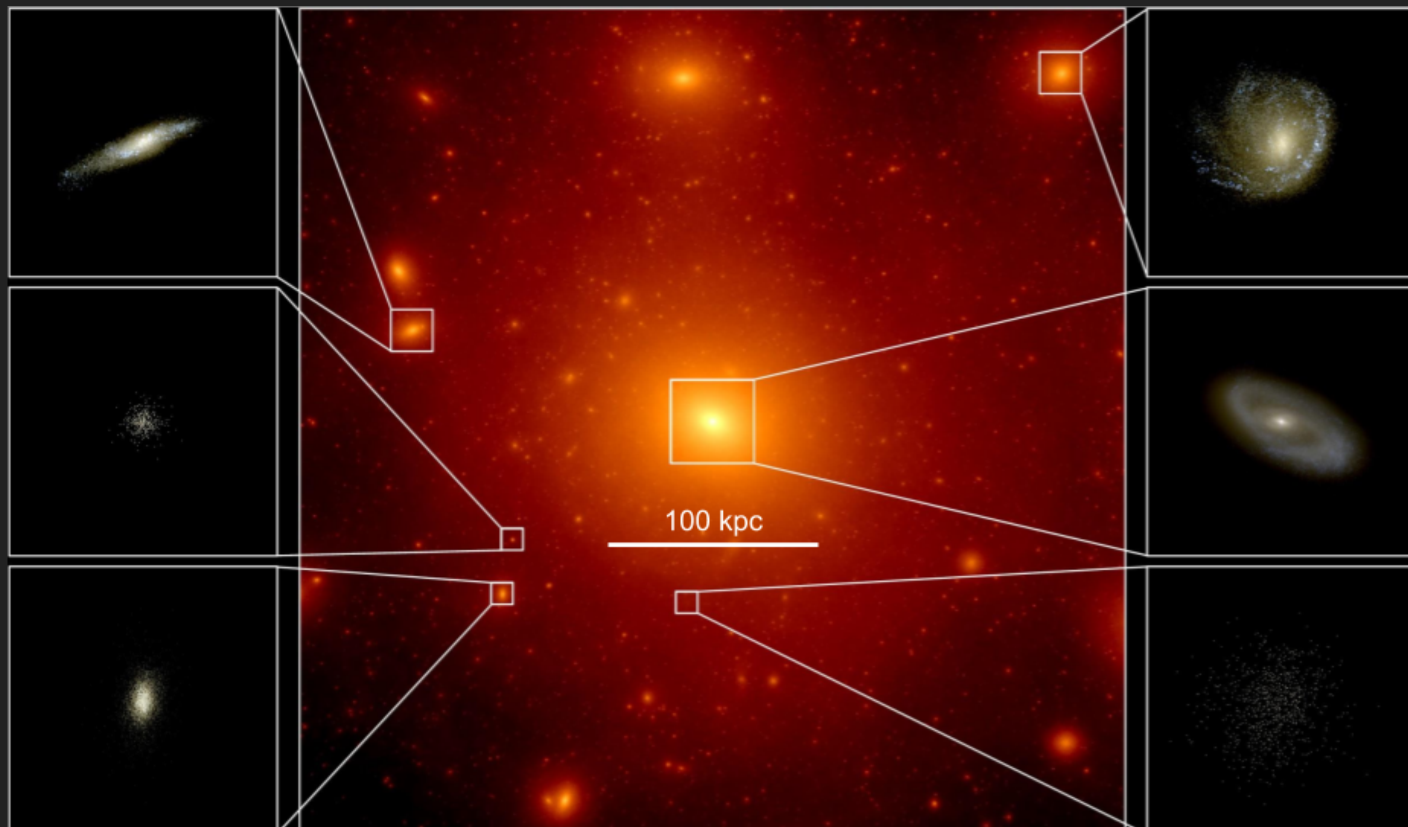
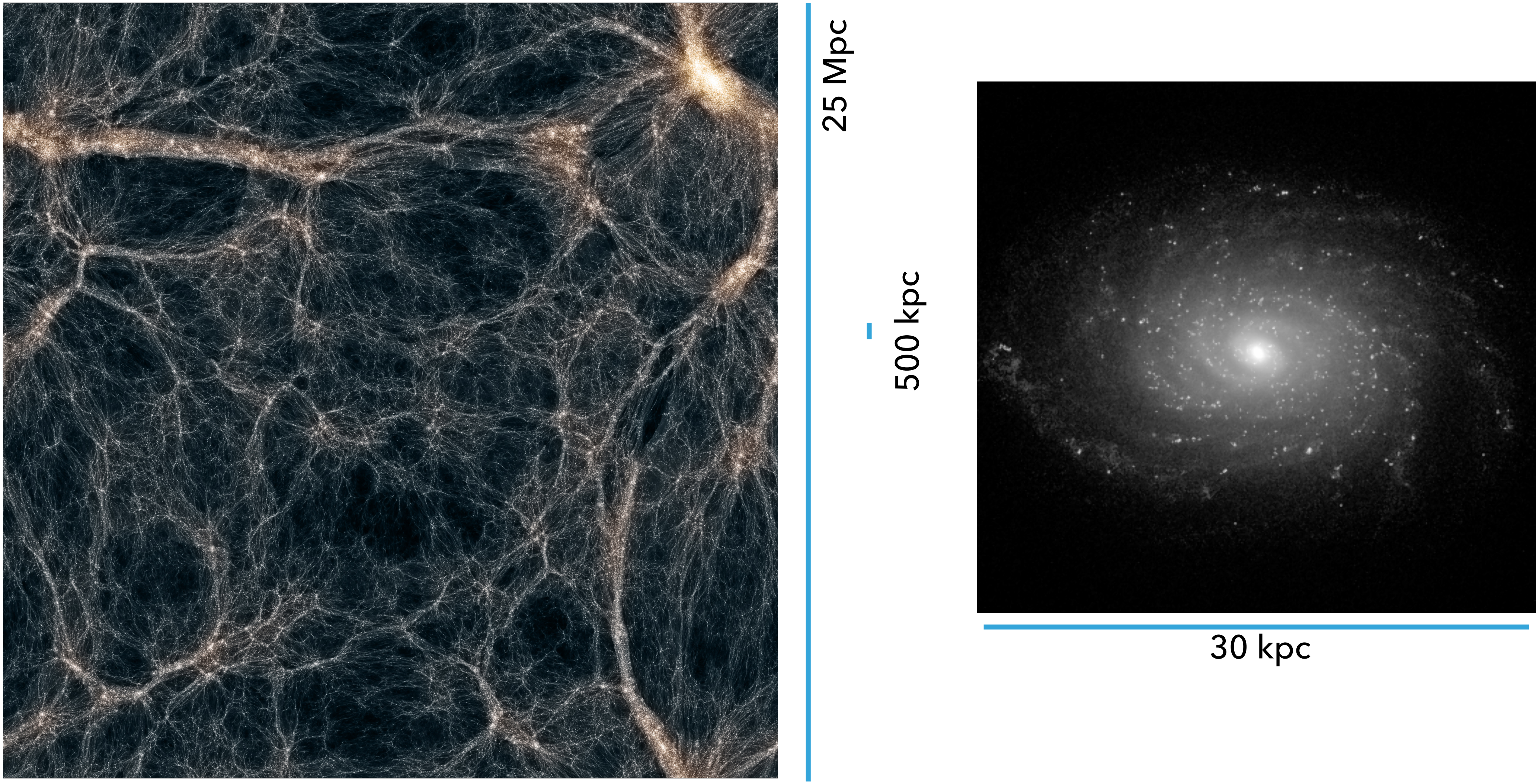


