Why the Universe can't be Infinite and why it Expands

Francesco Sacco

francesco215@live.it

July 15, 2021
University of Pisa

Abstract

The maximum entropy a region of space can cointain is proportional to the surface area

I. Why the universe can't be Infinite

The entropy of a black hole is

$$S = \frac{k_b c^3}{4G\hbar} A = \alpha V^{2/3} \tag{1}$$

where

$$\alpha = \frac{k_b c^3}{4G\hbar} \sqrt[3]{3} \left(\frac{3}{4}\right)^{2/3} \tag{2}$$

and A and V is the surface of the black hole
Therefore the entropy per unit volume of a black hole is

$$s_b = \frac{S}{V} = \frac{\alpha}{\sqrt[3]{V}} \tag{3}$$

And it decreases as the volume of the black hole gets larger and larger.
The main property of black holes that we are going to keep in mind is that a black hole of volume V has the maximum entropy any spherical volume V can have.
Suppose we have a universe enclosed in a volume of radius R and that on large scales we can say that it has constant entropy density $s_u = dS/dV$.
The maximum volume of this universe V_{max} is

$$V_{max} = \left(\frac{\alpha}{s_u}\right)^3 \tag{4}$$

Therefore the univere can't be infinite if it is homogeneus on large scales and flat

II. Why the universe expands

Suppose the volume of the Universe for some reason is exactly V_{max} it would last a blink of an eye before collapsing into a black hole. That is because the total entropy has to increase. If the universe has some kind of law that keeps it's volume always equal to V_{max} we would have an expanding universe.
This could explain why our universe in expanding, and why the expantion of the universe isn't constant throught the age of the universe.