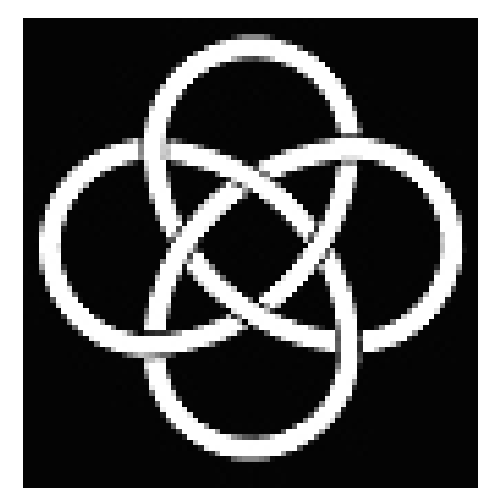


# Gravitational clustering of matter in the Universe



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## Gravitational clustering

- Gravity is the most powerful force in the Universe at very large scales. All the objects in the Universe interact with each other by gravitational attraction.
- If we assume a perfectly uniform distribution of matter then it will remain so forever (see the top three panels in Figure 1). This is because gravitational pull on every object due to other objects will be equal from all directions.
- However, if there are some over-dense regions, matter in the neighborhood of these regions will fall towards the over-dense regions (see the bottom three panels in Figure 1).
- It is believed that the galaxies, clusters of galaxies and other structures which we see in the Universe, formed due to gravitational clustering of matter.

