# How local environment affects the AGN activity?

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# Introduction

- AGNs : quasars mode (radiationally efficient) and radio mode (radiationally inefficient) based on the rate of accretion.
- Quasar mode: fresh cold gas accretion and Radio mode: slowly accreting hot gas from IGM.

- The environment can affect this supply of gas and increase gravitational interaction hence, is expected to play a role in dictating the AGN properties.

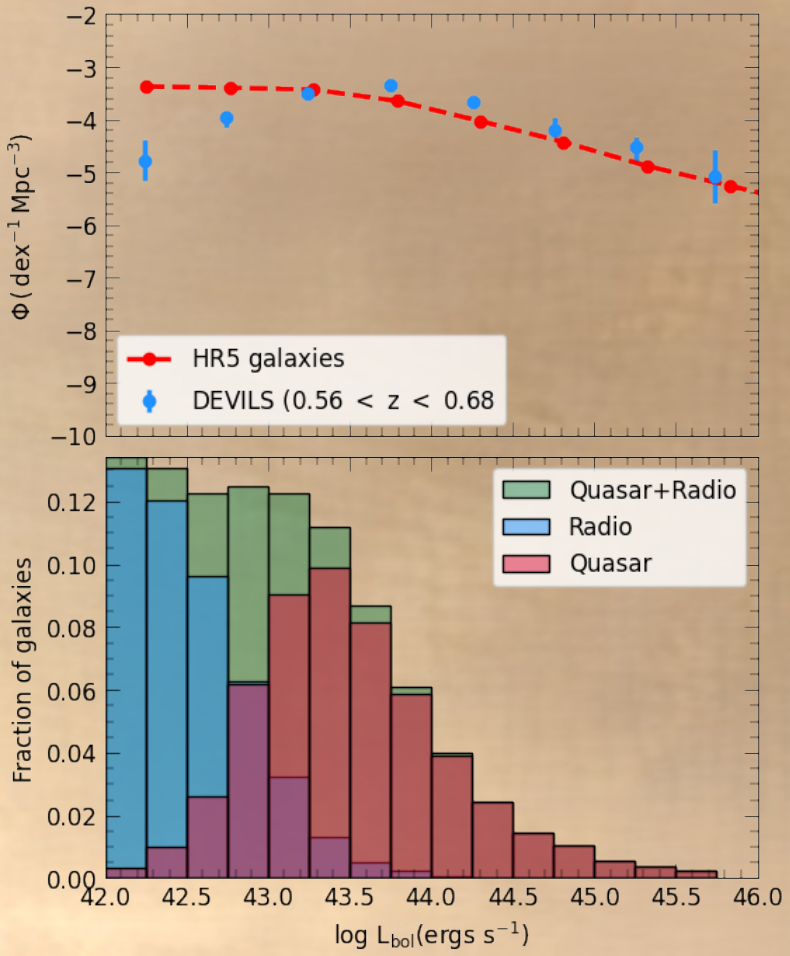
- Observations have given different results:
  - Supporting the effects of the environment on AGN properties : Padilla et al.(2010) , Bradshaw et al.(2011), Bornancini & García Lambas (2020)

  - Negligible effect on AGN properties by local environment: Carter et al. (2001) , Miller et al.(2003), Amiri et al.(2019)

This study tried to address this question from a simulation perspective.

