Simulating the Universe on a Supercomputer

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Questions in cosmology:

• What is the nature of the universe and what is it made of?

• What are matter, energy, space, and time?

• How did we get here and where are we going?
As we begin the 21st century

The matter–energy composition of our universe

- Dark Energy: 74%
- Dark Matter: 22%
- Atoms: 4%
What happens to these fluctuations as the universe evolves?
Fluctuations amplifier: Gravity

- Fluctuations grow through **gravitational instability**
  - **Regions with a higher density** than the mean \((\rho > \langle \rho \rangle)\) will exert a greater gravitational pull on the surrounding matter, and so attract it. **They will then become even denser** \((\rho \text{ increases})\)
  - **Regions with less density** than the mean will lose matter to the denser regions, and so become even less dense \((\rho \text{ decreases})\)
Cosmological simulations

Well-specified initial conditions: inflation and components

Physics:
Gravity
Hydrodynamics
Radiative processes
Star formation
Black holes
10^{13}

65000 cores

at TACC - Ranger

Kraken – Cray XT5
100000 cores
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