Assignment 1

The Cosmic Web

When trying to untangle the mysteries of the Universe we live in, we assume that our place in it is not special: from wherever in space you are, the picture is the same. Even more so, the pictures has to be the same in all directions no matter where you are looking from. On scales large enough, the universe is therefore **homogeneous** and **isotropic**. We call this the ***Cosmological Principle***.

On smaller scales, however, the density of matter that the Universe contains is very much **not** homogeneous: there is structure that resembles a spider web, made of objects called voids, filaments, walls and nodes which make up ***the Cosmic Web***. These objects are not stationary: they evolve in time with the mass elements that make them up flowing from one structure type to another.

Mass elements in the Cosmic Web

In this project my job will be to use the Illustris simulation of the Cosmic Web to assess the movement of individual mass elements in the cosmic structure in time: I will be looking at mass elements in the various types of objects and following them from a redshift value of $z = 127$ to today at redshift value $z = 0$. The prediction is that they follow **anisotropic collapse** theory, which says that there is a direction of flow: first mass outflows from less dense regions (voids) into the walls that border them, then into nearby strings/filaments and finally towards the endpoints of these filaments (nodes).

Timeline

Research (April 23 - June 25)

In this period I will read relevant papers and resources, learn about the NEXUS and Illustris tool to help me carry out the research.

Key moments

- Draft report handing in (June 14)
- feedback provided by supervisor (June 21)
- final report hand-in (June 28)
- Symposium (July 4)

paper by M. Cautun et al. on Cosmic Web evolution Rien **recommended two pages 2948 - 2950**

This essential piece of work highlights the main ideas in mass transport across the cosmic web. According to **gravitational instability theory** overdense regions collapse along the directions of the largest eigenvalues of their deformation tensor, giving rise to cosmic pancakes. For structures with secodnary and tertiary positive deformation tensor eigenvalues, the second and third dimension contract, giving rise to filament and fully collapse objects respectively. Most of the mass follows this prediction, however, the authors find that sizeable fractions of mass components flow in the opposite 'direction' (ex from wall to void). These are actually from underdense regions, which are harder to classify/identify. A quantitative measure of mass transport for individual mass items is given. Further, using the velocity field of the particles, which is the mechanism responsible for mass flow on large scales, offers conclusive proof that the mass travelling in the 'wrong' direction is nothing but an artefact of the cosmic web identification methods.