THE MILKY WAY GALAXY AT UNPRECEDENTED RESOLUTION

Alyson Brooks (Associate Professor,
Rutgers, the State University of New Jersey)

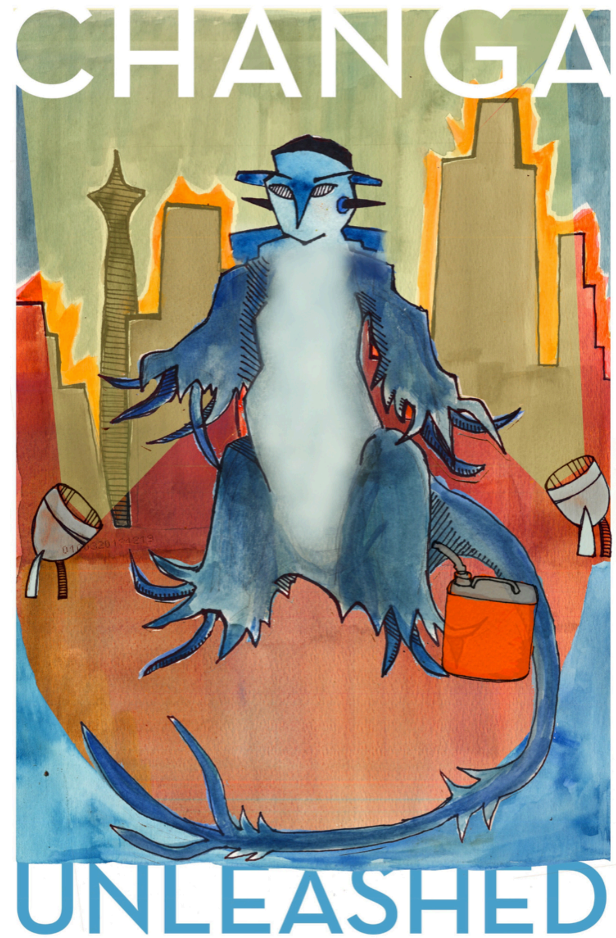
The Challenge: Enormous Dynamical Range



ChaNGa

https://github.com/N-BodyShop/changa

- written in parallel programming language Charm++
- N-Body Tree code for calculating gravity
- Smooth Particle Hydrodynamics to solve Euler equations for gas
- good scaling with highly clustered particle distributions due to
  - flexible domain decomposition
  - better scheduling to hide communication latency



