Low-Mass Galaxy Interactions Trigger Black Hole Accretion

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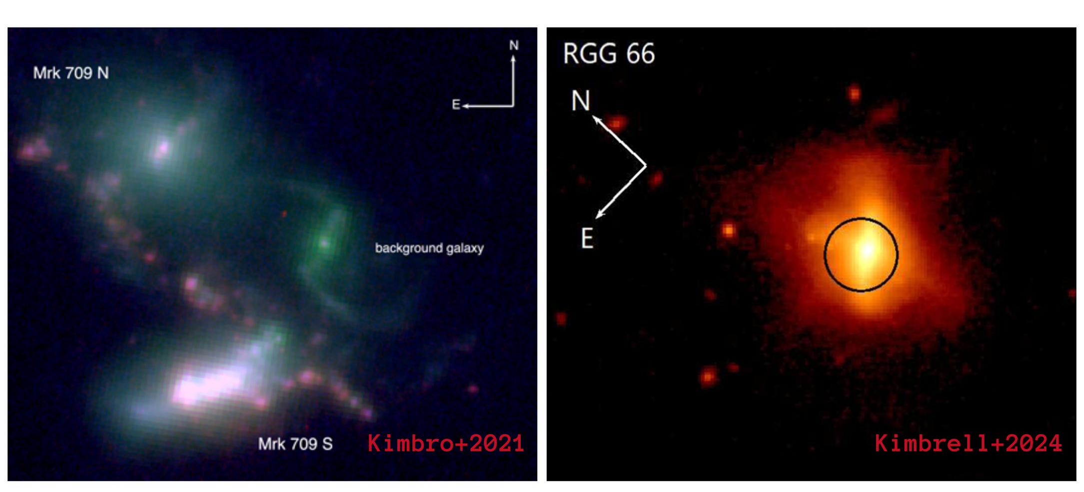
1. Introduction

Recent discoveries of supermassive black holes billions of times more massive than our Sun, existing less than 700 million years after the Big Bang, represent a major puzzle. **How did these black holes manage to grow so much so fast**? One well-studied mechanism known to trigger the black hole accretion and subsequent growth is galaxy interactions. The early Universe is likely dominated by dwarf galaxies that undergo multiple concurrent and consecutive mergers with other dwarfs. Due to a small sample of known dwarf-dwarf mergers and an even smaller sample of AGN in these interacting systems, no work examined the low-mass end of the relationship between galaxy interactions and black hole accretion. We compiled a new catalog of low-mass interacting systems and Chandra-detected AGN. This work, for the first time, demonstrates the efficiency of low-mass galaxy interactions in triggering AGN and provides new clues important for modeling the growth of the first supermassive black holes.

2. Summary of Literature

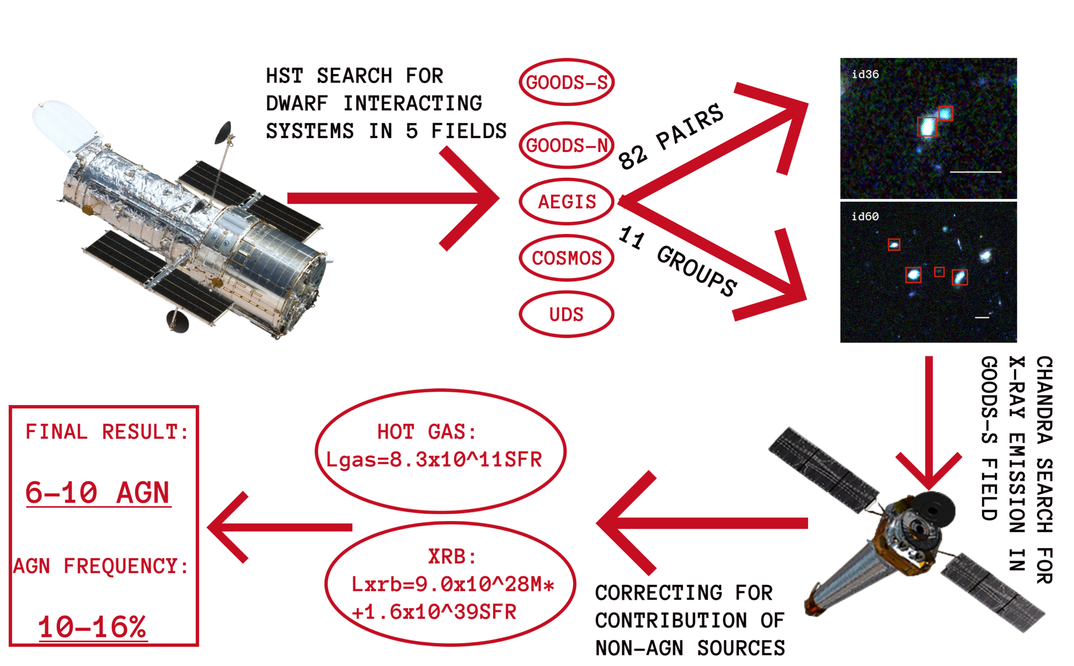
Stierwalt et al. (2015) [1] reported the discovery of 104 dwarf galaxy pairs in the *Tiny Titans* catalog. Additionally, Stierwalt et al. (2017) [2] published a sample of seven dwarf galaxy groups. None of these dwarf interacting systems has been reported to have an AGN. Aside from these large-scale surveys, only two confirmed AGN in dwarf-dwarf mergers are known, Mrk709 [3, 4] and RGG66 [5].



