Misaligned Discs and black hole growth

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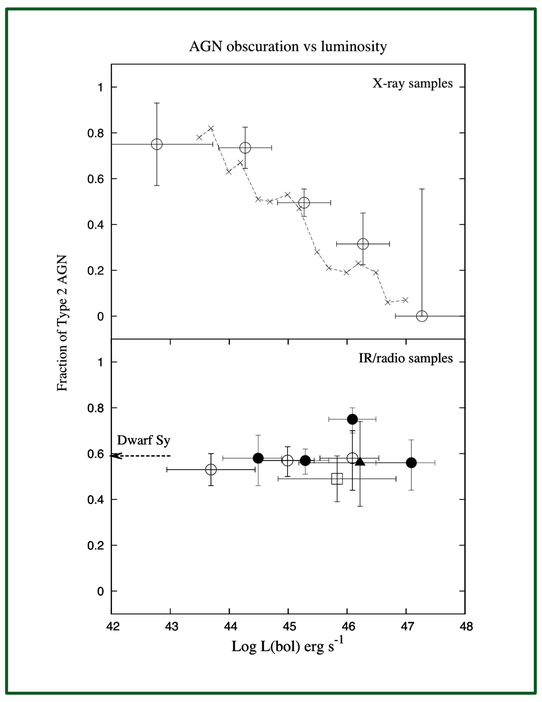
Introduction

Any account of the growth of black holes with cosmic epoch must take account of the large number of obscured AGN, how this depends on both luminosity and redshift, and how it is related to the merger history of galaxies. We show that locally ~50% of AGN may be obscured by warped discs, regardless of luminosity. This has implications for both the mass and spin growth of black holes.

The Type 2 fraction



Type 2 fraction versus bolometric luminosity.
Upper : Tueller et al 2009, Hasinger 2010.
Lower : various IR, radio, and volume limited samples

We consider carefully the number of true Type 2 AGN - as opposed to those which show X-ray absorption, and those which have low-excitation and very weak emission lines, which are prevalent at low luminosities.

IR, radio, and volume-limited samples show no luminosity effect, with Type 2 fraction f_2=0.55 and the fraction of additional reddened broad-line objects being f_{1R}=0.15

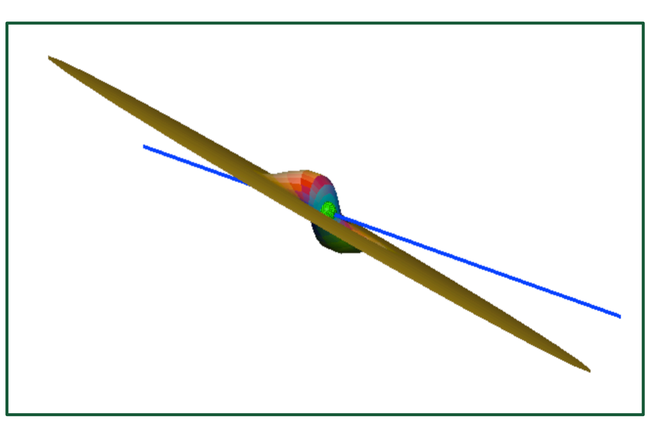
X-ray samples however show a clear luminosity-obscuration effect. We speculate that this is because of partial covering by Compton-thick material - even "de-absorbed" fluxes do not tell us the true X-ray luminosity (Mayo et al in preparation).

Nuclear gas flow

The "Type 1R" objects are probably host-obscured. True Type 2 objects are probably hidden by a nuclear obscurer. This needs to have a large covering factor to explain the obscured fraction. Identifying the nuclear obscurer with the mid-IR SED peak suggests that this is on ~pc scales. This leads towards the traditional "torus" picture. However, nature tends to make either cold thin rotating things or hot spherical things. Cold rotating donuts are unlikely.

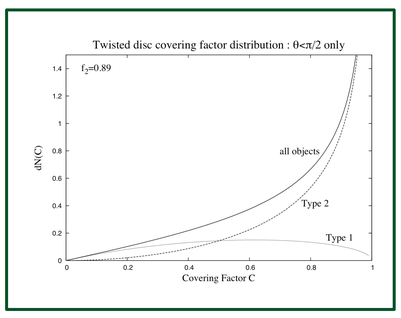
One way to make a thin cold structure with large covering factor is a warped disc (eg Sanders et al 1989). The scale height of kpc-scale starburst discs is ~100pc, far larger than the BH sphere of influence, so that fuelling is likely to be in sporadic events that are essentially isotropic (eg Nayakshin and Cuadra 2007)

Close to the BH vertical viscosity may maintain the disc axis parallel to BH spin. The incoming material must align with the central disc at some intermediate warp radius (eg King et al 2005, Volonteri et al 2007)



Misaligned discs

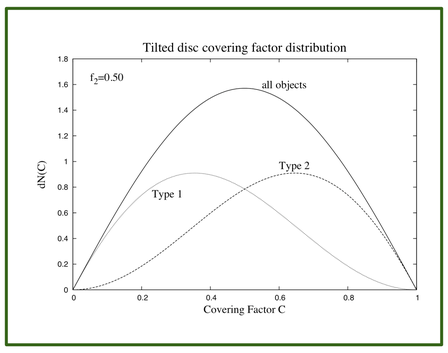
A simple prediction is made for the distribution of covering factors if we assume that incoming material has a *random direction* with respect to the BH.



If during alignment the line of nodes rotates at least one whole turn (fully twisted discs) we predict too many obscured objects, f_2=0.9

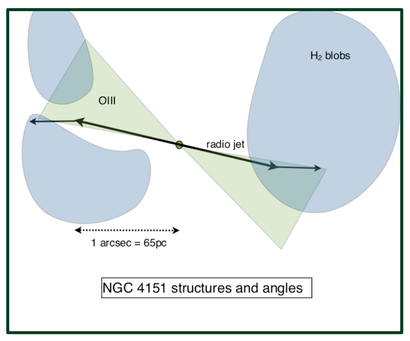
If the line of nodes does not rotate (tilt only discs) we predict exactly f_2=0.5, closed to the observed value.

Note also that objects seen as Type 2 have on average twice as large a covering factor as Type 1

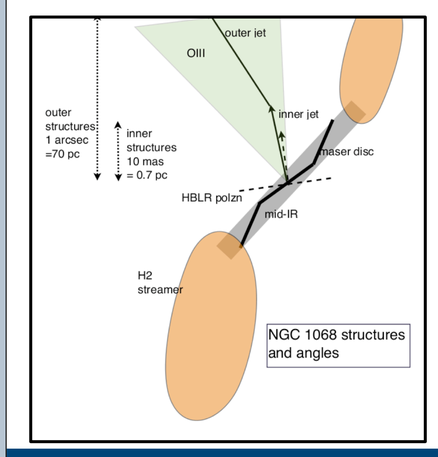


Are AGN asymmetric ?

If obscuration is due to a tilted warped disc, it will not be azimuthally symmetric, which could lead to interesting effects. Some of these effects may already have been seen.



As a Type 1 AGN, in the usual torus scheme, NGC 4151 should not show emission line cones, but it does. With a tilted disc obscurer, this can occur over a significant range of "side on" viewing angles. Also, the jet does not bisect the cone, which again is not unnusual for a tilted disc.



The archetypal Type 2 AGN, NGC 1068, shows structural position angles which seem to rotate as one moves outward. The nuclear jet and "hidden BLR" polarisation angle agree well, but the (one sided) emission line cone and the pc scale maser disc are misaligned by 20-40 degrees. IR interferometry shows incoming H2 streamers which are misaligned by ~70 degrees (Sanchez et al 2009) (Note this figure is NOT to scale !)

Possible implications

(1) The local correction for obscured AGN is a factor two. (2) For radio sources at least, this ratio is the same at high-z. There is not yet clear evidence for an early "obscured growth" epoch. (3) Mergers willl determine the mass growth but not the spin growth; they make a kpc scale reservoir that feeds the BH chaotically. Probably early BH do a random walk in spin until "freezing out" at a fairly low spin (cf Volonteri et al 2007).

References

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King et al 2005 MNRAS 363 49
Volonteri et al 2007 ApJ 667 704
Tueller et al 2009 ApJS 186 378
Hasinger 2008 A&A 440 905
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