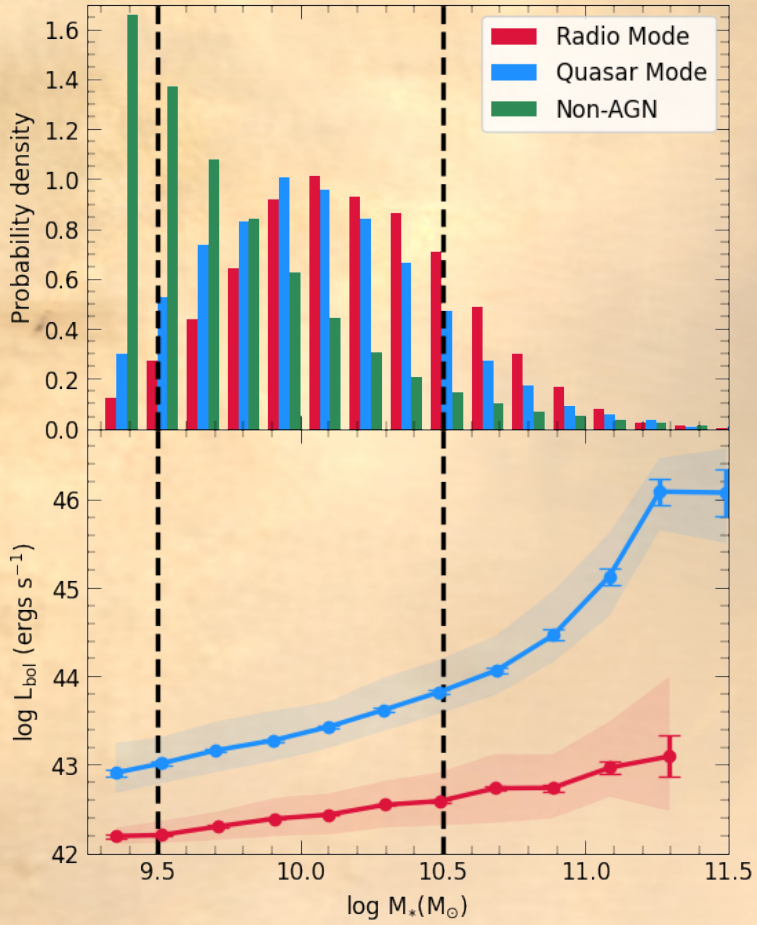
# Data from HR5

- We use HR5 galaxy catalog data  galaxies for analysis in the zoom-in region.
- We use the last snapshot (296) at redshift of 0.625 for our analysis.
- AGN: $L_{bol} \geq 10^{42}$ ergs/s , Radio: Eddington Ratio $\leq 0.01$, Quasar: Eddigton Ratio>0.01 (Churazov et. al.  2005)
- Total galaxies ~10,000 with ~3600 radio and ~4400 quasar mode galaxies.




Bolometric Luminosity calculated using accretion rate: Amarantidis et. al. 2019 and Griffin et. al. 2019.

# Mass bin selection




changes with

Staellar mass bin: maximize the number of AGNs but also be in the regime that is not highly varying.

We scale our bolometric luminosity of individual galaxies by the median linear (in log scale) relation between and

→

Log $L_{bol}$ log $(L_{bol}/L_{scale})$

# Variables

- We need stellar mass independent quantities.
- We scale the AGN host galaxy properties by the stellar mass matched properties of Non AGN galaxies.



