Star Formation, Quenching, and AGN Activity in IllustrisTNG at High Redshifts and in Dense Environments

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Early, Massive Galaxies

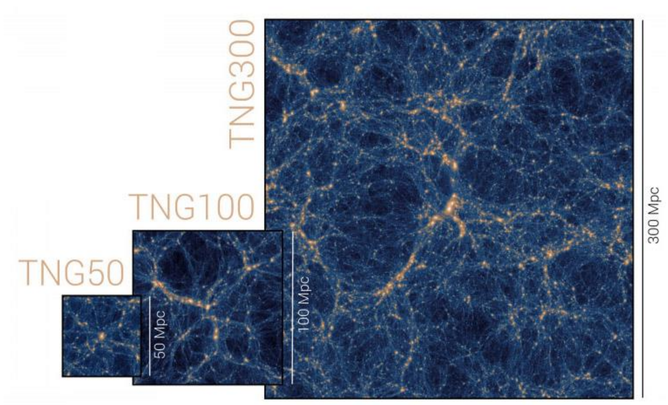
What suppresses their star formation so early in cosmic time?

Local, Satellite Galaxies

Is there a link between environmental effects and AGN feedback?

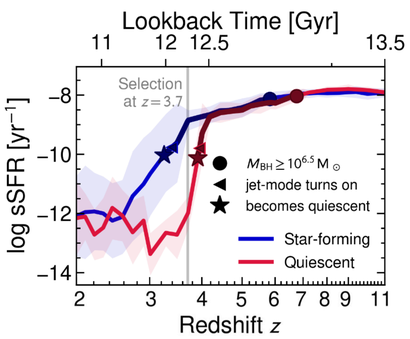
The IllustrisTNG simulations can naturally realize galaxies in a wide range in a diversity of cosmic environments and epochs.

Supermassive black hole feedback model crucial to reproducing the population of massive galaxies in the local Universe.

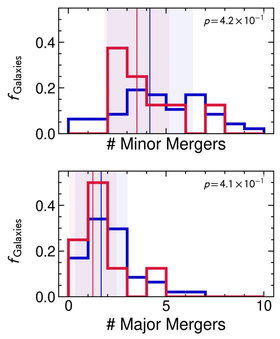


There is a clear correlation between quenching and the kinetic-mode of AGN feedback at $z > 3$.

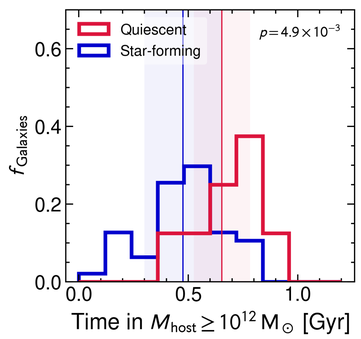
1. AGN Feedback



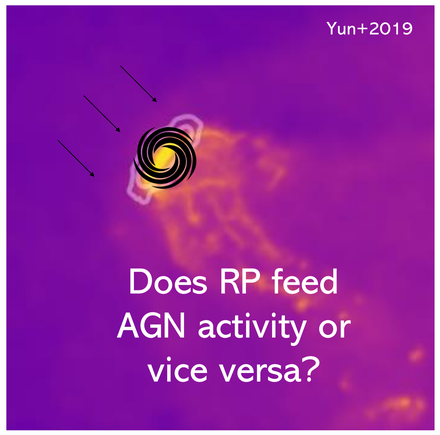
2. Mergers

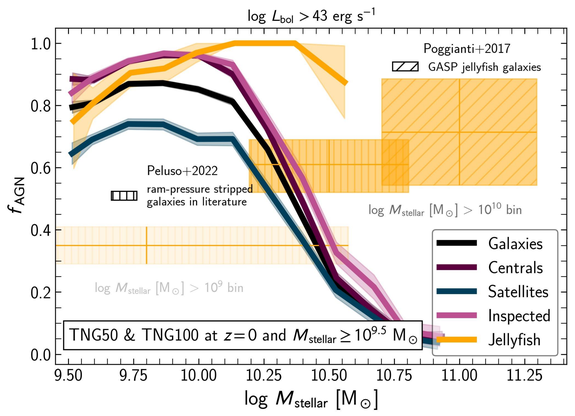


3. Environment



Ram-pressure stripped jellyfish galaxies have higher AGN fractions than centrals and other satellites.