3. Methodology

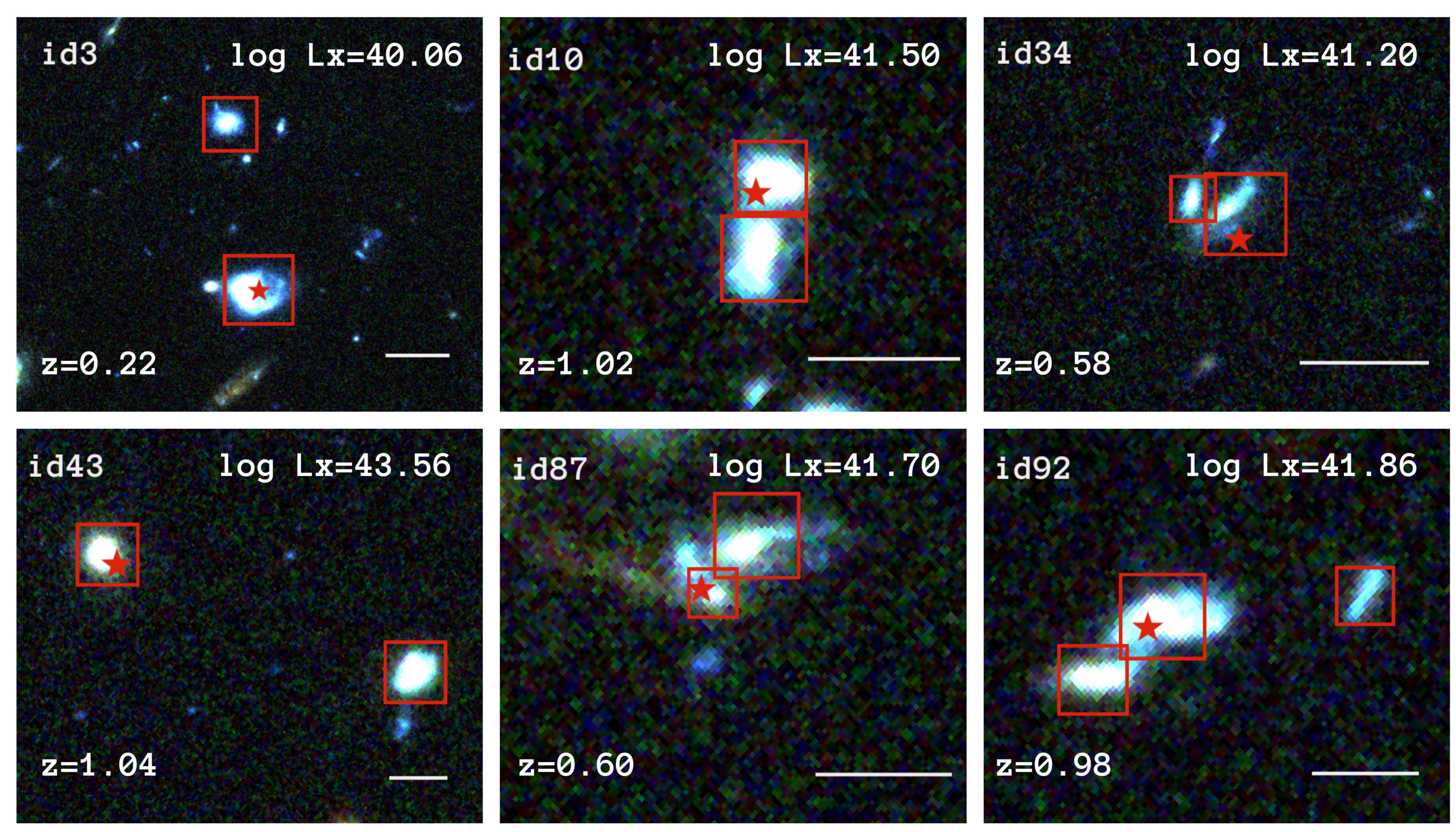
We studied environments of ∼1600 dwarf galaxies with $\log(M_*/M_\odot)<9.7$ from the 3D-HST survey residing in CANDELS fields. We discovered 82 new dwarf-dwarf galaxy pairs and 11 new dwarf galaxy groups.