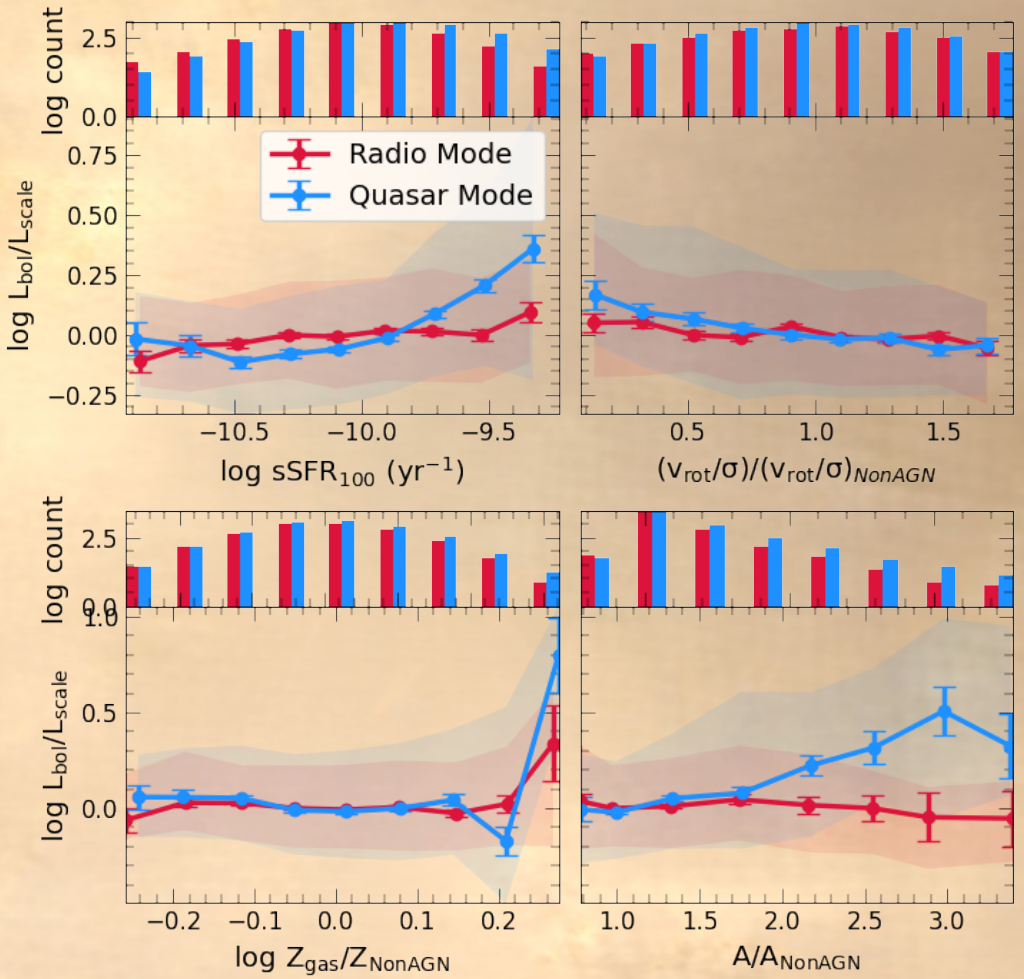
Property X of the host galaxy →

is the median value of the property X in the Non-AGN sample with similar stellar mass.

# Results: Host galaxy properties

**sSFR**

Significant increase in AGN activity with increase in SFR for Quasar mode.




**Kinematics**

Mild increase kinematics (vrot/sigma) of the AGNs in both modes.

**Metallicity**

Increase in AGN activity for AGN with increase in gas metallicity

**Morphology**

Increase in AGN activity for Quasar mode with more asymmetry.

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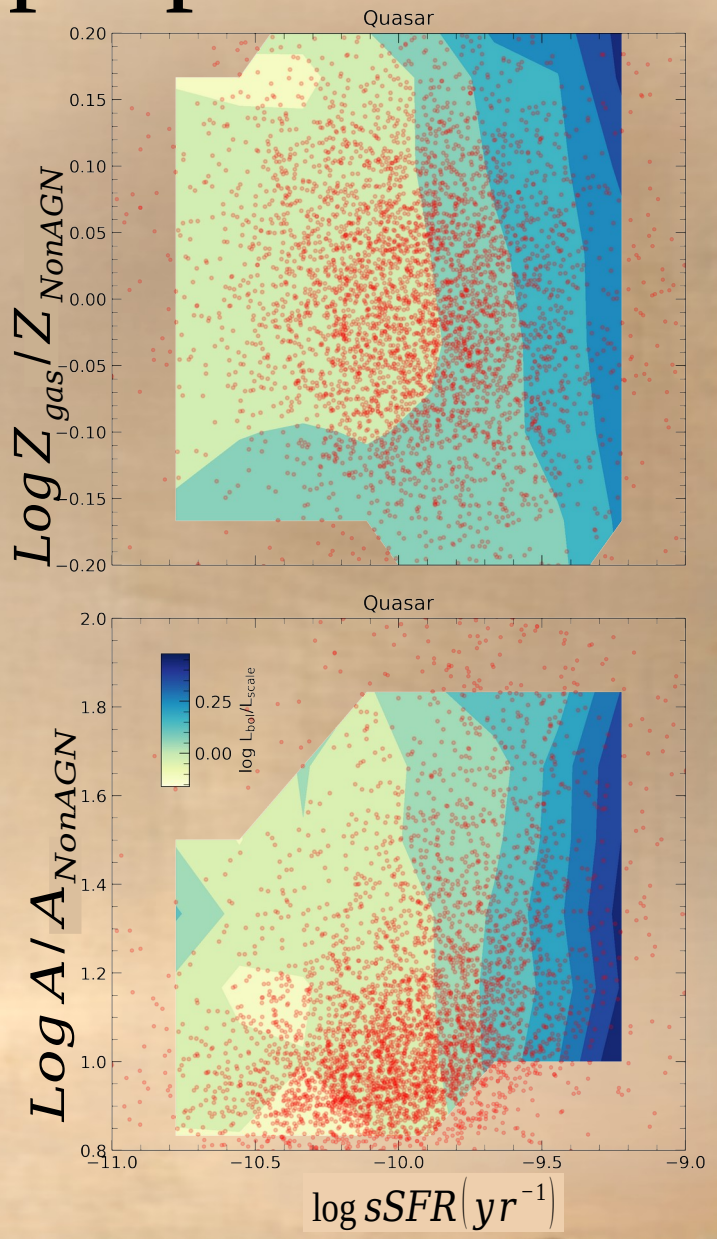
But which one is most important ?

