MERGER-FREE BLACK HOLE AND GALAXY GROWTH

Observations & Simulations

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ABSTRACT

The observed correlation between galaxy and black hole mass is usually attributed to the contribution of major mergers to both. Using a sample of galaxies whose disc-dominated morphologies indicate a major-merger-free history, we show that such systems are capable of growing supermassive black holes at rates similar to quasars. Comparing black hole masses to conservative upper limits on bulge masses, we show that the black holes in the sample are typically larger than expected if processes creating bulges are also the primary driver of black hole growth. The same relation between black hole and total stellar mass of the galaxy is found for the merger-free sample as for a sample that has experienced substantial mergers, indicating that major mergers do not play a significant role in controlling the co-evolution of galaxies and black holes. Results from the Horizon-AGN simulations also indicate the bulk of black hole growth is triggered by merger-free processes, with black hole mass correlating more strongly with total stellar mass than with bulge mass, at all redshifts and for all galaxy merger histories. We suggest that more fundamental processes contributing to galaxy assembly are also responsible for black hole growth.

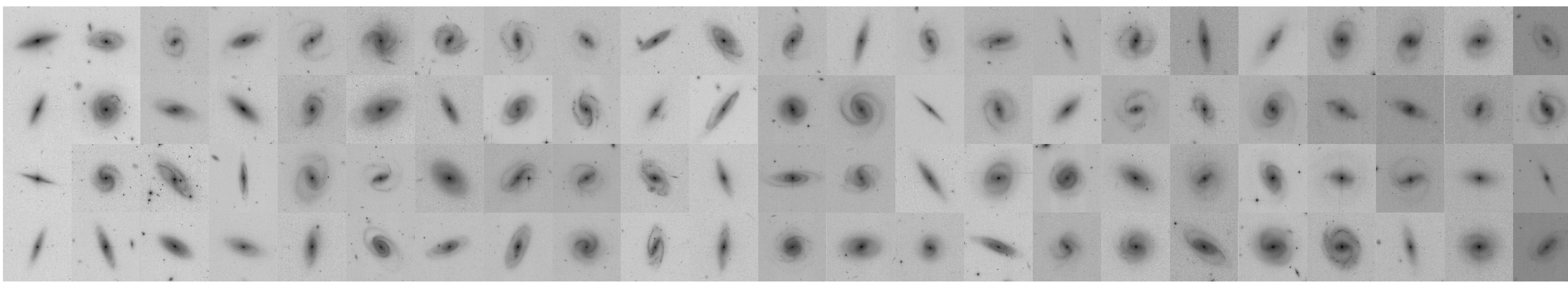

FIGURE 1. Examples of disk-dominated galaxies hosting luminous, unobscured AGN. Images are *HST*-ACS snapshots from a Cycle 24 survey (MAGNUS, the Merger-free AGN hUbble Survey, PI: Simmons) of 121 targets at $z < 0.25$ identified as AGN by their X-ray and IR properties and as likely disk-dominated galaxies by morphological analysis of SDSS images. Full AGN-bulge-disk decomposition is underway; below we describe results using bulge fraction upper limits derived from SDSS imaging (Simard et al. 2011) and attributing AGN light to a bulge, i.e., the upper limits are conservative.

