DECOMPOSING THE DYNAMICS OF CIRCUMGALACTIC GAS WITHIN ASTROPHYSICAL SIMULATIONS

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Background

There exists a diffuse halo of gas surrounding the typical photogenic perception of a galaxy. Known more formally as the circumgalactic medium (CGM), the significance of this region is increasingly believed to play a critical role within the evolution of galaxies[1]. In this research, we demonstrate some of the characteristics of the CGM within both cosmological and idealized simulations to describe its presence and behavior. Cosmological simulations allow us to study the large-scale structure of a simulated universe to understand macroscopic intergalactic interactions while idealized simulations offer a more detailed perspective of a single evolving galaxy.

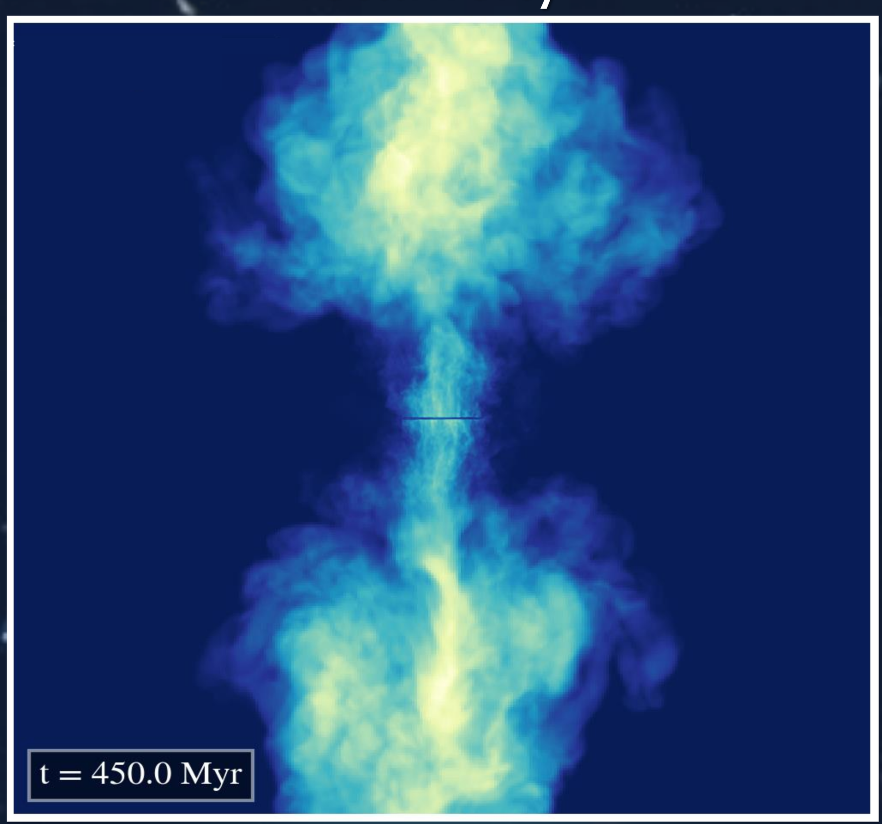
Methodology

- To generate our simulations we used Enzo[2], a multi-physics hydrodynamic simulation code.
- We conducted analysis of our simulations with yt[3], a python package enabling us to probe a myriad of our simulation's components including temperature, metallicity, density, and velocity profile.
- In order to view the velocity structure within sections of our cosmological simulations, the bulk velocity of the relevant region was subtracted to account for the holistic motion of the simulation.
- In separating the phases of our isolated galaxy, we derived filters to identify regions of outflow, inflow, and circumambient gas.