ChaNGa

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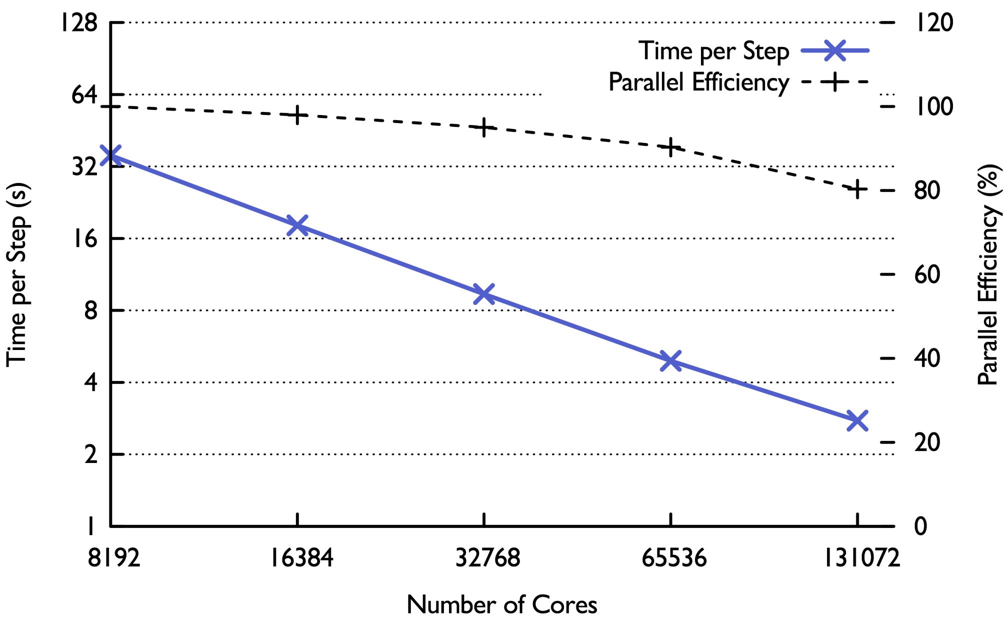
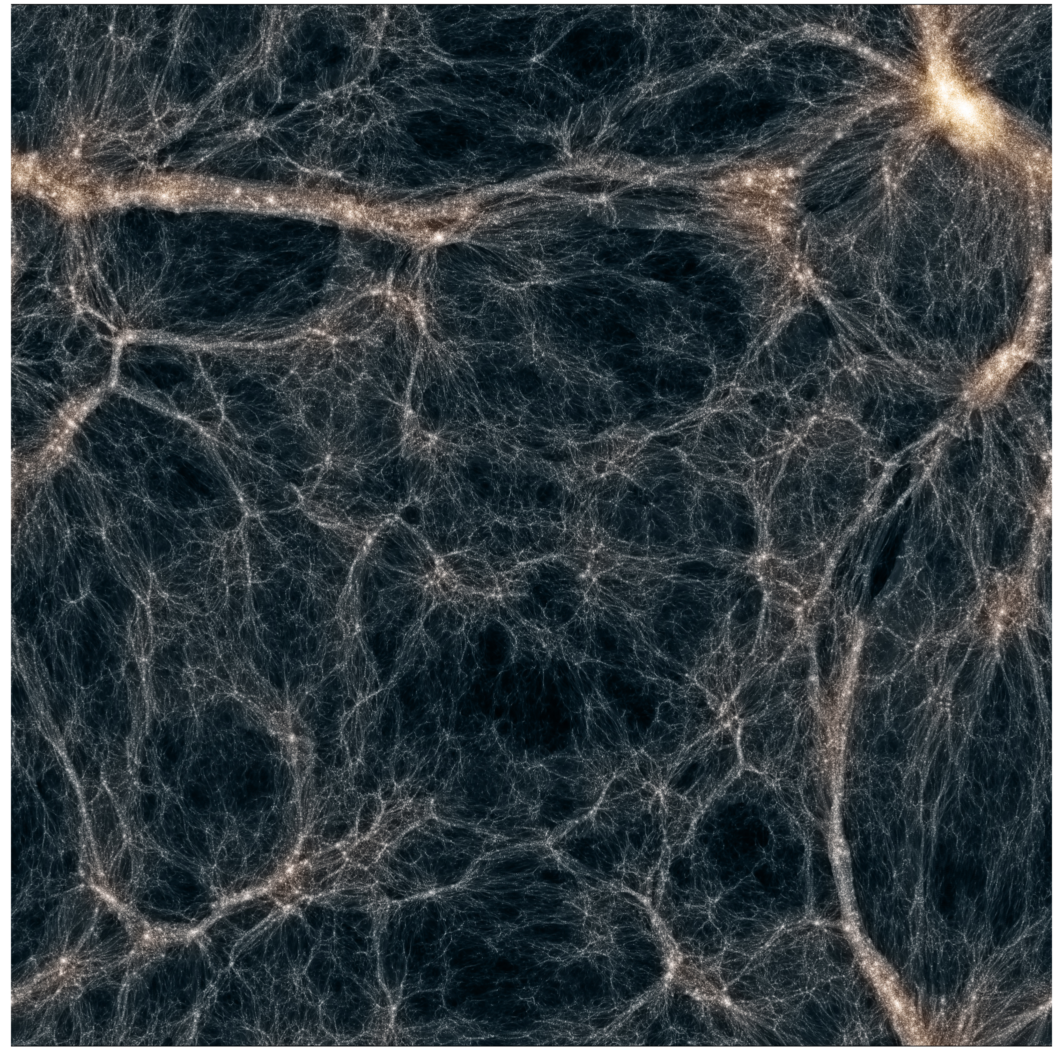


Menon et al. (2015), *Computational Astrophysics & Cosmology*, Vol. 2, p. 1 (using Blue Waters)



ChaNGa

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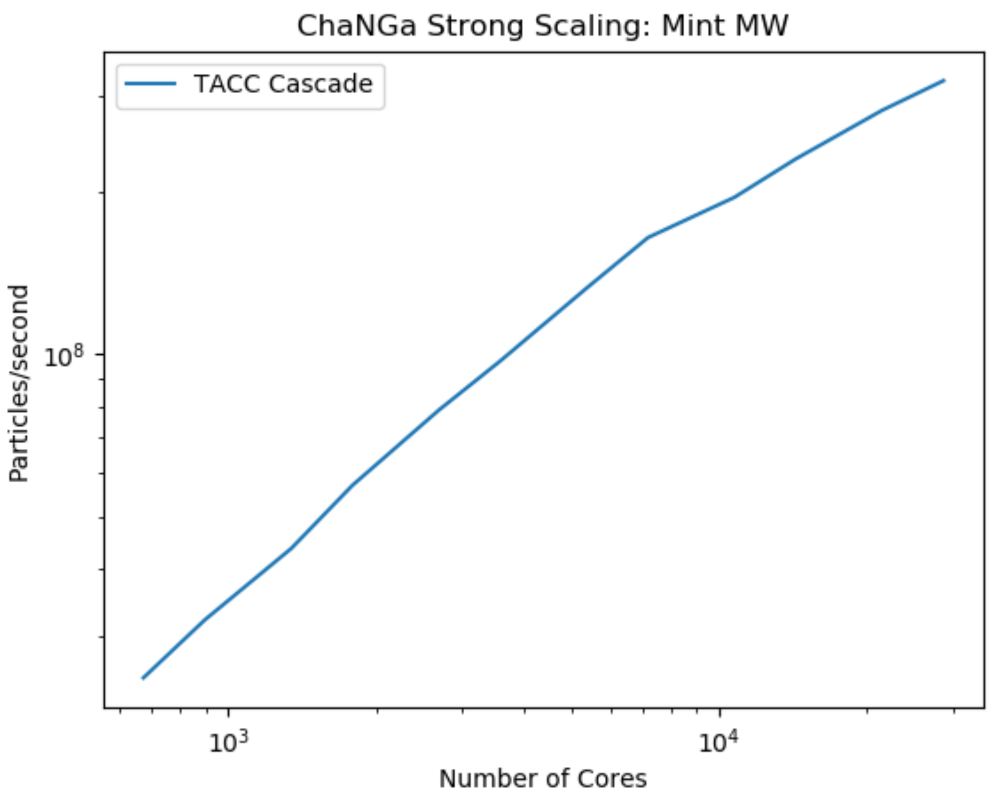