**Metallicity**

Increase in AGN activity for Quasar with increase in gas metallicity

**Morphology**

Increase in AGN activity for Quasar mode with more asymmetry.




**sSFR is the property that primarily correlates with AGN activity.**

# Environment

- Local density: spline kernel smoothening with a varying width of distance to $20^{th}$ neighbour.

- Stellar mass of the neighbor should be more than half of AGN, i.e., $M_{*,neigh}/M_{*,AGN} > 0.5$. : major merger scenario.

- For multiple neighbours: minimum $d_{neigh}/R_{vir,neigh}$ ratio is taken

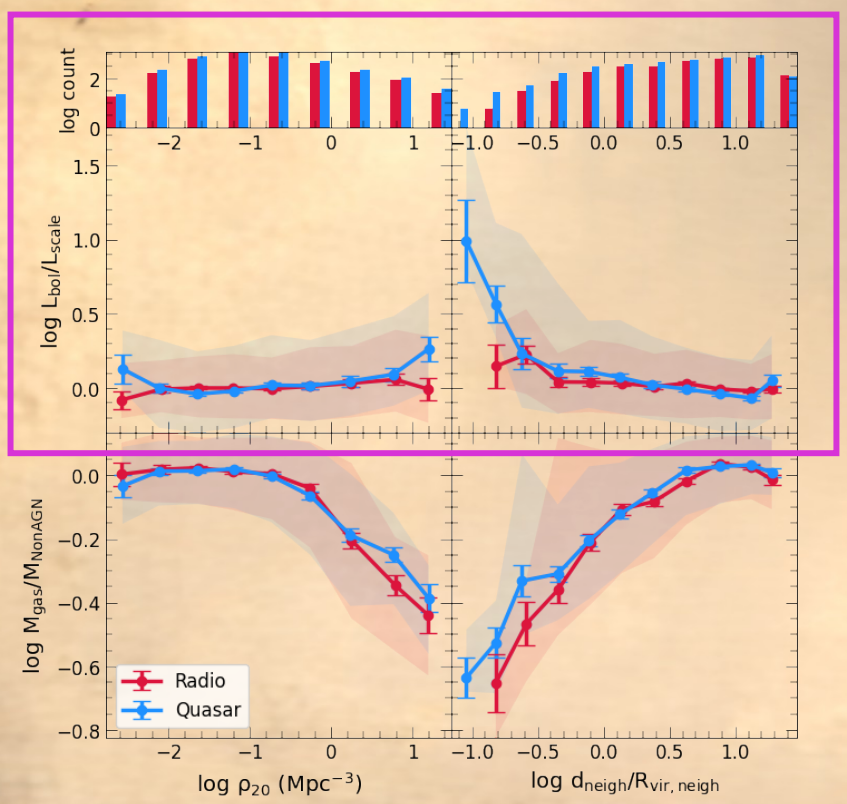
    - $d_{neigh}$ is the distance to the galaxy
    - $R_{vir,neigh}$ is the virial radius of the galaxy marked as the neighbour.

