Bar-driven fuelling as a means of merger-free supermassive black hole growth

Izzy Garland[1], Brooke Simmons[1], Chris Lintott[2], Rebecca Smethurst[2]
[1]Lancaster University, United Kingdom
[2]Oxford University, United Kingdom

Introduction

It is well established that mergers are able to fuel AGN. However, recent studies have shown that up to 65% of black hole mass formed since $z\sim2$ has occurred in the absence of major mergers[1] (i.e. in disk-dominated galaxies[2]), potentially via large-scale galactic bars. These bars are known to be an important part of galaxy evolution, although the full extent of their impact remains largely unknown. It has been shown that they can efficiently transport large amounts of material down to the central kiloparsec of their host galaxy, where that material could be accreted onto a central supermassive black hole[3] (SMBH). We combine longslit spectroscopy and SDSS photometry to investigate the effect of large-scale bars on AGN by comparing a sample of active disk galaxies with a carefully matched sample of inactive disk galaxies.

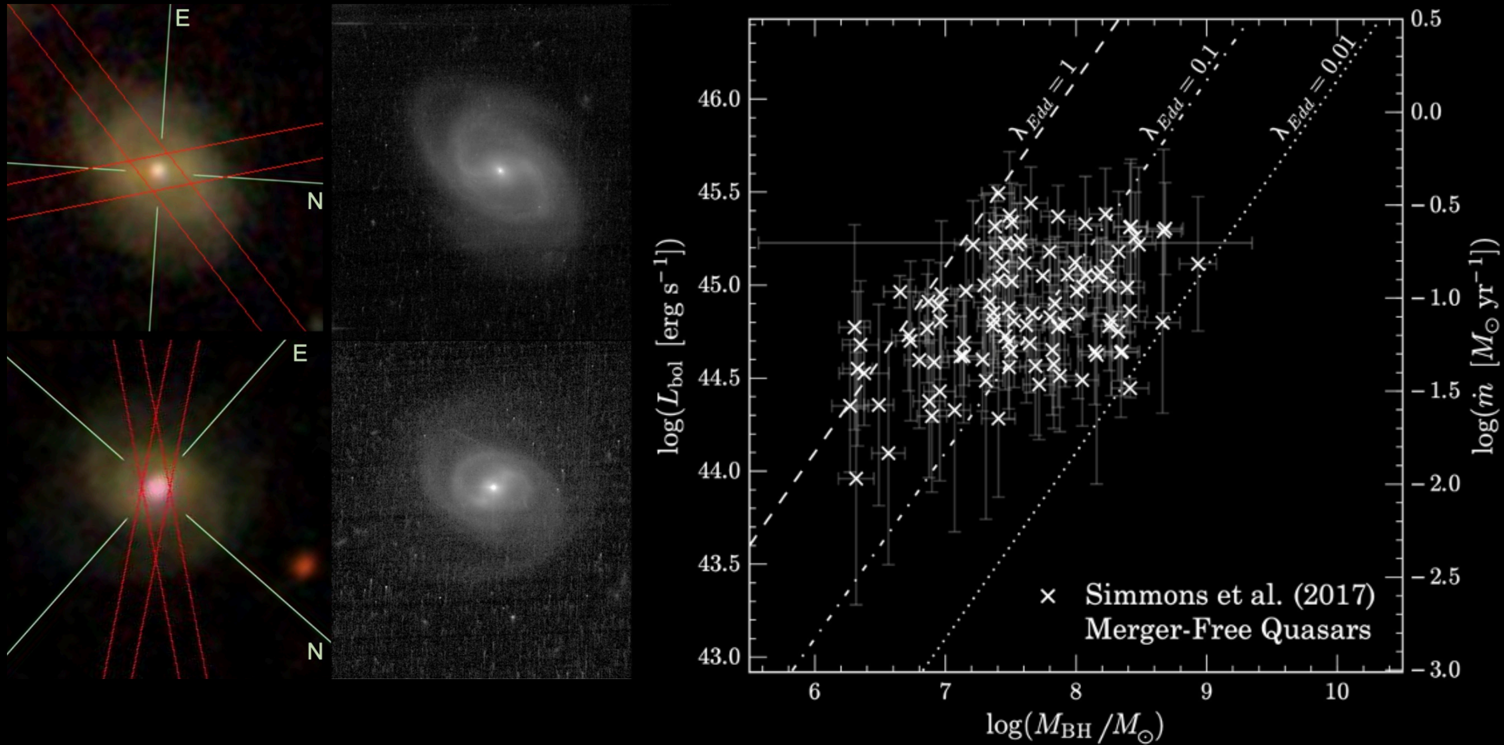
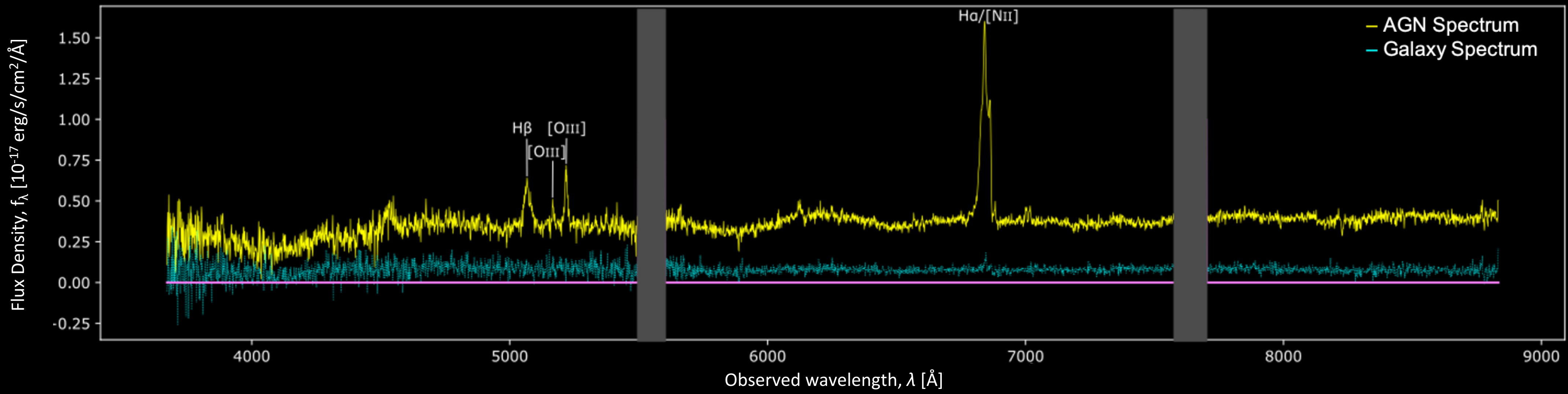