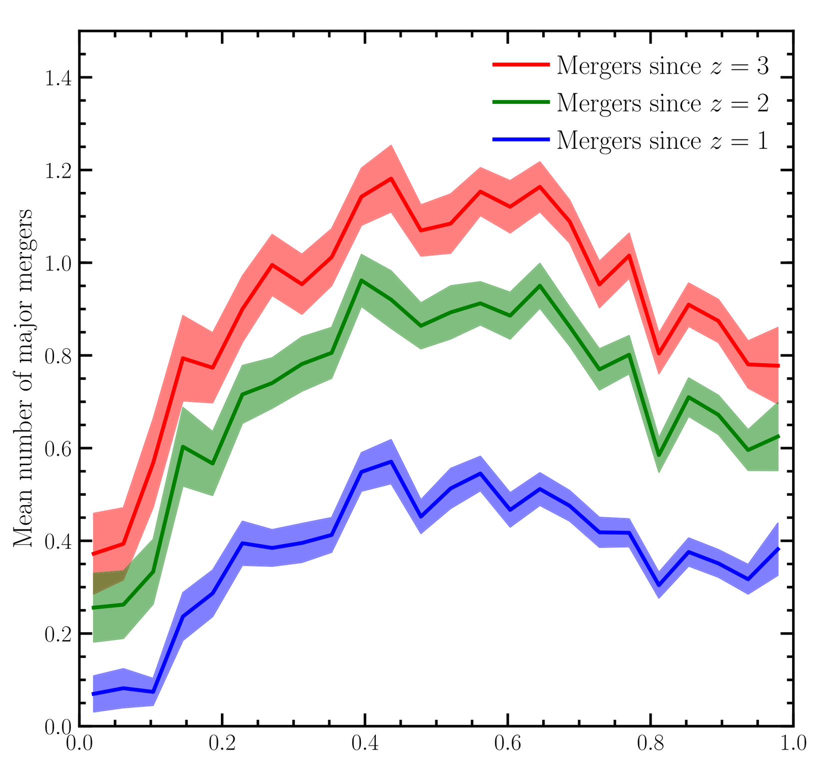

FIGURE 2. Horizon-AGN simulation results showing link between morphology and merger-free history: bulgeless ($B/T < 0.1$) and disk-dominated galaxies are very unlikely to have undergone a major merger since at least $z \sim 2$. Bulgeless galaxies in these simulations span a wide range of stellar masses, but are typically Milky-Way sized ($\log M_* \sim 10.5\ M_\odot$). From Martin et al. (2018).

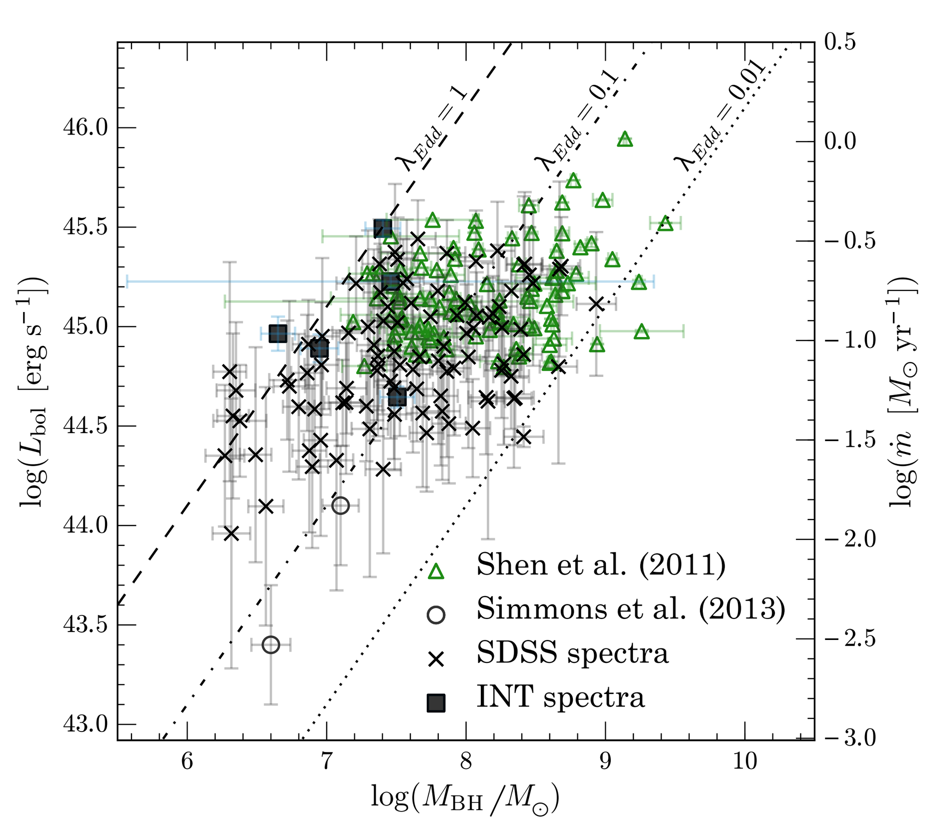

FIGURE 3. Comparison of MAGNUS AGN (with merger-free histories) with typical SDSS quasars (with histories including major mergers; Shen et al. 2011) at the same redshifts. Disk-dominated galaxies can host AGN with quasar luminosities. The median M_{BH} and L_{bol} of the MAGNUS sample are slightly lower than those of the SDSS quasars, but the Eddington ratio (λ_{Edd}) distributions are statistically indistinguishable. From Simmons, Smethurst & Lintott (2017).