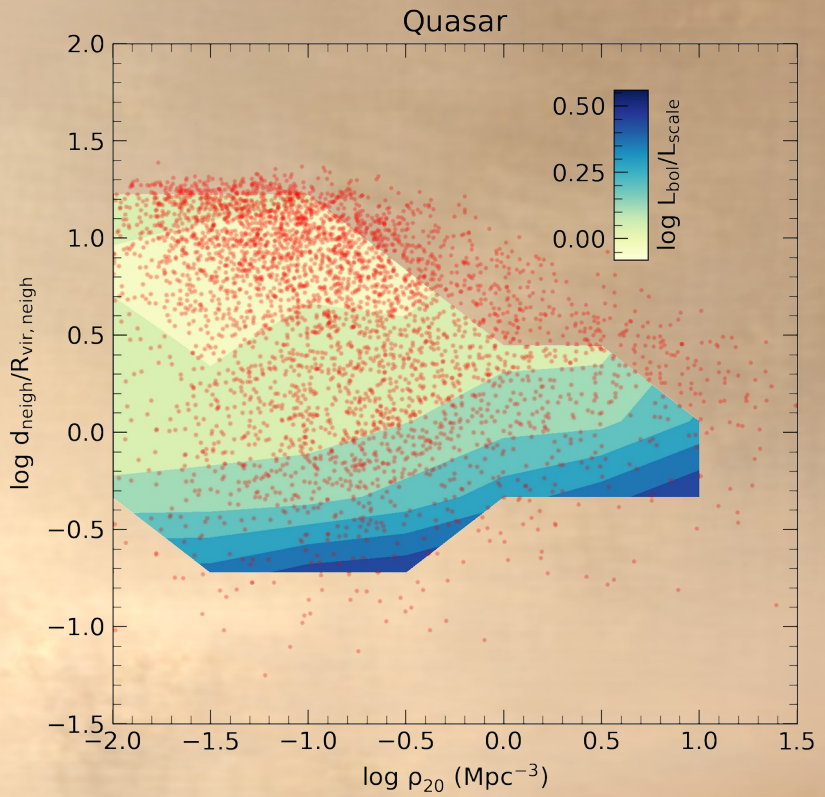
# Results: environment

## Lbol

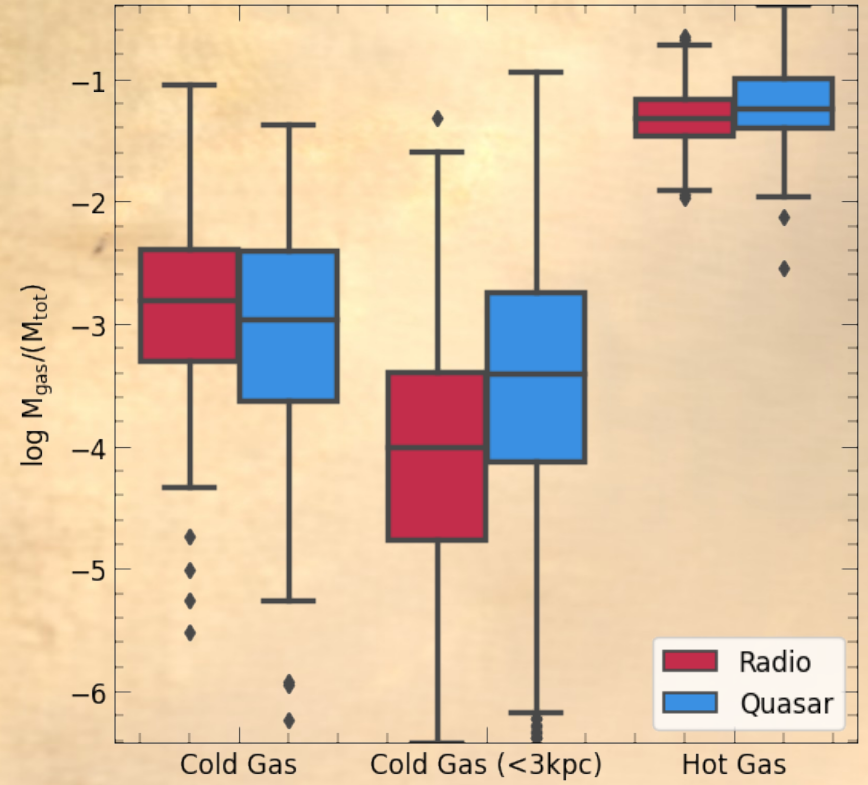
- Increase for Quasar mode in denser local environment or presence of a close neighbour.
- Low to no change for Radio mode