Observations

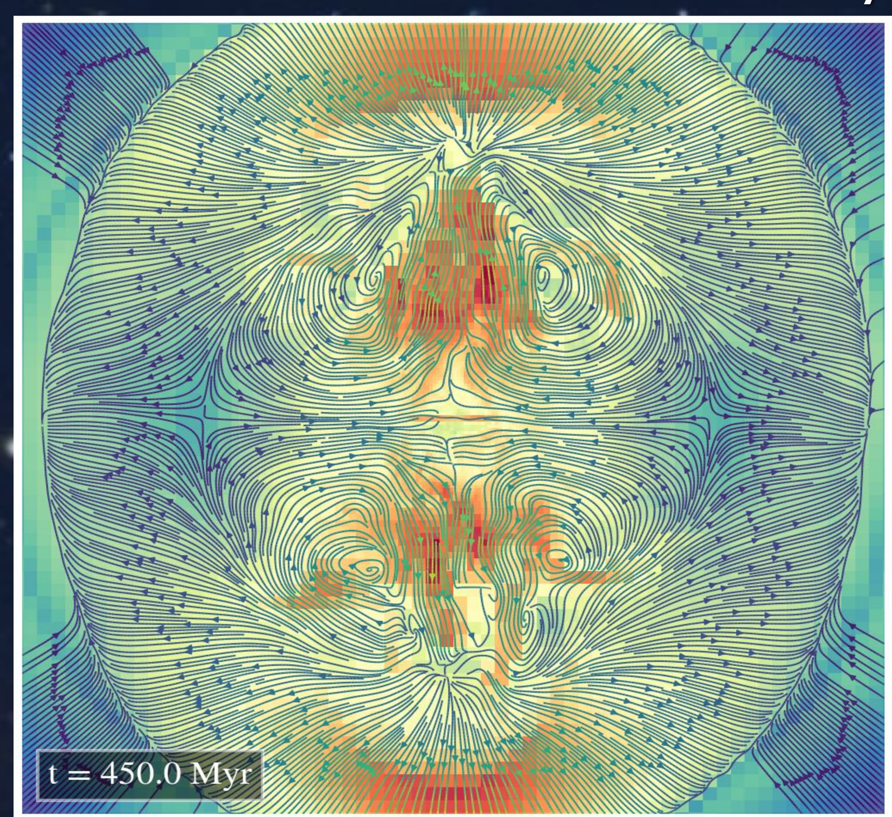
Idealized Simulations

Metallicity

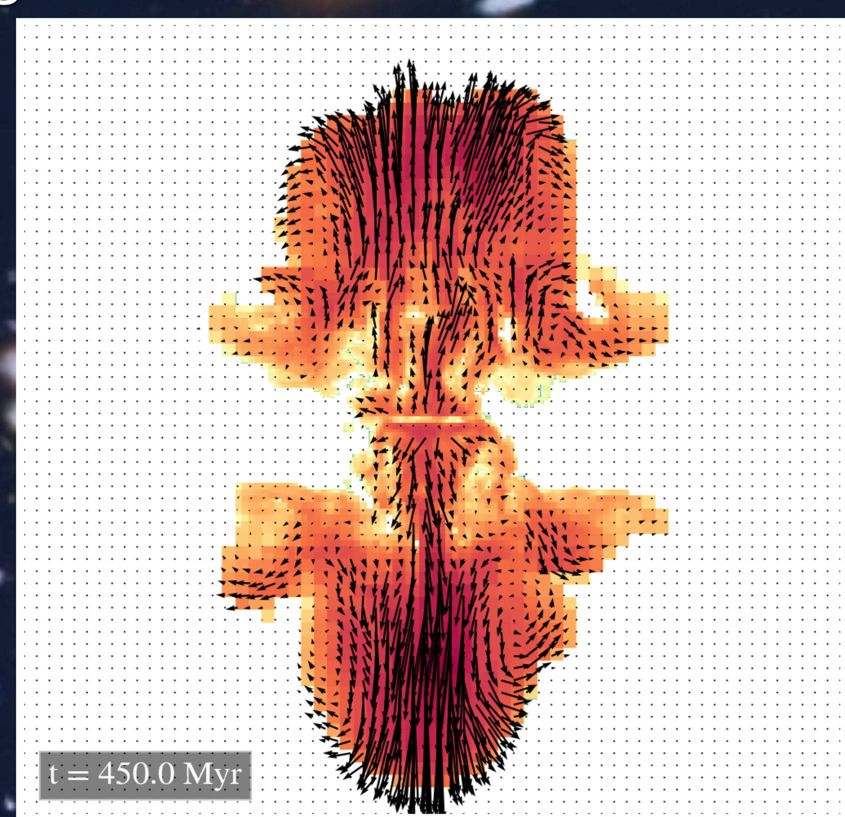


Metal-enriched outflows flaring from the disk of an isolated galaxy