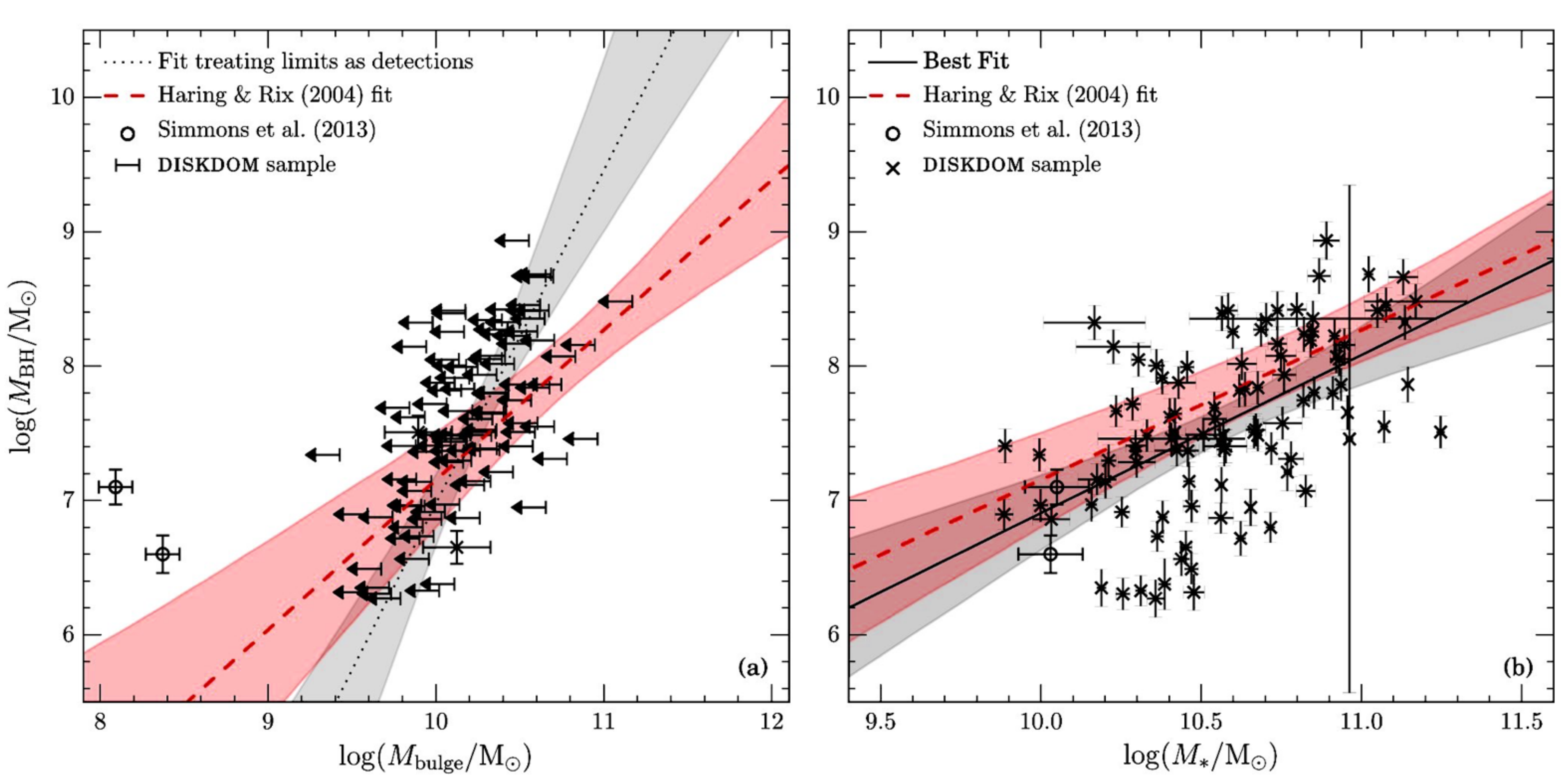

FIGURE 4. Black hole mass, estimated via broad Ha line width and luminosity (Greene & Ho 2005), versus host galaxy (a) bulge mass and (b) total stellar mass for the MAGNUS sample. Bulge mass estimates are conservatively derived using existing bulge-disk decompositions from Simard et al. (2011), in which unresolved AGN light is attributed to the bulge. Even assuming all upper limits are detected real values (which is highly unlikely given the luminous nature of these AGN), a fit to MAGNUS bulge masses (black dotted line) is inconsistent with a canonical relation derived from Elliptical and S0 galaxies (Haring & Rix 2004; red dashed line). Shaded regions show 99% confidence regions. When