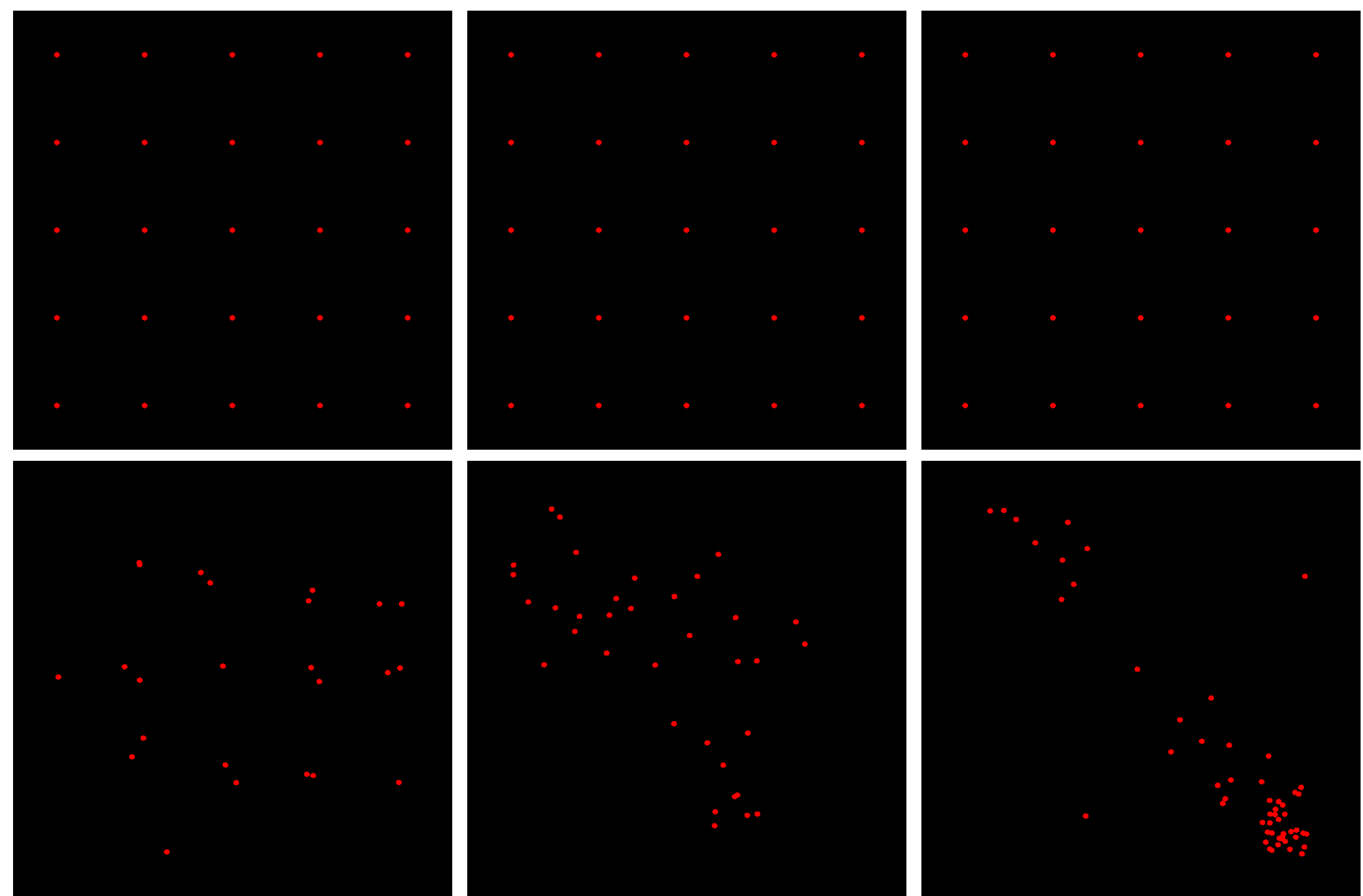


Figure 1: This figure shows gravitational clustering in a homogeneous (top three panels) and inhomogeneous (bottom three panels) distribution of matter.

## Evolution of structures due to gravitational clustering in a cosmological N-body simulation

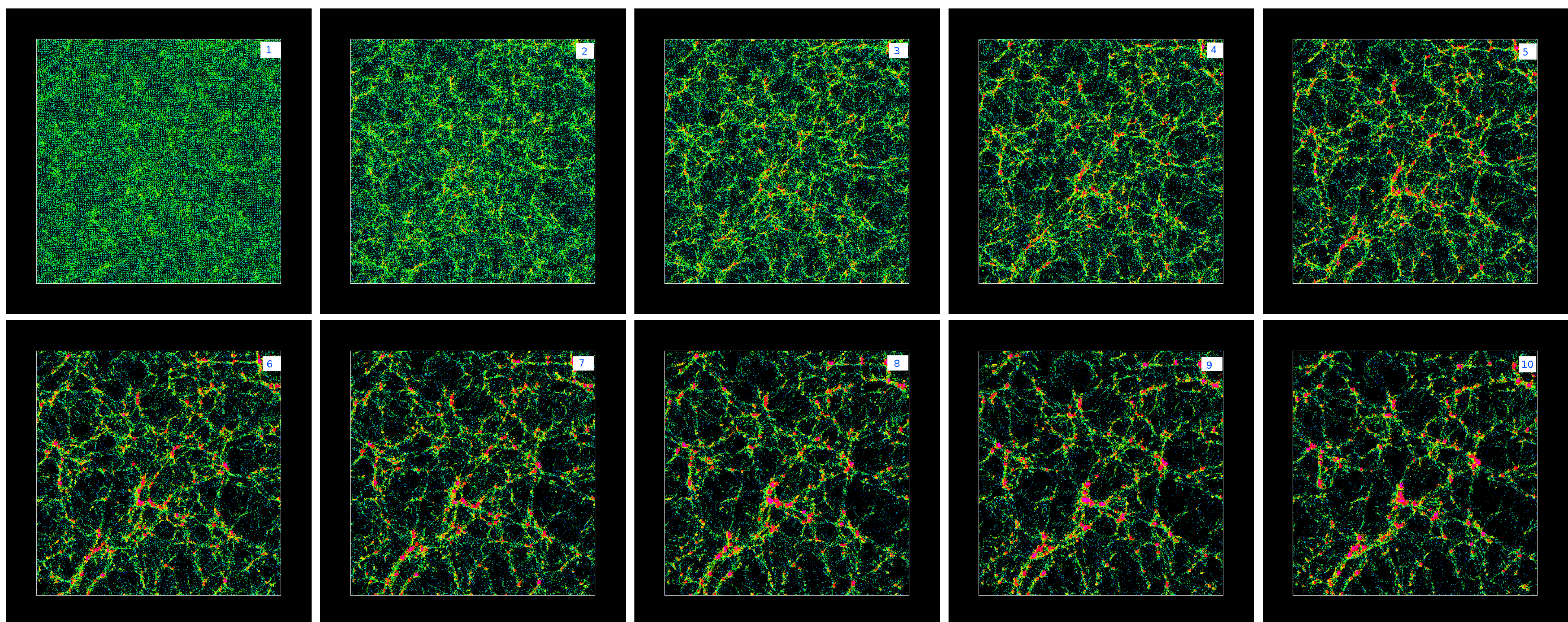
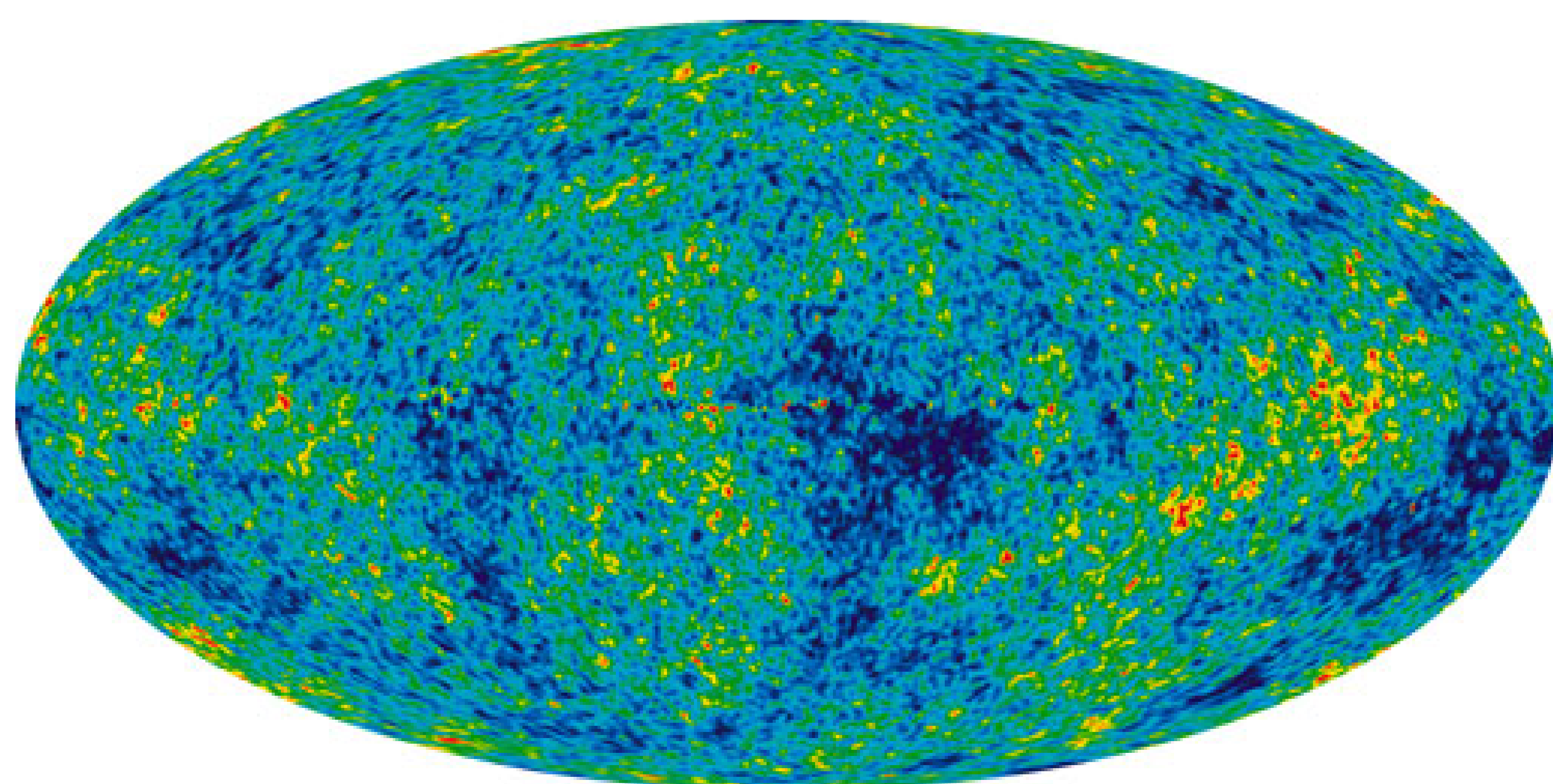


Figure 2: In a cosmological N-body simulation a large number of particles, which represent matter in the Universe, move due to mutual gravitational attraction. The panels in the above figure show the positions of particles at different epochs (see the number at the top right corner).