Velocity Magnitude

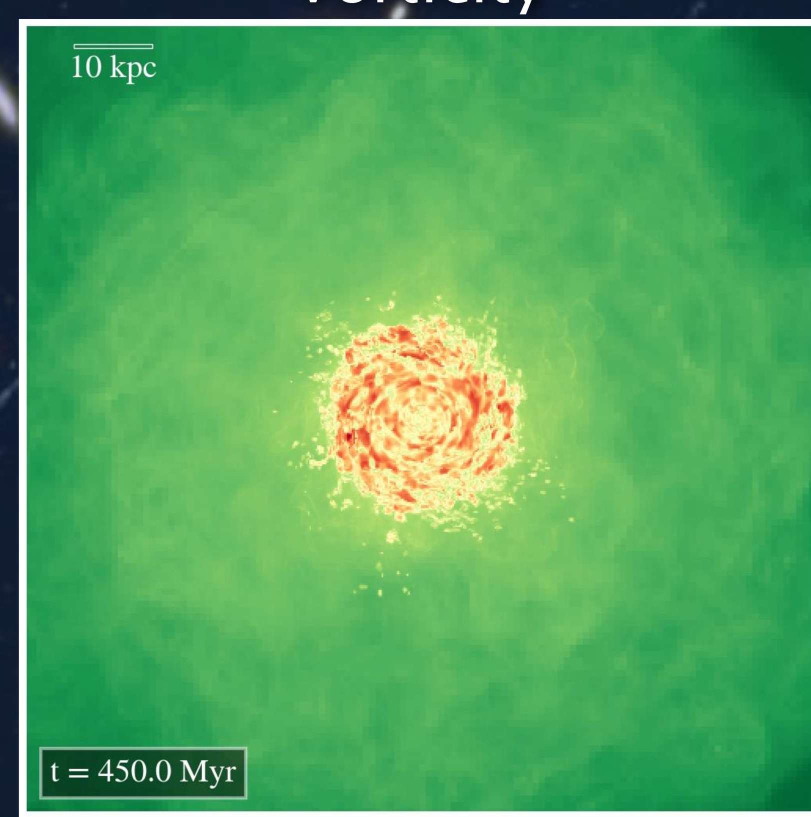


Annotated velocity of circumgalactic gas



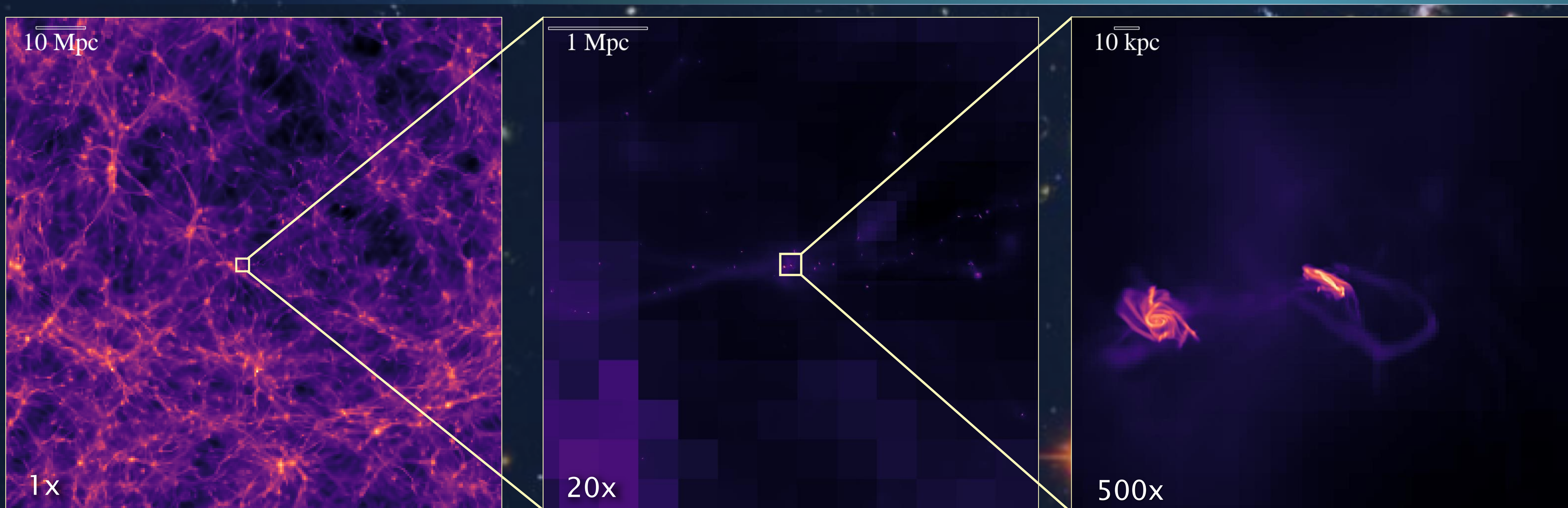
Outflow region composed of fast-moving, hot, and metal-rich gas

