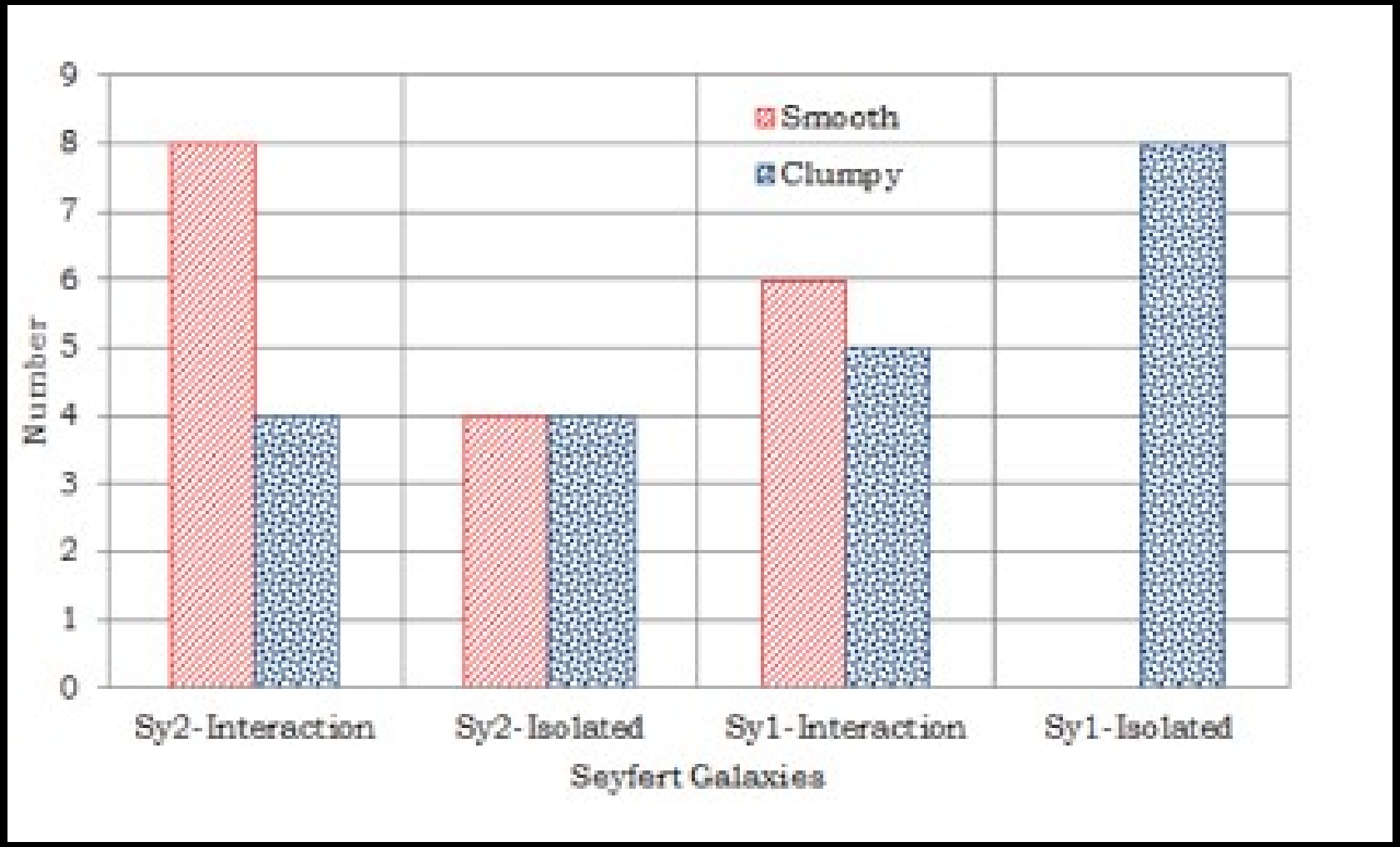


4. Narrow-line AGN is formed.

5. Stronger and stronger AGN drives away dust torus and quenches star formation. Merger completes.



6. Broad-line AGN with fewer gas-rich neighbours.



Mendoza-Castrejón et al. (2015)

And newer, additional support:

- Donoso et al. (2014):
  - difference in clustering around "obscured" vs "unobscured" AGN.
- Koulouridis (2014):
  - non-HBLR Sy-2s have more neighbours than HBLR Sy-2s.
  - HBLR Sy-2s more often in early-type galaxies than non-HBLR Sy-2s
- Bitsakis et al. (2015): fraction of AGN in dynamically young vs old groups
- Kocevski et al. (in press): Type-1s rare in galaxy pairs.

Summary

1.) **Lack of Type-2 AGN in elliptical host galaxies: Type-2 AGN "fragile" state? Reverse morf – rho???**

2.) **Lack of Type-1s in close pairs.**

3.) **Type-2 AGN have many more gas-rich companions at d < 150 kpc.**

4.) **Viewing angle, different covering factor, luminosity-bias from clumpy dust torus, bad measurements of emission line or morphology-dependence is not sufficient explanation to lack of statistical support for the Straw Person Model...plus must be a mass bias not only from the covering factor.**

Ongoing work

Thanks for your attention!!

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- Swedish Royal Academy of Science and Crafoord's funding

The hypothetical luminosity test 1

What luminosity bias is needed to reproduce the same neighbour colour distributions?

1. Assume geometric AGN unification and Gaussian distribution of the covering factor of the torus.

2. Define luminosity displacement E_dis=Mr,intrinsic- Mr,observed for Type-2 AGN.

3. What luminosity displacement in Type-2 AGN is needed to reproduce the following two properties:

   1) Same average color plus same color-distance dependence as

   Type-1 AGN with neighbours.

   2) Same morphology distributions as Type-1 AGN and reaction to nearby neighbour.

4. Do this for two extreme cases of broadening of the luminosity distribution (none and infinite).

The hypothetical luminosity test 2

5. Calculate the median and standard error of colours of the original volume-limited Type-1-galaxy pairs.

6. Iterate the “new” Mr for Type-2 AGN with a varying luminosity displacement for the previously mentioned two cases.

7. Does there exist any luminosity displacement E_dis where Type-1 and Type-2 have similar neighbour populations and reproduce the same morphological behavior?