CREATING GALAXIES IN A VIRTUAL UNIVERSE

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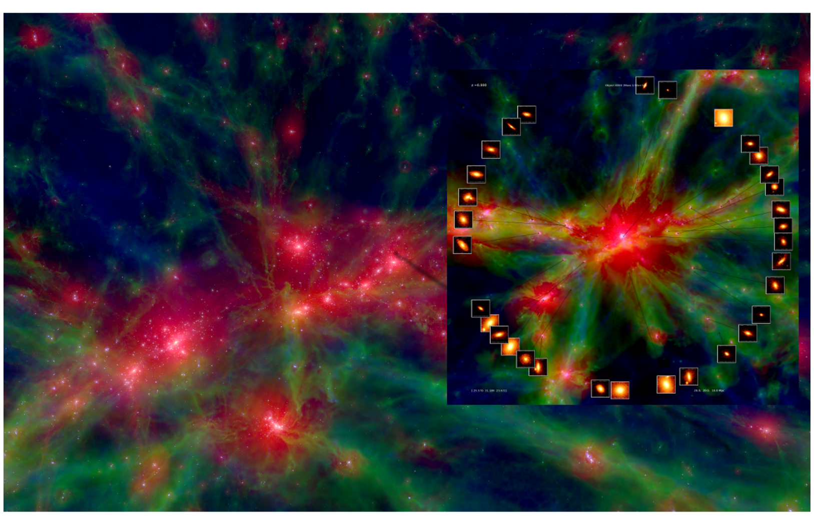
Description:

Imagine being able to create a virtual the Universe, complete with realistic galaxies and quasars, inside a computer. The EAGLE project aims to do exactly this. The first phase of the project make a ground-breaking step, creating a virtual Universe in which the masses and sizes of the galaxies formed compared well with observations. This creates a 'laboratory' with which we can experiment with galaxy formation, quantifying the roles of the physical processes such as gas cooling, metal enrichment and feedback from stars and black holes. The current EAGLE simulations are, however, limited in two respects. Firstly the simulations only marginally resolve galaxies, making it hard to reliably study the internal structure of the galaxies (such as their Hubble-type and morphology). Secondly the simulations have relatively small volume, sufficient to understand the average properties of galaxies, but not to understand the diversity of the galaxy population. A larger volume simulation would also break new grownd in using galaxies to test theoretical models for the growth of cosmic structure and to search for deviations from Einstein gravity. In this project, the student will join the Eagle team in advancing to the next level of realism and volume.

- Increasing the resolution of the simulations will allow us to understand the origin of galaxy's structural properties, such as Hubble's famous 'tuning-fork', and to identify the key processes that are involved in this. This will lead to a deeper understanding of the diversity of galaxy shapes and sizes; of the processes that regulate star formation and black hole growth. The aim of the project is to quantitatively compare the outputs of the simulation with observational programmes such as MANGA, SAMI and KROSS that measure the evolution of galaxy structure and dynamic over cosmic time, and to compare to galaxies seen through their gas content with ALMA and the future square kilometer radio telescope, SKA.
- Increasing the volume of the simulation will allows us to: (1) identify statistical samples of rare (and bright) objects this is critical since these are the only objects that can be detected in the distant Universe and to understand the origin of the diversity of galaxy properties; and (2) to trace the gravitational structure of the Universe on large scales galaxies, making it possible to test cosmological models and search for departures from Einsteins theory of gravity.

The student needs to have good computational skills, as the project will involve developing physics modules within the new SWIFT cosmological code, and good analytical and physics skills in order to understand the outcome of the simulations. A few useful links are given below.
• The Eagle Project pages (http://icc.dur.ac.uk/Eagle/)
• A paper summarising the first phase of the Eagle project (http://adsabs.harvard.edu/abs/2015MNRAS.446..521S)
• A first step towards understanding the diversity of galaxies (http://adsabs.harvard.edu/abs/2016arXiv160707445B)



The complex large-scale structure of the Universe as traced by dark matter, gas and galaxies. The upper half of the figure emphasises the gravitational structures built by the collapsing dark matter. These trap the diffuse gas (baryons) which is then able to cool and collapse to form stars. The lower half shows the diffuse baryons, with the colours reflecting the gas temperature (blue/cool to red/hot). Yellow/white colours highlight galaxies. Seen on this scale (100 Mpc across) galaxies appear almost point-like. The inset panel zooms in on the a single halo and shows some of the galaxies within it.

Notes: