How Do Supermassive Black Holes Get Starved?

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M31 Bulge: a Case Study

- The SMBH of $M_{bh} \sim 2 \times 10^8$ Msun; the observed upper limit $L_x \sim 1 \times 10^{36}$ erg/s.
- Gas is being supplied from both the disk and bulge: e.g., evolved stars release $\sim 0.1$ Msun/yr in the M31 bulge.
- If accreted by the SMBH, the expected $L_x \sim 6 \times 10^{44}$ erg/s.
- So this gas is not accreted and is also not accumulating in the bulge (only $\sim 10^6$ Msun is observed).

IRAC 24 micron, K-band, 0.5-2 keV

Li & Wang 2007; Li & Wang, Wakker 2009
The Gas is heated and is escaping!

Characteristics of hot gas in the bulge:

- Bipolar morphology
- \( z_0 \sim 600 \text{ pc} \)
- \( T \sim 3 \times 10^6 \text{ K} \)
- \( L_{0.5-2 \text{ keV}} \sim 3 \times 10^{38} \text{ erg/s} \)
- Enhanced X-ray emission from a circumnuclear spiral.

IRAC 24 micron, K-band, 0.5-2 keV

Li & Wang 2007; Li & Wang, Wakker 2009
Hydro-simulation of SNRs, bulge wind, nuclear disk, and SMBH accretion

- Full box size = 4 kpc
- Adaptive mesh refinement down to 0.5 pc (FLASH code)
- A cool gas inflow is assumed to continuously feed the nuclear disk around the SMBH of $3 \times 10^8 \text{ Msun}$.
- The Ia SN ($4 \times 10^{-4} \text{ /yr}$), and stellar wind injections follow the stellar light.
- The injections drive a bulge wind and also reduces the accretion to the SMBH.
- The disk is being evaporated $\rightarrow$ mass loading to the hot gas.

Density cut

Tang et al. 2009
FUSE Detection of the OVI absorption line toward the M31 nucleus

- Absorption in the integrated stellar FUV spectrum (mostly due to HB stars)
- Effective foreground $N_{\text{OVI}} = 4 \times 10^{14} \text{ cm}^{-2}$
- The absorption line centroid at $V \sim -280 \text{ km/s}$, compared to the M31 bulge's systemic velocity $-300 \text{ km/s} \rightarrow$ gas falling toward the center!
- A likely scenario is that the OVI traces the stellar mass loss being heated to hot gas.
S0 galaxy: NGC 5800

Li et al. 2009
Conclusions

• Large amount of gas is injected into galactic bulges, but is not accreted by SMBHs or accumulating.
• Type Ia SNe can effectively heat the gas and drive bulge-wide outflows.
• Such outflows can greatly influence galaxy evolution as well as starve the SMBHs.