Star Formation, Quenching, and AGN Activity in IllustrisTNG at High Redshifts and in Dense Environments

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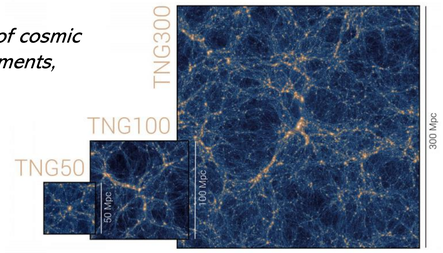
The IllustrisTNG simulations are a set of large-scale, cosmological + magnetohydrodynamical simulations for galaxy formation and evolution.

For a wide range of cosmic times and environments, includes:
- dark matter
- gas
- supermassive black holes
- stars
- magnetic fields



Supermassive Black Hole Feedback

Feedback energy depends on the SMBH mass growth.

1. High accretion rates → thermal, "quasar" mode
2. Low accretion rates → kinetic, "radio" mode

Crucial to quenching massive galaxies, consistent with observations of the local Universe!

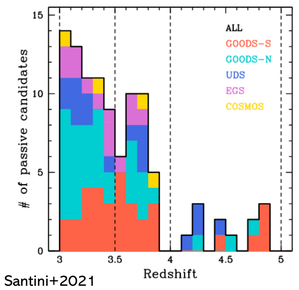
Submitted to MNRAS
Kurinchi-Vendhan+2023
arXiv:2310.03083

Paper in preparation…

Early, Massive Galaxies

with Marion Farcy[4], Michaela Hirschmann[4], and Francesco Valentino[5]

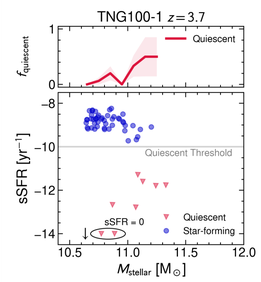
What suppresses their star formation so early in cosmic time?



Observations reveal the emergence of quiescent galaxies up to $z \sim 5$.

Theoretical studies may agree qualitatively, but our understanding of the physical processes behind these galaxies is still incomplete!

Quiescent vs. Star-forming Galaxies in IllustrisTNG at $z > 3$…

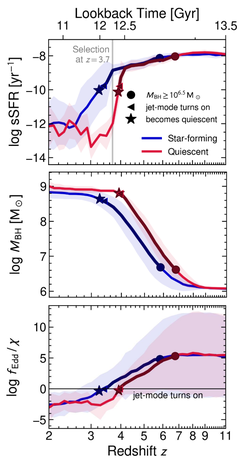


We study massive galaxies with $M_{stellar} > 10^{10.6}\ M_\odot$ and define quiescence as sSFR $< 10^{-10}\ yr^{-1}$.

For three samples from different simulation volumes and redshifts:
1. TNG100-1 $z = 3.7$
2. TNG100-1 $z = 3.0$
3. TNG300-1 $z = 3.7$

Findings are consistent across samples.

Possible Origins of Quiescent Galaxies: Internal and External Effects

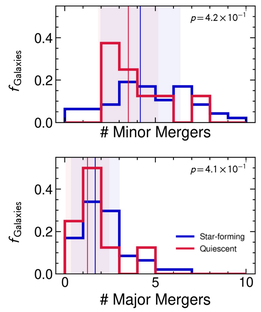


Compared to star-forming galaxies at the same time, quiescent galaxies:

1. AGN Feedback

…seed their SMBHs earlier, which grow faster.

…are exposed to kinetic-mode feedback for longer times.

