Student questions: Arif Babul colloquium on "Galaxy Clusters as Cosmological Probes?"
2/14/18

Question 1: Can cluster formations ever stop?

The formation of galaxy clusters cannot be understood in isolation from the formation of cosmic structure, in general. That's because in any given region of space, the smallest galaxies form first; these merger to form bigger galaxies, which in turn merge to form galaxy groups and so on. Galaxy clusters are the most recent objects to have formed. We are already seeing some clusters merging together to form even bigger objects - known as superclusters.

Had I been asked this question 15 years ago, I would have said: No…there will always be galaxies merging to form groups; groups merging to form clusters, and clusters merging to form superclusters.

But today, we know that the Universe is starting to expand faster and faster. This means that there is a competition between gravity that wants to pull things together (and build structures like clusters) and Hubble expansion that is moving objects apart. At some point, the expansion will start winning and the formation of clusters will cease.

Question 2: What distinguishes a high vs. low omega universe?

I am finding this a hard question to interpret. If you are asking me what makes one universe high omega and another low omega, the answer is the amount of total mass-energy in the universe. A universe it lots of matter will be a higher omega universe.

If you are asking what are the properties of a high vs. low omega universe, then there are several different properties. For one, a high omega universe expands much less rapidly if the mass-energy is mostly made of ordinary matter. The geometry of space is also different. Expansion and geometry are the two main properties.

Question 1: How can galaxies be the biggest and the youngest?

Biggest is a measure of size and youngest is a statement about when they formed. If big galaxies form relatively recently - because (see answer to previous Question 1) they are being built up of smaller galaxies smashing together - then hopefully it is straightforward to see that galaxies can be the biggest and the youngest at the same time. The key idea is that cosmic structures form via mergers of smaller (and older) systems.

Question 2: What is the difference between yellow/orange galaxies and blue galaxies? Are they bigger, hotter, farther away?

Typically, the yellow/orange galaxies are mostly made up of middle-aged and old stars. These are galaxies are not making new stars in large quantities. Blue galaxies are made up of mostly young stars and are busy making new stars. In the first instance, color is not necessarily related to distance. Still, galaxies long long time ago were generally forming stars more rapidly than galaxies today so an earlier version of the Milky Way galaxy (our own) or Andromeda would have been bluer.

Question 1: How does the movement and size of galaxy clusters effect weak lensing measurements ?

While galaxy clusters move very rapidly, viewed from earth, they appear nearly stationary. For the kind of work I was discussing, we don't worry about their motion. It doesn't really have any effect on the weak lensing measurements.

The size (and mass) together have a huge effect. As you know from Newton's equation, the strength of gravity depends on the combination GM/R where M is mass and R is size. If I have a cluster of the same mass but much smaller, than its gravity will be stronger and the lensing effects will be more dramatic and easier to see/measure.

Question 2: Assuming that we accurately know the mass of our own galaxy, is there a way to reverse engineer, through modeling, the expected mass results from a point in space looking back toward or own galaxy?

I am sorry I don't understand this question.

Question 1: How many clusters are thought to exist?

The answer to this question depends on the mass of the clusters. Massive clusters are very rare and low mass clusters are more common. Typically, the number density is 10^{-5} clusters per Mpc^3 or put another way, about 1 cluster in a cube-shaped region of space a hundred million light years in length.

Question 2: Can information you're seeking be used to predict future changes in galaxies?

If we understand the basic cosmological parameters, we can predict how the universe will change into the future and this in turn, allows us to predict how galaxies and more importantly, the arrangement of galaxies in the universe, will change with time.

More to come….To be continued.