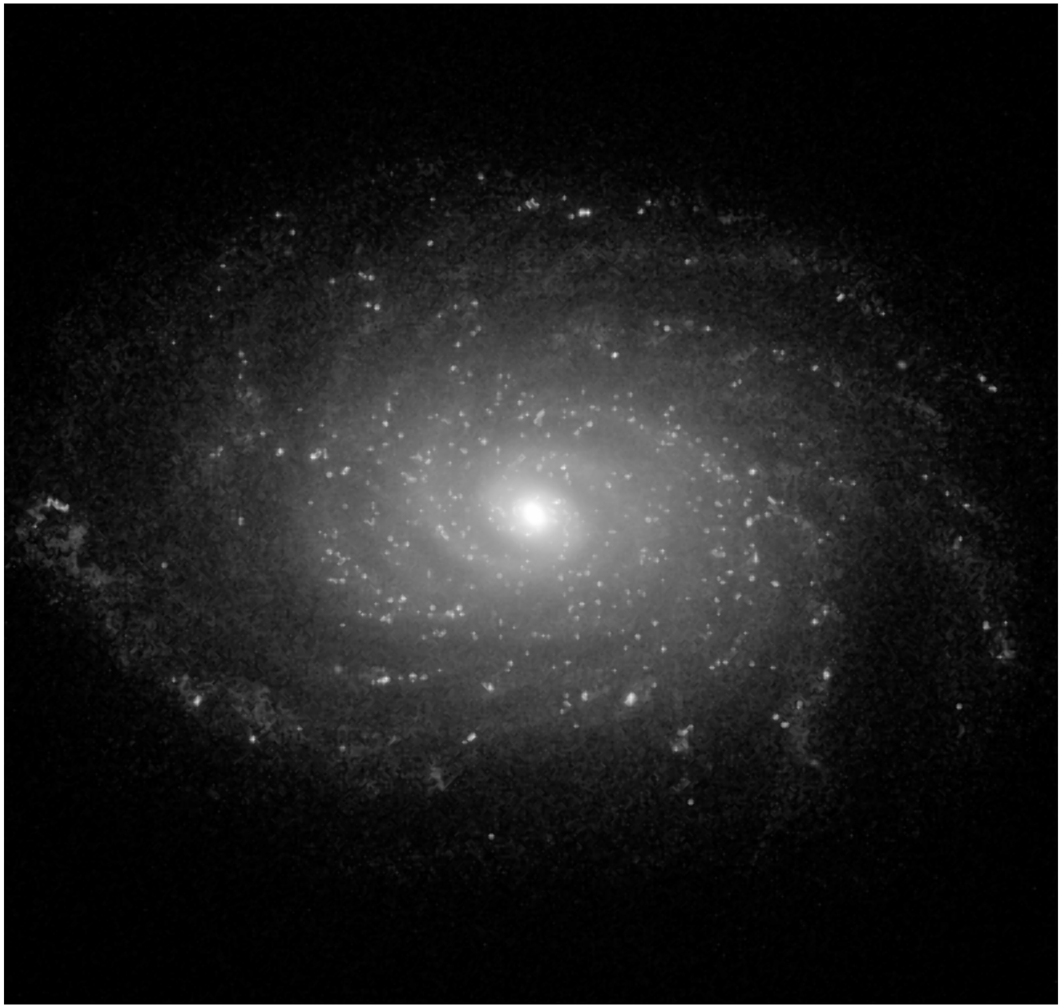
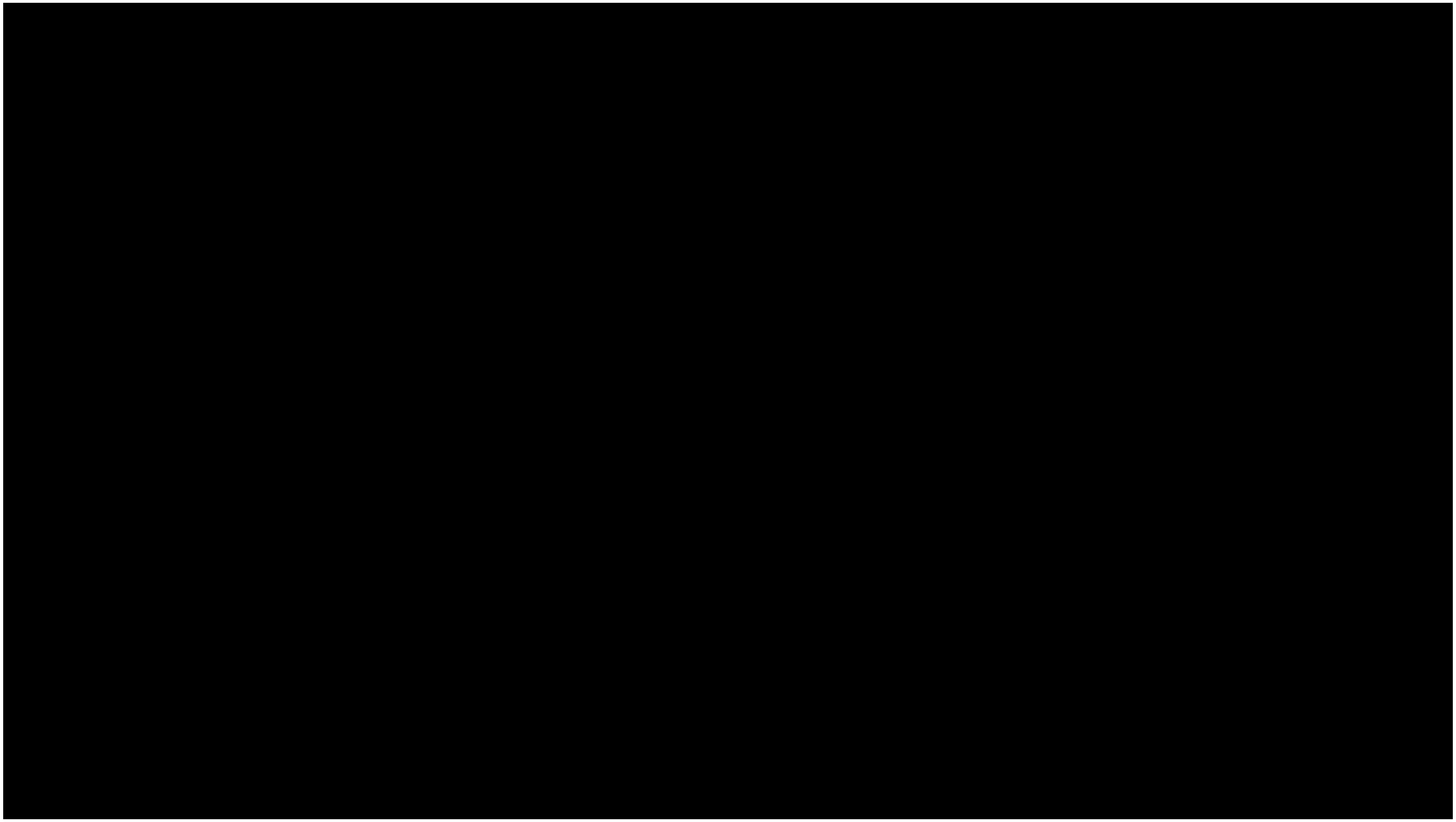




The Formation of the Stellar Halo

http://bit.ly/NBodyShop



stars only
(colored by amount of heavy elements)

Dwarf Satellite Neighbors

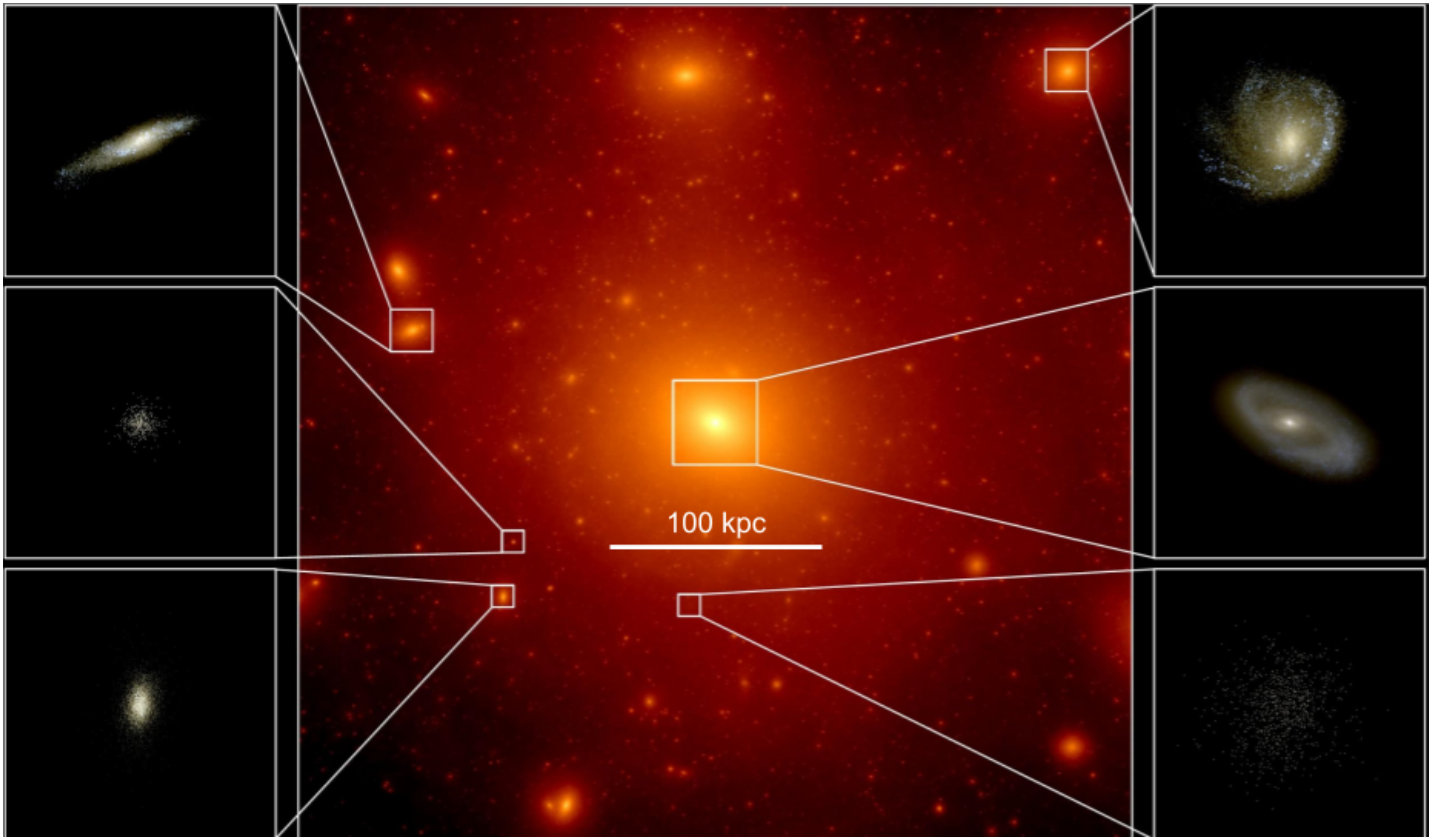
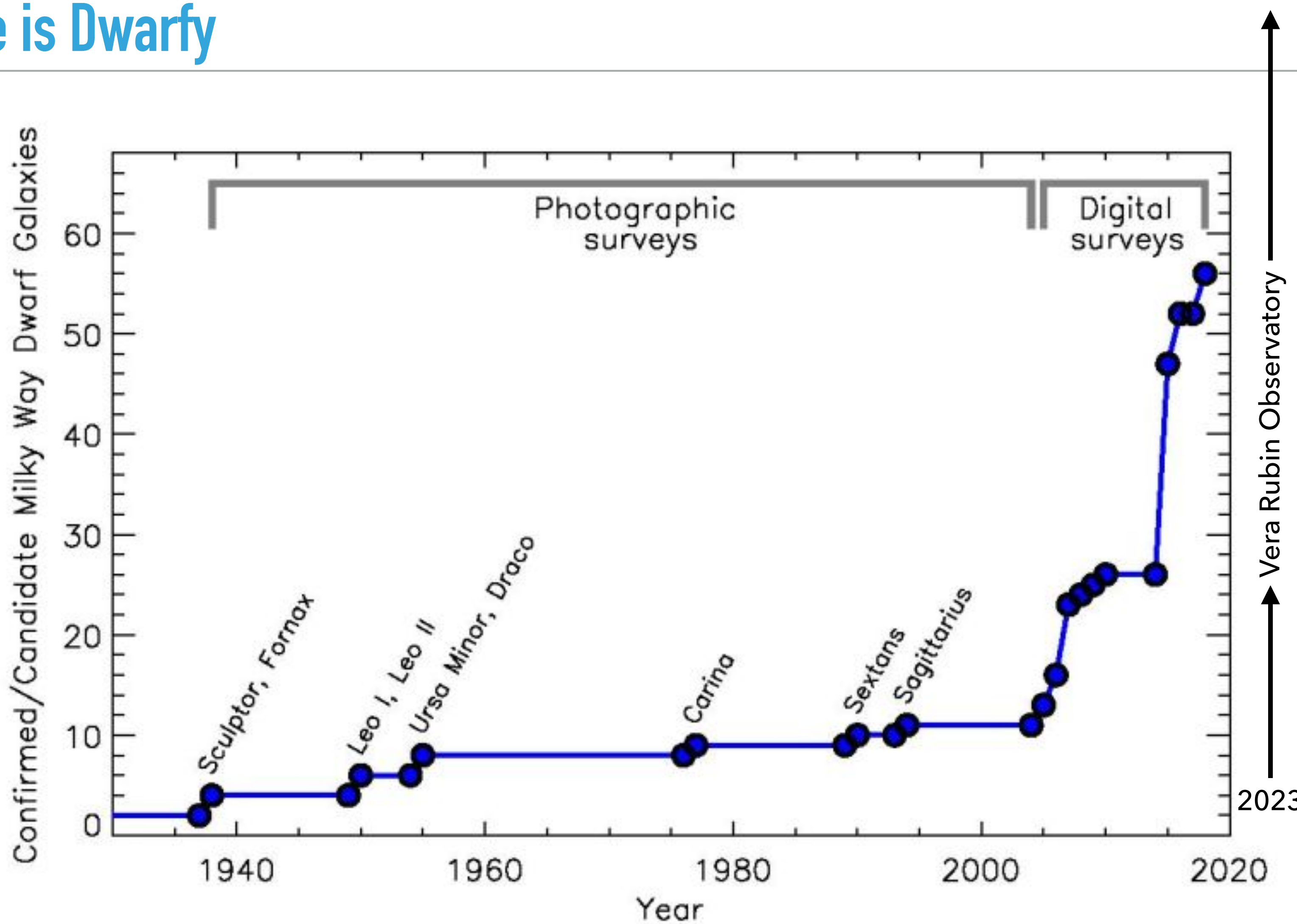


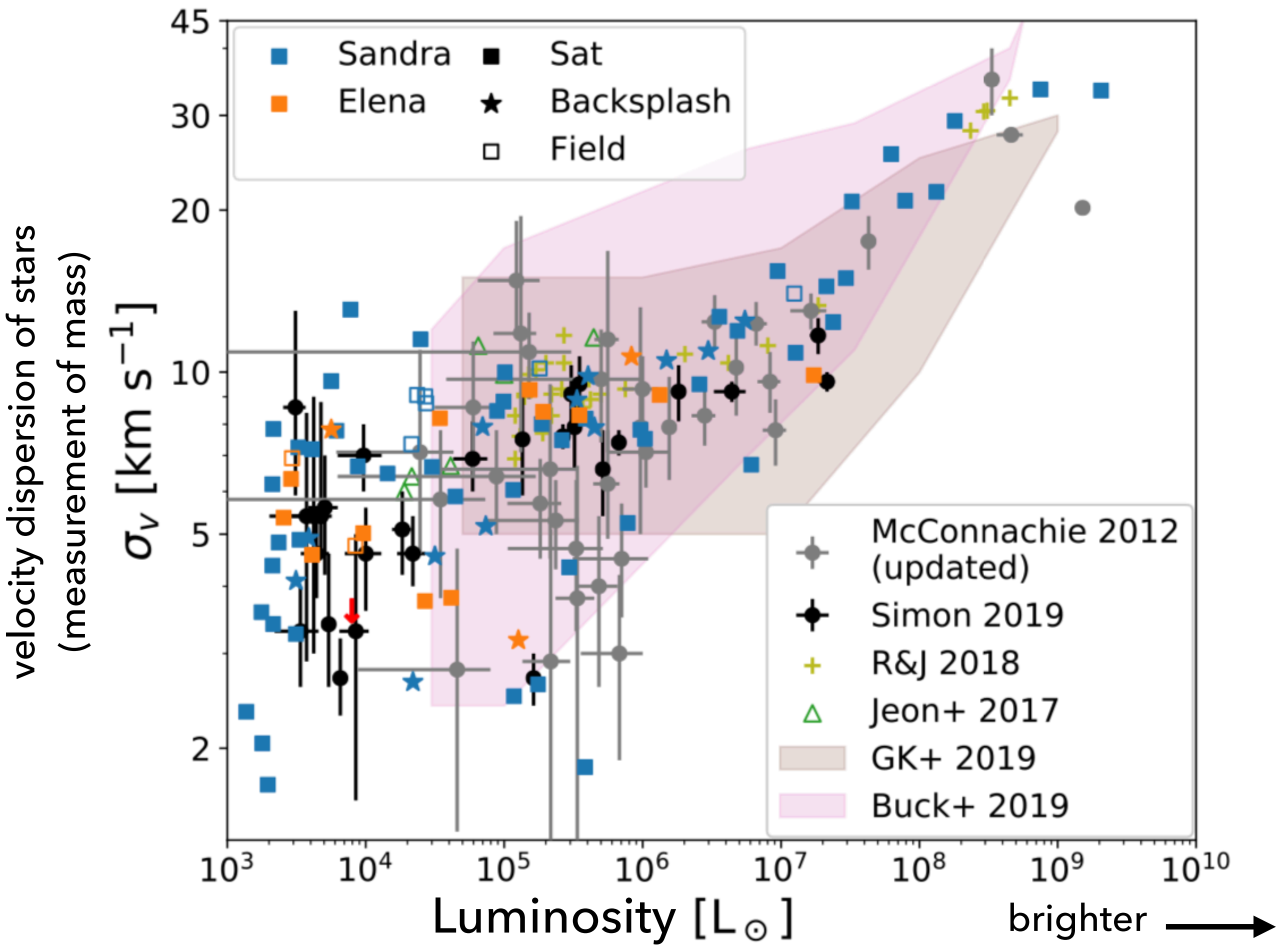
image credit: Elaad Applebaum

The Future is Dwarfy



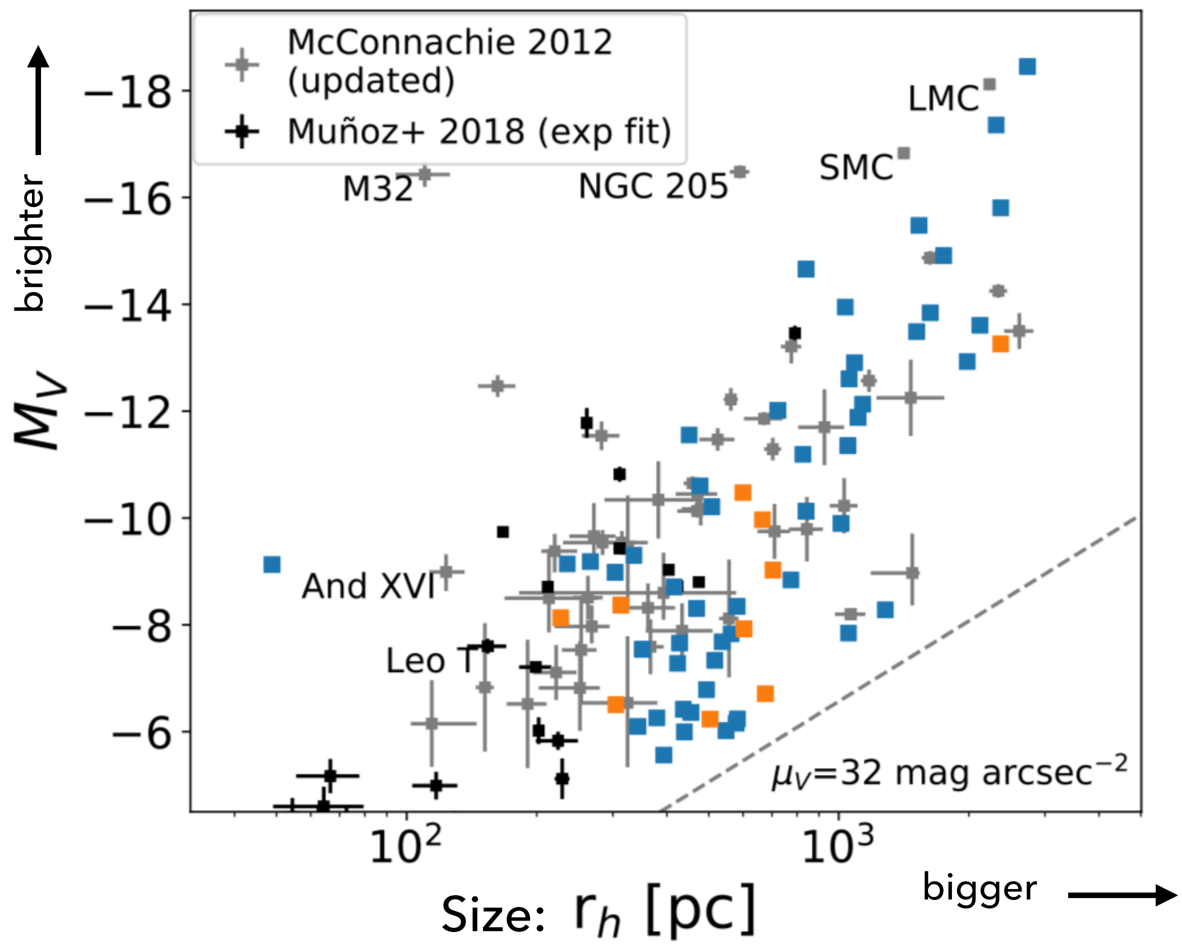
J. Simon, ARA&A (2019)

The First Simulation to Reproduce the Full Diversity of Dwarf Galaxies



Applebaum, Brooks, et al., 2021, The Astrophysical Journal, Vol. 906, p. 96, arXiv: 2008.11207

The First Simulation to Reproduce the Full Diversity of Dwarf Galaxies



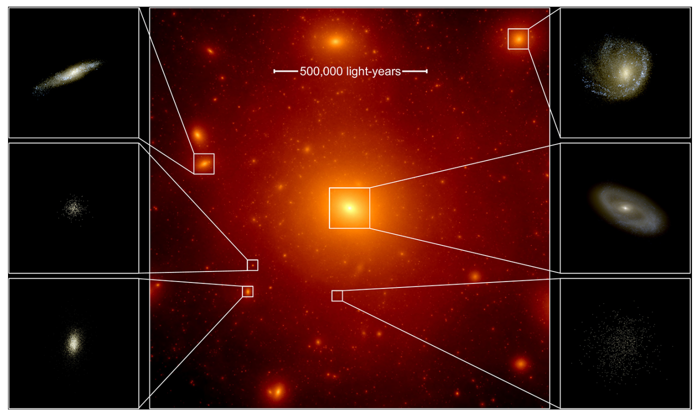
Applebaum, Brooks, et al., 2021, The Astrophysical Journal, Vol. 906, p. 96, arXiv: 2008.11207 https://www.tacc.utexas.edu/-/galaxy-simulations-could-help-reveal-origins-of-milky-way

TACC Press Release

GALAXY SIMULATIONS COULD HELP REVEAL ORIGINS OF MILKY WAY

TACC's Frontera supercomputer aids the search for dark matter in the universe

Published on September 23, 2020 by Todd Bates, Rutgers / Faith Singer-Villalobos, TACC



Computer simulation of a galaxy resembling the Milky Way (center) and its small (dwarf) galaxy neighbors. The center panel shows the amount of dark matter (brighter is denser). The small panels show what a telescope might see. The research was funded by the National Science Foundation. Image credit: Elaad Applebaum.

Rutgers University astronomers have produced the most advanced galaxy simulations of their kind, which could help reveal the origins of the Milky Way and dozens of small neighboring dwarf galaxies.

Their research also could aid the decades-old search for dark matter, which fills an estimated 27 percent of the universe. And the computer simulations of "ultra-faint" dwarf galaxies could help shed light on how the first stars formed in the universe.

"Our supercomputer-generated simulations provide the highest-ever resolution of a Milky Way-type galaxy," said co-author Alyson M. Brooks, an associate professor in the Department of Physics and Astronomy in the School of Arts and Sciences at Rutgers University–New Brunswick.

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- Multimedia (https://www.tacc.utexas.edu/news/multimedia)
- TACC In The News (https://www.tacc.utexas.edu/news/tacc-in-the-news)

STORY HIGHLIGHTS

Rutgers University astronomers have produced the most advanced galaxy simulations of their kind, which could help reveal the origins of the Milky Way and dozens of small neighboring dwarf galaxies.

Their research also could aid the decades-old search for dark matter, which fills an estimated 27 percent of the universe. And the computer simulations of "ultra-faint" dwarf galaxies could help shed light on how the first stars formed in the universe.

According to one of the lead scientists, the Frontera supercomputer at TACC is the fastest system she has ever used and allows her team to take advantage of up to thousands of nodes on supercomputers.

The Rutgers-led team generated two new simulations of Milky Way-type galaxies and their surroundings. They call

Conclusions

- To understand the diversity of observed galaxies, we must be able to simulate their full environment.
- This allows us to make predictions for upcoming astronomical surveys, like the Vera Rubin Telescope's Legacy Survey of Space & Time (LSST).
- Simulating scales from ultra-faint dwarfs to Milky Way galaxies is computationally challenging! These are the first simulations to ever do it.
- Ongoing: LRAC to examine new Milky Way-like galaxy with modified initial conditions to run controlled experiments ("genetic modification').