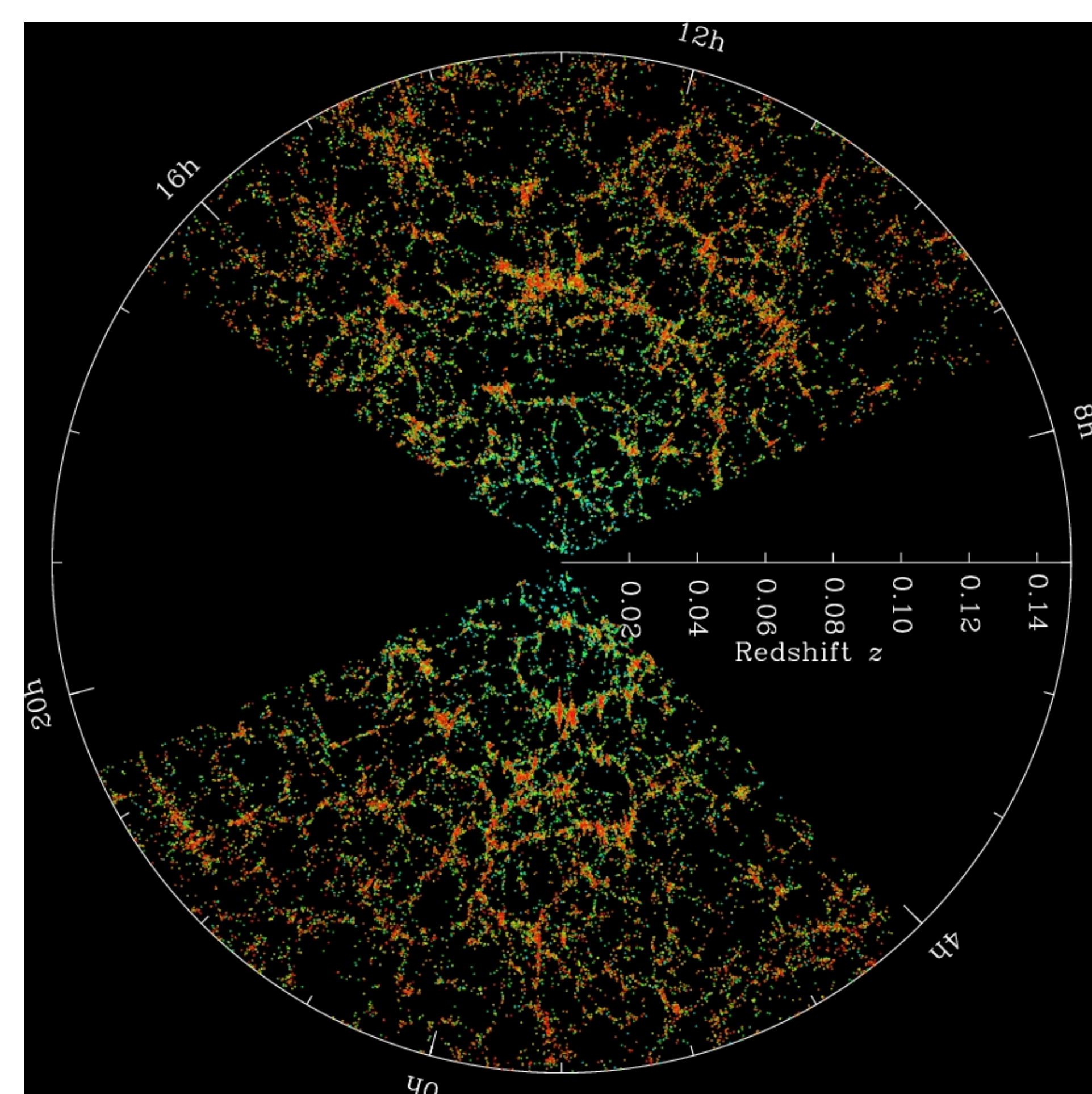
## Temperature fluctuations in the Cosmic Microwave Background (CMBR) sky as observed by the WAMP satellite



Courtesy : <http://wmap.gsfc.nasa.gov/>

Figure 3: Galaxies and other structures in the Universe as observed in the Sloan digital sky survey (right panel) formed due to gravitational amplifications of the primordial density fluctuations, which are observed as temperature fluctuations in the CMBR sky.

## Distribution of galaxies in the Sloan Digital Sky Survey



Courtesy : <http://www.sdss.org/>