Fig 1. The image on the left shows two examples of galaxies from the sample of 86 disk-dominated galaxies with little-to-no bulge component hosting luminous AGN. Within this first image, on the left is the SDSS image[4], overlayed with two red rectangles representing the angle that was observed using the longslit Shane Kast double spectrograph at Lick Observatory. The greyscale galactic images are the corresponding HST images (HST-GO-14606, PI: Simmons). The SDSS images have been rotated to match the orientation of the HST images, with the cardinal points North (N) and East (E) indicated in light green. The plot on the right shows several properties of our sample, such as the black hole mass, the bolometric luminosity, and the star formation rate from SDSS spectra. This plot is adapted from Simmons et al. 2017[5].



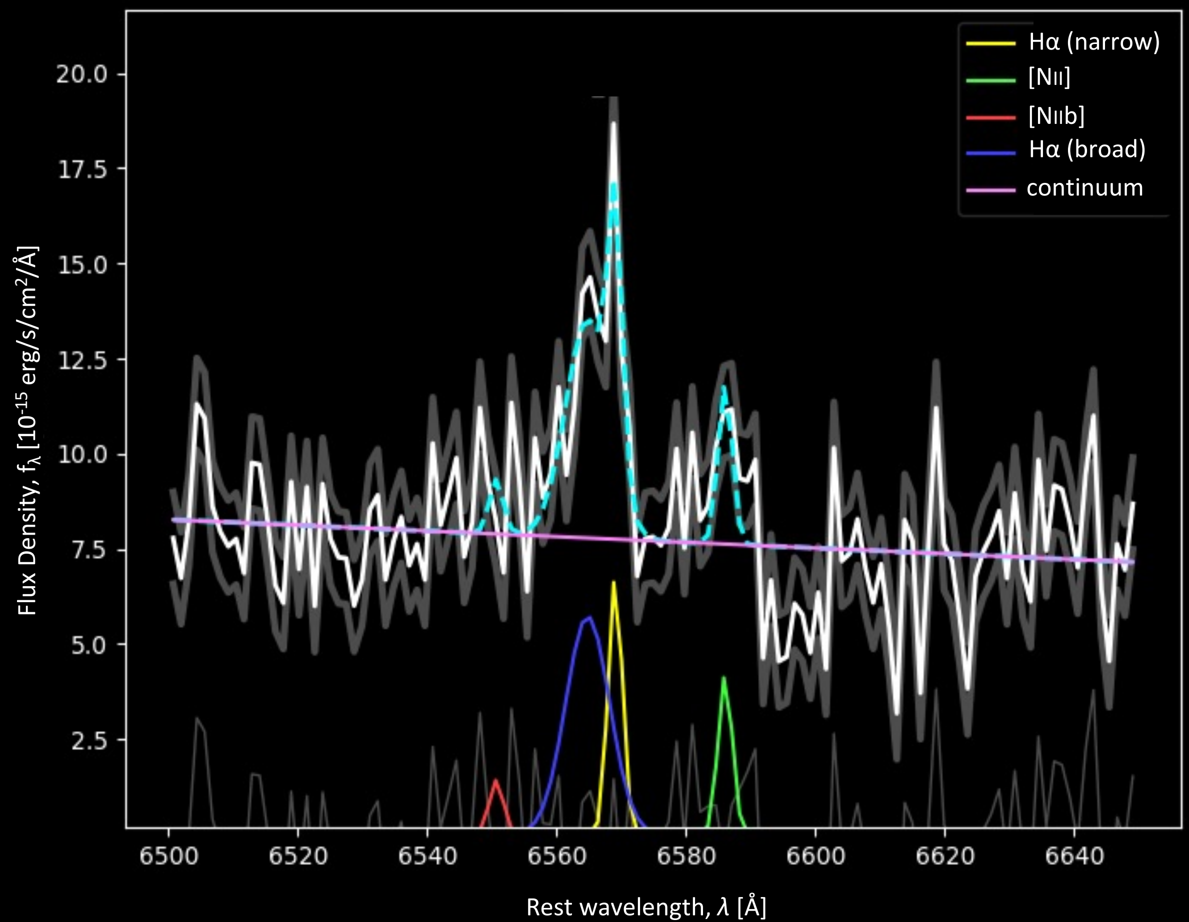
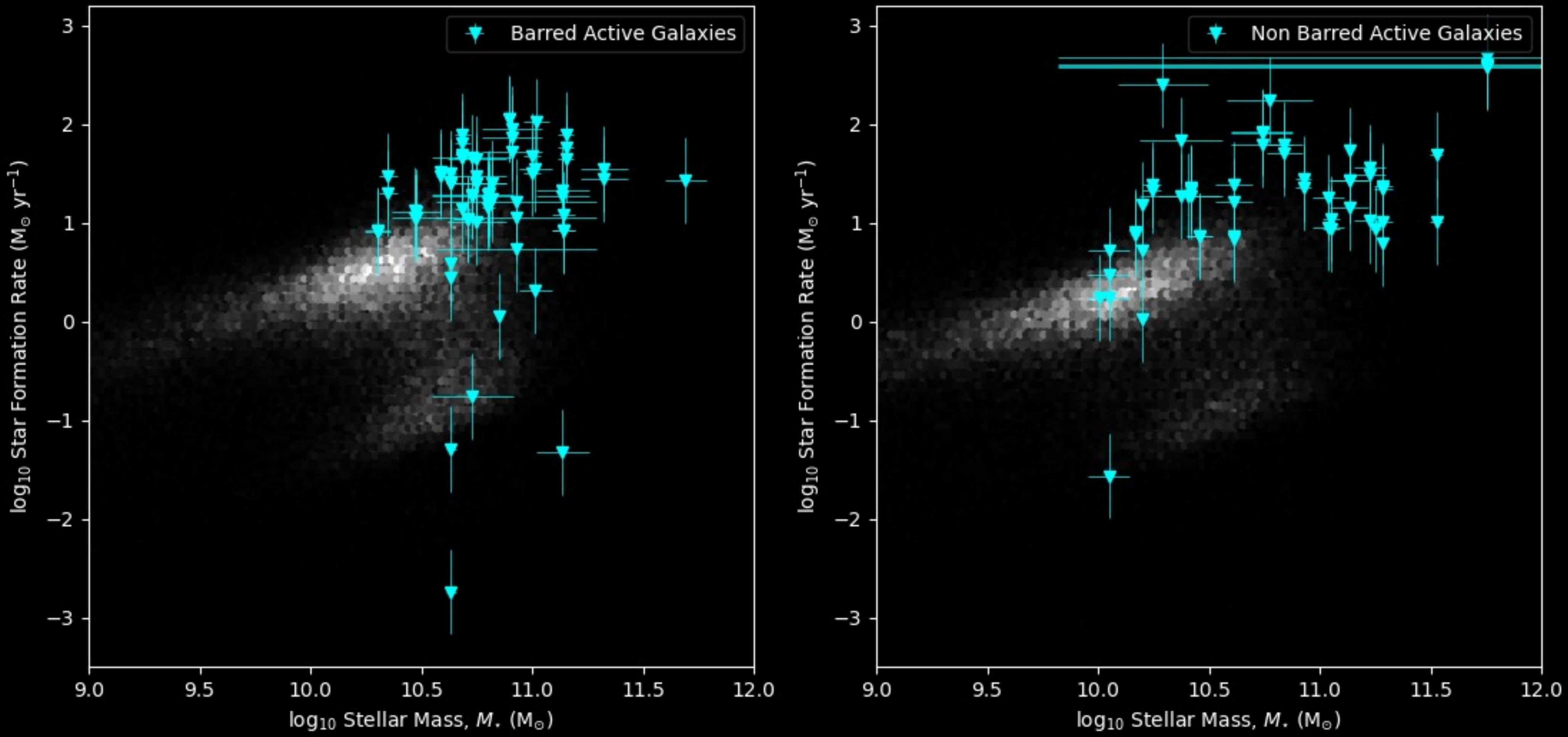


Fig 2 (above). A reduced spectrum of the galaxy J081324.00+542236.7, redshift 0.042 (top row of Fig 1). The yellow solid line is the spectrum taken over the central AGN of the galaxy. The cyan dashed line is the spectrum taken over the disk of the galaxy. In grey are the flags, where the fitting software is to ignore these parts. At around 6900Å, the Hα-[NII] complex can be seen, with high flux over the centre, and a much smaller flux over the disk. At around 5200Å lies the [OIII] doublet, from which the redshift was calculated, as this is a well known, very clear line, with the primary component having a rest wavelength of 5007Å. The flag at around 7800Å is due to the Na-D absorption lines in the atmosphere, and the flag at around 5500Å is due to an artifact of the spectrograph.

Fig 3 (left). The Hα-[NII] flux over the galactic disk, fitted with four gaussians and a continuum. We use the Hα (narrow) flux to calculate the SFR.

Fig 4. The parameter space occupied by active and inactive galaxies, with barred galaxies on the left plot, and non-barred disk galaxies on the right plot, with the active galaxies represented by cyan triangles, and the inactive galaxies by the inverted greyscale colour map. The stellar masses for our sample were obtained from SDSS photometry[6], and the preliminary SFR was calculated using the narrow Hα flux[7]. Our comparison sample was drawn from the MPA-JHU catalogue[8] and classified using Galaxy Zoo 2[9] (GZ2), a citizen science project dedicated to the classification of galaxies. The stellar mass and SFR for these galaxies were taken from the OSSY catalogue[10]. We apply a redshift cut to this sample of $0 < z < 0.65$ in order to ensure a high enough resolution that classifications can be considered more accurate. In general, the active galaxies have a larger SFR. The stellar masses of the AGN sample are also higher than in the inactive sample, indicating that to truly isolate the effect of bars, it is necessary to control for the mass. The barred galaxies appear to occupy the same parameter space as the non-barred galaxies; however, a larger sample is needed to confirm this without controlling for mass and SFR.