considering total stellar masses of both systems, however, the relations are consistent. From Simmons, Smethurst & Lintott (2017).

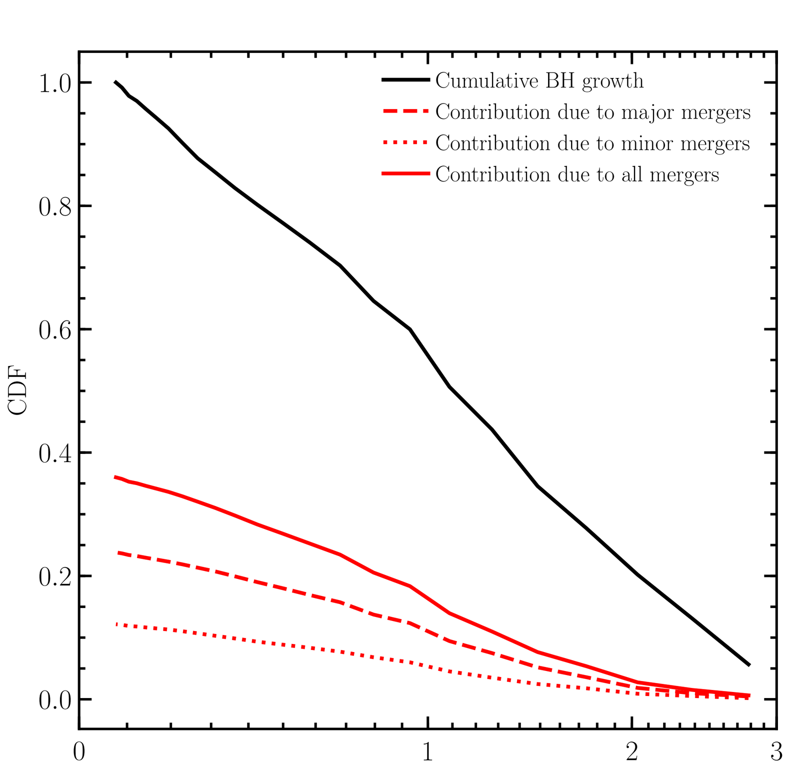

FIGURE 5. Tracking the triggers of SMBH growth in the Horizon-AGN simulation: compared to the total growth of black holes at all redshifts (black solid line), mergers are responsible for a minority of growth at any redshift. Merger-driven BH growth is calculated by taking the excess growth over the rate of secular BH growth before and after the merger event. Major mergers are defined as having a mass ratio of 1:4 or higher. Merger-free (secular) processes account for 65% of cumulative supermassive black hole growth. From Martin et al. (2018).