But which one is dominant?

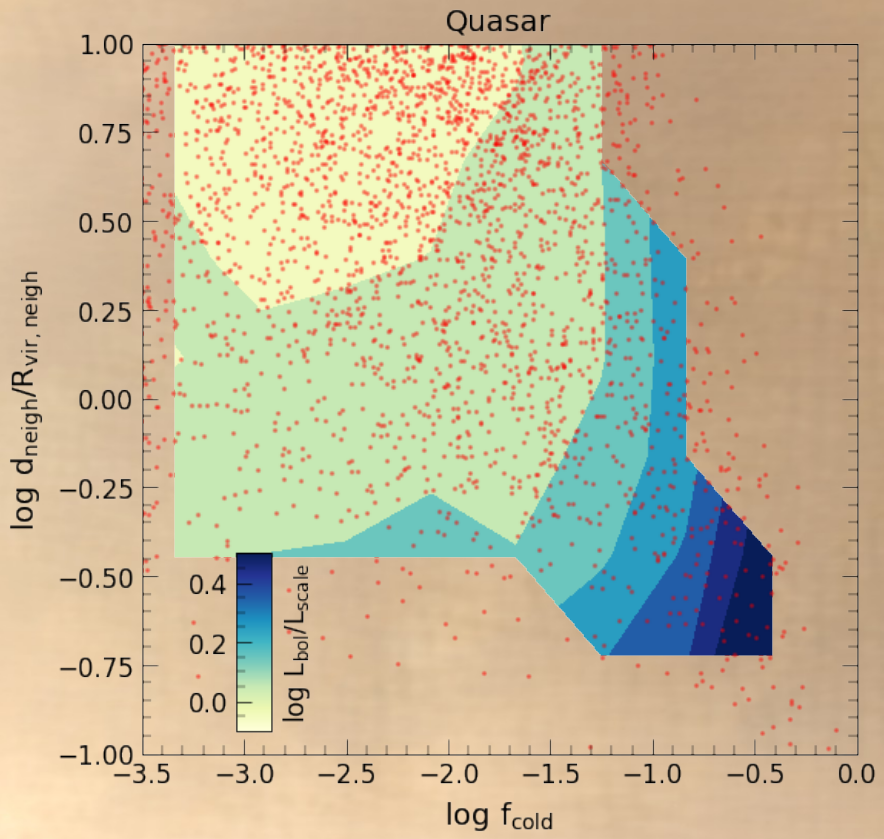


# Gas mass fraction




Host galaxies of quasar mode AGNs intrinsically have more cold gas mass content than radio mode.




Presence of high cold gas mass content in the host galaxy is the main driver of AGN activity. For low cold gas content, the presence of a nearby neighbour regulates the AGN activity.

# Summary

- Compared to the background density, the nearest neighbour environment is the dominant quantity dictating the AGN activity.
- Cold gas content in the host galaxies is crucial in triggering AGN activity.
- For relatively low cold gas content, the presence of a nearby neighbour regulates the AGN activity.