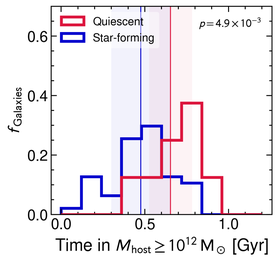


2. Mergers

…experience roughly the same number of mergers.

3. Environment

…spend more time residing in denser environments.



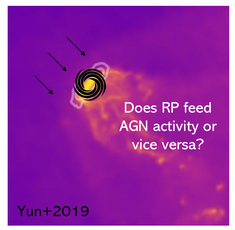
Environment likely contributes to SMBH growth.

Local, Satellite Galaxies

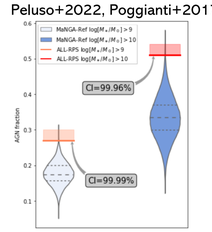
with Eric Rohr[3] and Annalisa Pillepich[3]

Is there a link between environmental effects and AGN feedback?

A significant fraction of ram-pressure stripped jellyfish are hosts of AGN.

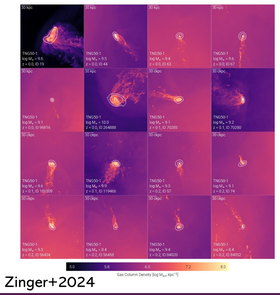


Peluso+2022, Poggianti+2017

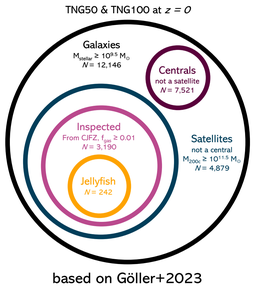


Jellyfish Galaxies in IllustrisTNG

"Cosmological Jellyfish" Zooniverse Project



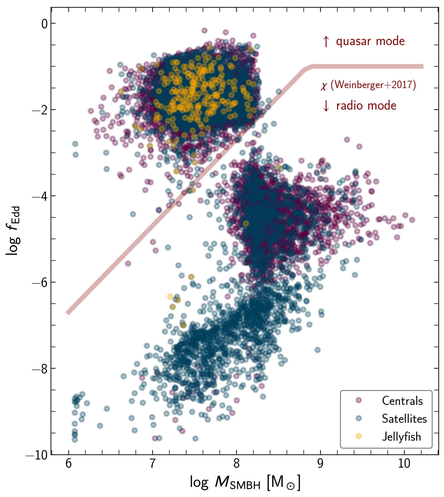
Zinger+2024



based on Göller+2023

Presence of SMBHs in TNG Jellyfish Galaxies

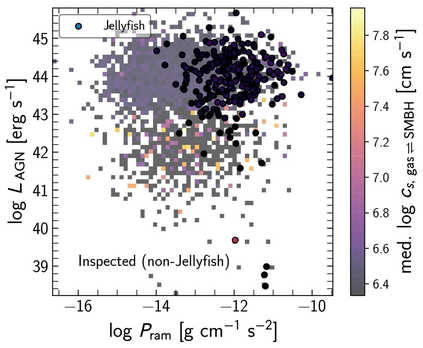
According to TNG, jellyfish have more luminous and highly-accreting SMBHs than centrals and satellites at the same mass.

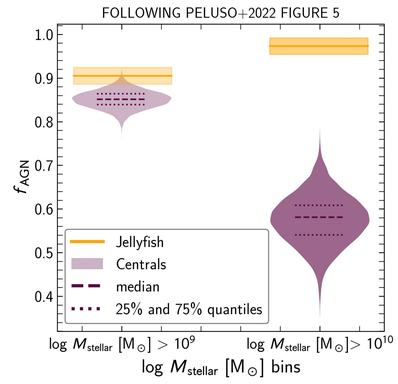


In the central regions of the jellyfish near the SMBH, the gas has higher pressures and densities, and lower sound speeds.

Leads to higher SMBH accretion rates.

Jellyfish have higher AGN fractions than centrals and satellites.





Closing the loop: *How does ram-pressure affect the gas in the centers of jellyfish?*

[1] Caltech [2] FULBRIGHT [3] [4] EPFL [5] DARK