Abstract

The aim of this project is to study the ways in which the Universe can come to an end. 2 ways are discussed and they are the Big Crunch and the Big Smash. Also, we will look at how a Big Smash can be prevented in a Universe that violates the Dominant Energy Condition (DEC). It was believed that the Universe would ultimately stop its expansion due to gravity and contracts. In this case, it would have its fate sealed in a singularity known as the Big Crunch. However, recent observations showed that this is not the case and we are forced to consider other options. One alternative we are looking at is the Big Smash theory. In such a Universe, the rate of expansion increases as the Universe expands and the pressure and density increases as well. Thus, the Universe would be shattered into disconnected pieces in the future and this is another singularity known as the Big Smash.

Introduction

The expansion of the Universe began from a terrific explosion known as the Big Bang.
about 15 billions years ago. The most significant events are as follows:

- $10^{-4}$ seconds: Baryogenesis occurs, quarks condense under strong interaction to form nucleons (e.g., Protons and Neutrons).
- 1 second: Nucleosynthesis occurs, universe cools enough (photon energies $\sim 1$ MeV) for light nuclei to form (e.g., deuterons, alpha particles).
- $10^4$ years: Radiation density becomes equal to matter density, since the radiation density has extra factor of $a^{-1}$ due to red shifting. Matter density is the dominant energy density after this epoch.
- $10^5$ years: Recombination occurs and electrons are combined with nucleons to form atoms. This time also coincides with the decoupling of photons from matter, giving rise to a surface of last scattering of the cosmic background radiation.
- $10^{10}$ years: The present.

**The Big Crunch Theory**

If the density of the Universe is greater than the critical density, gravity will ultimately halt its expansion and causes it to contract. It was assumed that the Universe contained enough matter to cause it to contract but the total mass of the luminous matter in the Universe is only a fraction of what is required and thus, the search begins for the remaining non-luminous matter, the Dark Matter. Several possible candidates are chosen and this suggests that the density of the Universe is higher than what can be measured.

However, measurements using the mass-to-light ratio method and data from the Supernova Cosmology Project, the High-Z Supernova Search and the Cosmic Microwave Background (CMB) refute the Big Bang theory and this suggests that the Universe will expand forever.

**The Big Smash Theory**

Observations show that we are living in a Universe that has an increasing rate of expansion. We consider what happens when the Dominant Energy Condition (DEC) is
violated. In such a case, we have the equation of state, \( \omega < -1 \) where \( \omega \) is the pressure over the energy density and this Universe will be destroyed by excessive expansion in the future.

For smash free models, the size of the Universe is a power of \( \cosh \) function and \( \omega \) in this case is not a constant. We can let \( \omega \) approaches \(-1\) as time approaches infinity and we have something that is similar to the cosmological constant that describes the deSitter Universe and thus, a Smash is prevented.

**Conclusion**

Since we do not know the exact initial conditions of the Universe, we cannot accurately predict what will happen in the future. Assuming that nature is simple and the conservation laws hold, the deSitter Universe is most likely to be the model that best describes the Universe now but how accurate it will be in the future, only time can tell.

**References:**