We used **Chandra** to study the X-ray emission emanating from a subset of dwarf interacting systems residing in the GOODS-S field where the deepest X-ray data is available and low-luminosity AGN can be probed. Observed X-ray emission was corrected for non-AGN contributions, such as emission from X-ray binaries and hot gas. In the final sample, we kept only those interacting systems that required additional source of intensive X-ray emission to account for the observations. The final sample consists of six to ten new AGN, implying AGN frequency of 10-16%.

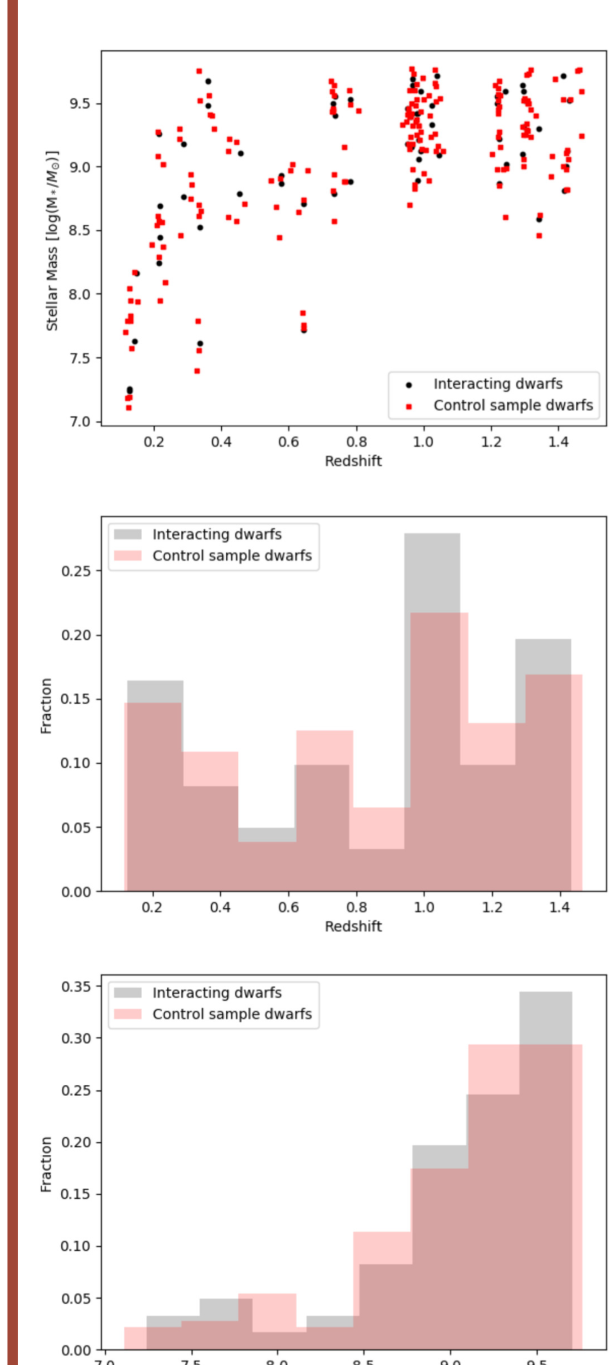


4. AGN in Interacting Dwarf Systems

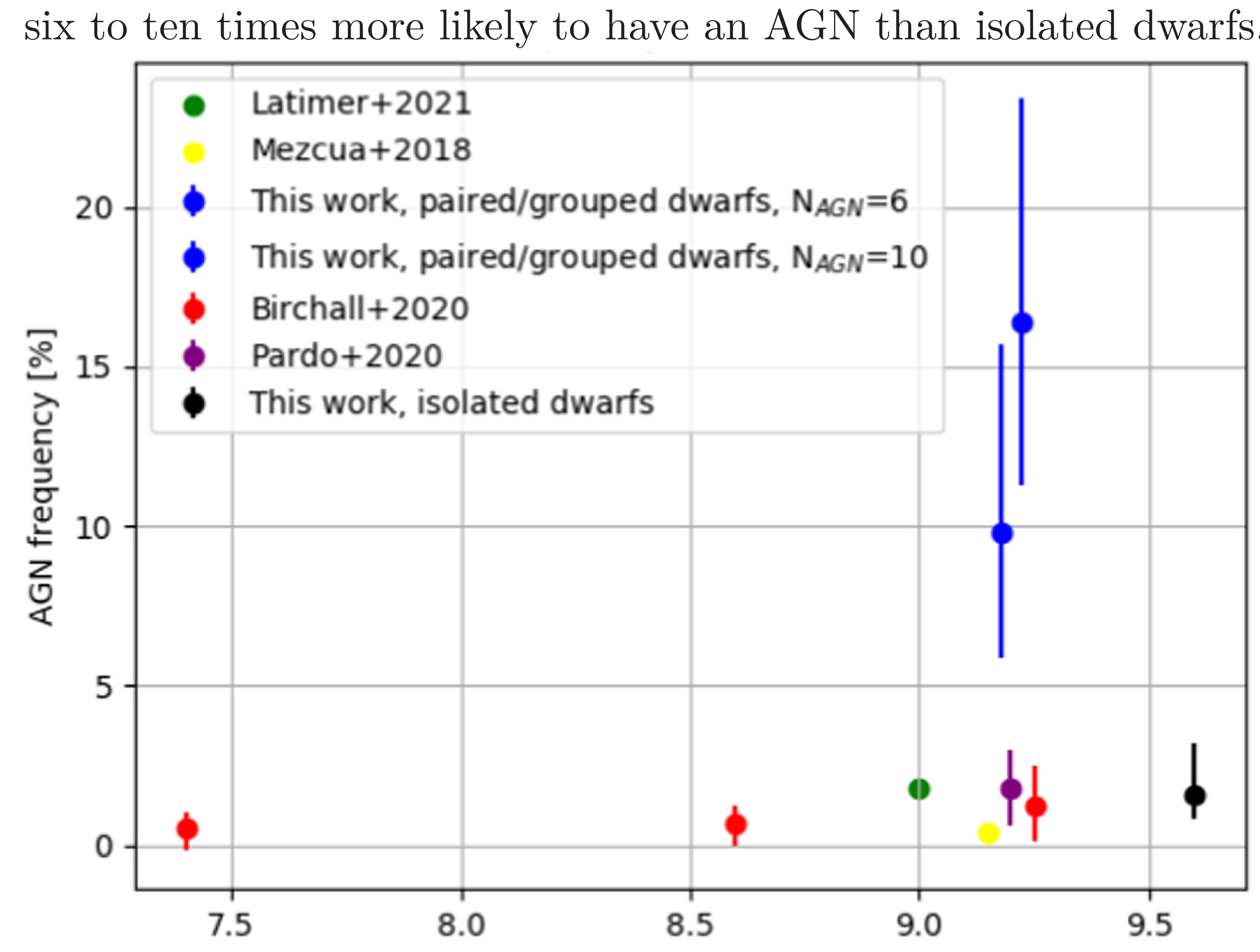
The following image shows six dwarf interacting systems with AGN. Four out of six systems are late-stage mergers where observed X-ray emission could be due to unresolved dual AGN. Hence, there are two limits on the number of AGN: a lower limit of six, assuming all four late-stage mergers are single AGN, and an upper limit of ten, assuming all four late-stage mergers are dual AGN. The image shows the ID from the original paper, corrected AGN luminosity, z, and a ∼10 kpc scale.



5. Interacting vs. Isolated Dwarfs



To evaluate the efficiency of low-mass interactions on AGN triggering, we conducted an AGN search in the control sample of isolated dwarfs. The control sample dwarfs also reside in the GOODS-S field and have the same stellar mass and redshift distribution as interacting dwarfs; the only difference is the environment. We found that interacting dwarfs are six to ten times more likely to have an AGN than isolated dwarfs.



6. Conclusions

1. In this work, we presented 82 new dwarf-dwarf galaxy pairs and 11 new dwarf galaxy groups.
2. We uncovered six to ten new AGN in dwarf interacting systems. The true number will be revealed through follow-up work investigating the presence of dual AGN.
3. We computed the first quantification of the impact of low-mass galaxy interactions on AGN triggering, providing new clues important for modeling the growth and emergence of the first supermassive black holes.

7. References

[1]Stierwalt, S., et al., 2015, ApJ, 805, 2
[2]Stierwalt, S., et al., 2017, NatAs, 1, 25
[3]Reines, A., et al., 2014, ApJL, 787, L30
[4]Kimbro, E., et al., 2021, ApJ, 912, 89
[5]Kimbrell, S., et al., 2024, ApJ, 974, 51