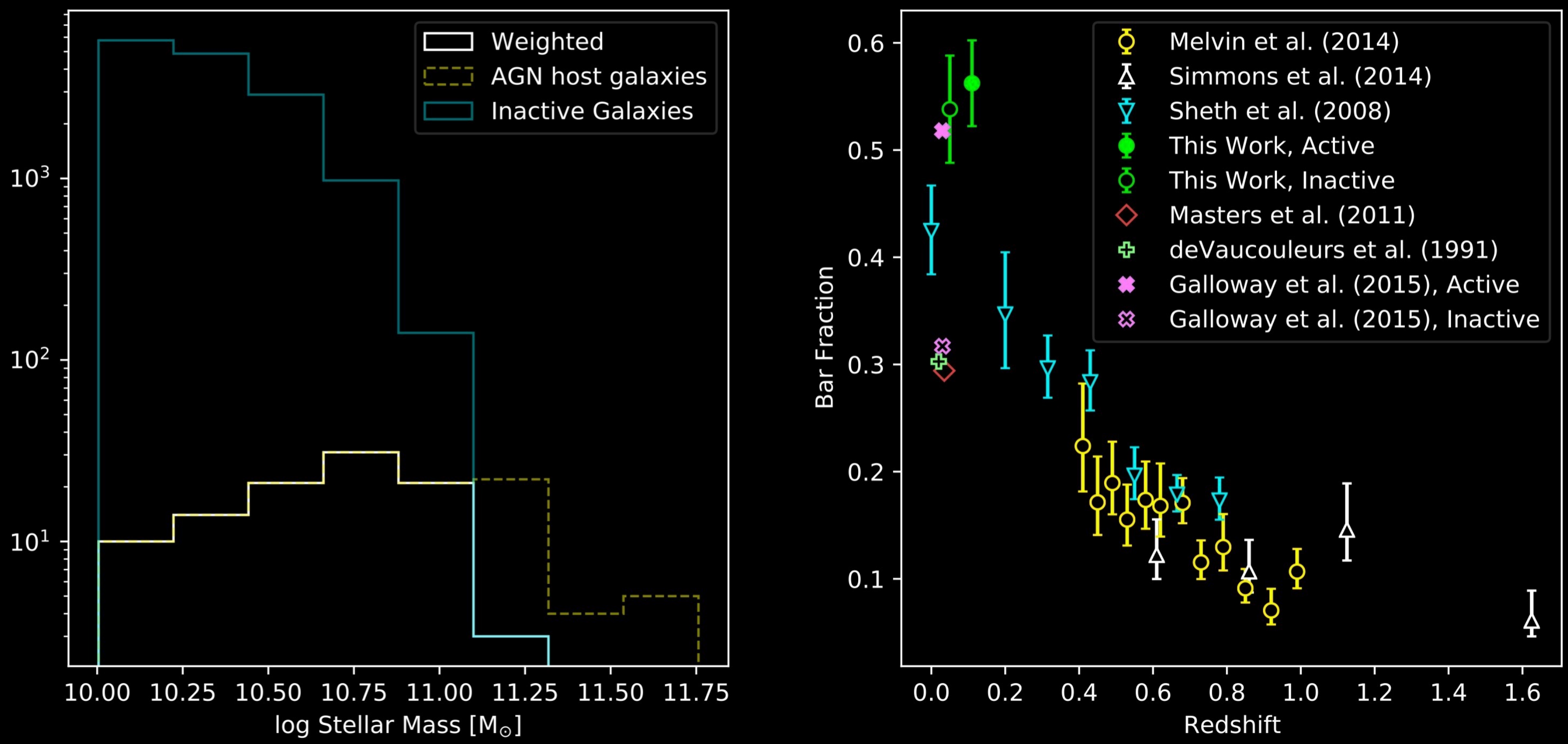


Fig. 5. The left figure shows a mass histogram with the AGN hosts in a yellow dashed line, and inactive disk-dominated galaxies in a cyan solid line, as well as the weighted histogram in white. The uncontrolled mass distribution differs significantly. The right figure shows the variation of bar fraction, f_{bar}, with redshift for several studies, where f_{bar} is the fraction of disk galaxies hosting a large-scale galactic bar. Where not indicated otherwise, the samples contain a mix of both AGN hosts and inactive disk galaxies. We used the weighted mass distribution to select a mass-matched sample of inactive, disk-dominated galaxies from our inactive sample. The mass-weighted f_{bar} is then plotted at the median redshift of our samples in order to visualize where it lies in comparison to other studies. The results from this study indicate that active galaxies are not significantly more likely to host a bar than their inactive counterparts. It should be noted however, that this does not include a measure of the strength of the AGN or bar, merely its presence (or lack thereof).

Conclusion

Our preliminary results show that the effects of large-scale bars on AGN remain ill understood. We have shown that after controlling for mass, there is no significant difference in the bar fraction in AGN host galaxies and inactive galaxies, indicating that bars are not a vital mechanism for fuelling AGN in the absence of mergers. Future work will also aim to control for SFR, as well as mass so that we can fully isolate the effect that large-scale galactic bars have, if such an effect exists, on a central AGN in their host galaxy.

References

[1] Martin, G. et al. (2018). *MNRAS*, 476(2):2801–2812. • [2] Martig, M. et al. (2012). *ApJ*, 756(1):26 • [3] Athanassoula, E. (2003). *MNRAS*, 341:1179–1198 • [4] Ahn, C. et al. (2012). *ApJS*, 203(2):21 • [5] Simmons, B. et al. (2017). *MNRAS*, 470:1559-1569 • [6] Baldry, K. et al. (2006). *MNRAS*, 373:469-483 • [7] Pflamm-Altenburg, J. et al. (2007) *ApJ*, 671:1550-1558 • [8] Kauffman, G. (2003). *MNRAS*, 341:33-53 • [9] Willett, K. et al. (2013) *MNRAS*, 435:2835-2860 • [10] Oh, K. et al. (2011). *ApJS*, 195(2):13