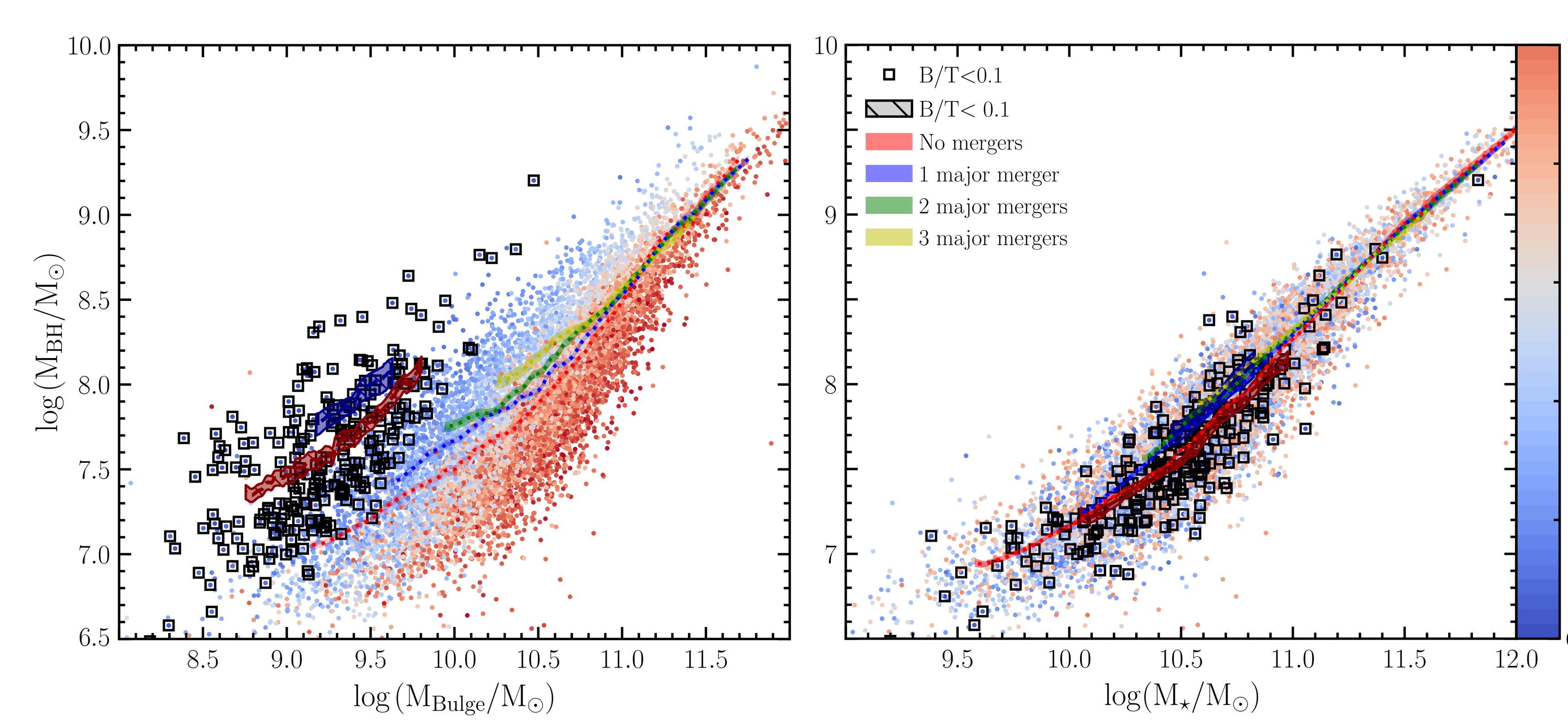

FIGURE 6. Black hole mass versus bulge mass (left) and total stellar mass (right) for galaxies in the Horizon-AGN simulations. Points are coloured according to their bulge-to-total ratio, with bulgeless galaxies ($B/T < 0.1$) additionally noted with a square point. Lines show averages for galaxies having had 0, 1, 2 or 3 major mergers since $z = 3$. While merger history clearly correlates with M_{bulge} (see Figure 2), merger history does not affect the stronger black hole-galaxy correlation at right: mergers are not fundamental to the co-evolution of black holes and galaxies. Both results are consistent with observations of merger-free galaxies in MAGNUS. From Martin et al. (2018).

SUMMARY

- Bulgeless morphology indicates a merger-free growth history since $z \sim 2$.
- Black holes can grow in merger-free galaxies at high growth rates ($\lambda_{Edd} \sim 0.1$) and up to high masses (to $\sim 10^9\ M_\odot$).
- Mergers are only directly responsible for a minority of black hole growth over cosmic time: 65% of cumulative black hole growth takes place in the absence of mergers.
- Black holes in disk-dominated galaxies can substantially outgrow their bulges.
- In both observations and simulations, merger history does not impact the black hole-galaxy relation; mergers are not fundamental to black hole-galaxy co-evolution.

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