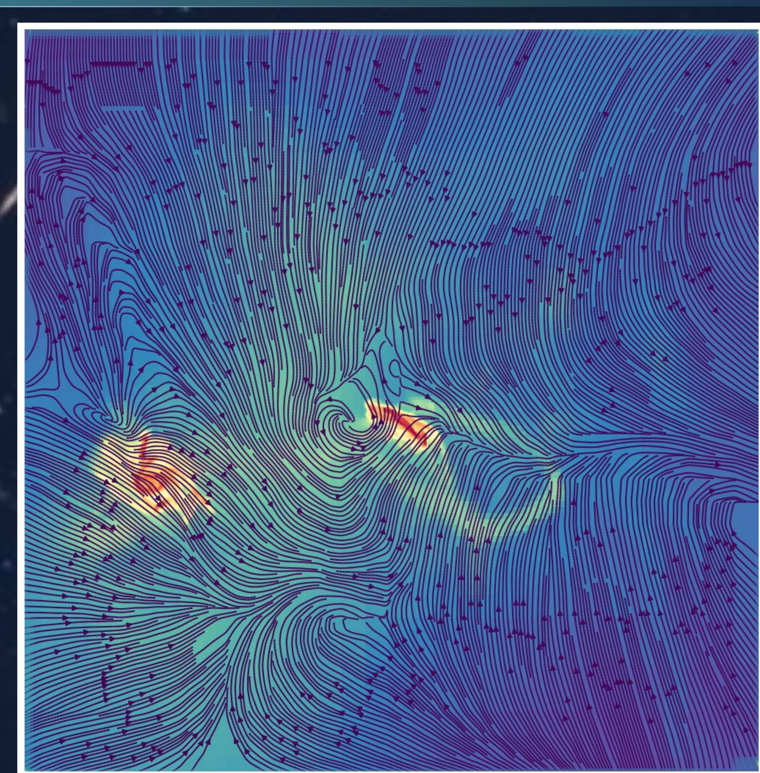
Vorticity



Overhead view along the z-axis detailing regions of turbulence

Cosmological Simulations





These filamentary structures are highways of great galactic density. Focusing on a high-resolution region, we see the merger of two galaxies underway and dissect the corresponding velocity profile of a slab along the region. Cosmological simulations offer a realistic rendition of the web-like architecture of our universe and further unveil the resulting interplay of dark matter and baryonic content.

Summary

In both our idealized and cosmological simulations, we observed the behavior and properties of the CGM to seek insight into real galactic regulation. While work remains to be done on calibrating the parameters of our simulations to best mimic characteristics of real galaxies, we nevertheless obtained a coherent analysis of the mechanisms of our tools and simulations. Future work might expand upon seeking correlation of differing CGM attributes with elements such as star formation or galactic quenching to more extensively evaluate the role performed by this influential shell of gas.

References

[1] Tumlinson, J.; Peeples, M.S.; Werk, J.K. 2017, ARA&A.
[2] Bryan, G.L.; et al. 2014, ApJS. 211:19. See enzo-project.org
[3] Turk, Matthew J.; et al. 2011, ApJS. 192:1. See yt-project.org

Background image courtesy of NASA and the Hubble Deep Field Team

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