Cosmological Model with Acceleration

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Abstract:

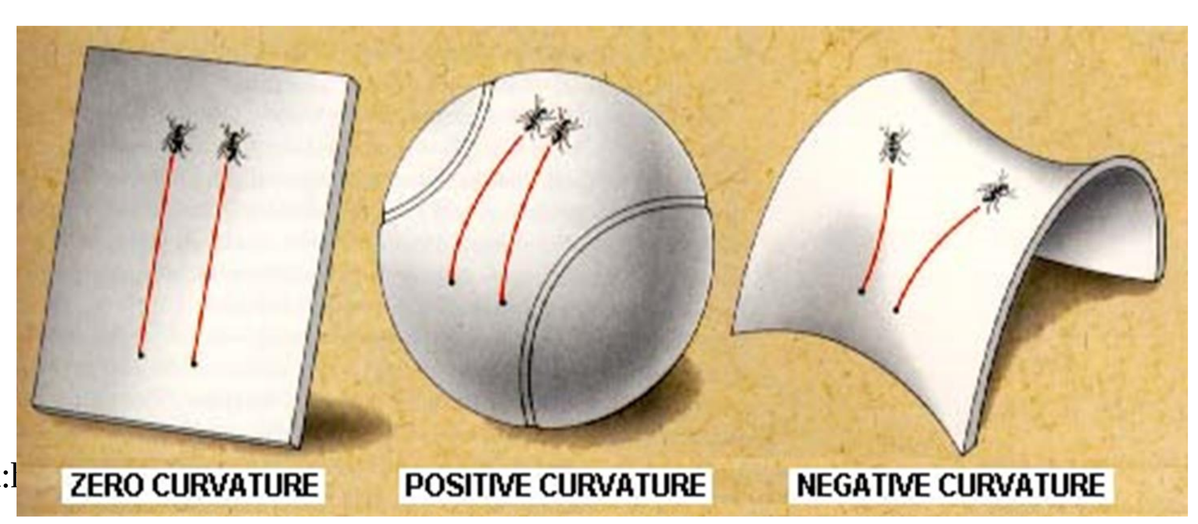
In this research we studied cosmological models to describe the large scale structure of the universe. We studied two models as case studies which describe acceleration. Here we studied various properties of the model such as the Hubble constant H(t) and the scale factor a(t). Hubble constant is related to the velocity of galaxies v and the distance to them d as v = H0 (t) d. The scale factor describes the expansion of the universe. In this poster, we will present various properties of the universe such as a(t), pressure, and density of the Universe.

Introduction:

The rate at which the universe expands is mainly dependent on just a few factors: the pressure, the density, and the geometry of space, i.e., the curvature of space (which are represented by different values of k); all of which are implemented into the Friedmann equation.

Curvature	Geometry	Angles of Triangle	Circumference of circle	Type of Universe
K = 0	Flat	180°	c = 2πr	Flat
K > 0	Spherical	> 180°	c <2πr	Closed
K < 0	Hyperbolic	<180°	**C>** 2πr	Open

Credit:l



Hubble's Constant:

In 1929, Edwin Hubble used the method of spectroscopy to measure the amount of redshift a distant galaxy has; during these measurements, Hubble discovered that redshift and distance were directly proportional, this discovery led to Hubble's Constant, H_0, which tells us the present expansion rate of the universe:

$$v = H_0 d$$

Scale factor a(t):

The scale factor is a function of time, and it is used to find the real distance between two objects in space, which can be represented by the following relationship:

$$\vec{r} = a(t)\vec{x}$$

Friedmann equation:

The Friedmann relates density, ρ, the curvature, k, and the scale factor, a:

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\rho - \frac{k}{a^2}$$

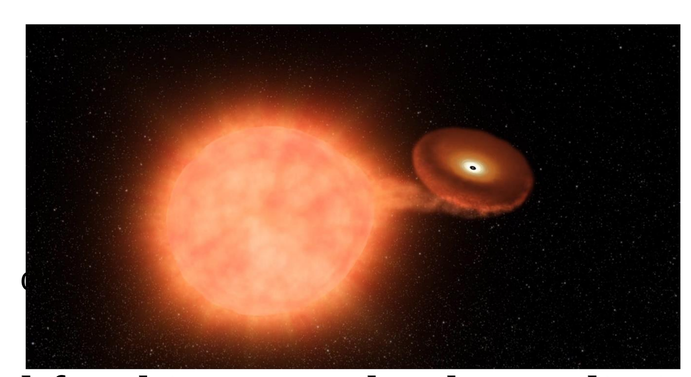
The Fluid equation:

This equation relates pressure, density , and the scale factor:

$$\dot{\rho} = 3\frac{\dot{a}}{a}\left(\rho + \frac{p}{c^2}\right) = 0$$

Acceleration of the Universe:

In 1998, the Hubble Space Telescope (HST) was able to observe very distant supernovae, commonly known as type Ia supernovae. In 1998, the astronomers who observed the distant supernovae found that the universe was expanding more slowly in the past than the present, which meant the rate of expansion for the universe was accelerating. Different models can be used to show how an accelerating universe may exist.



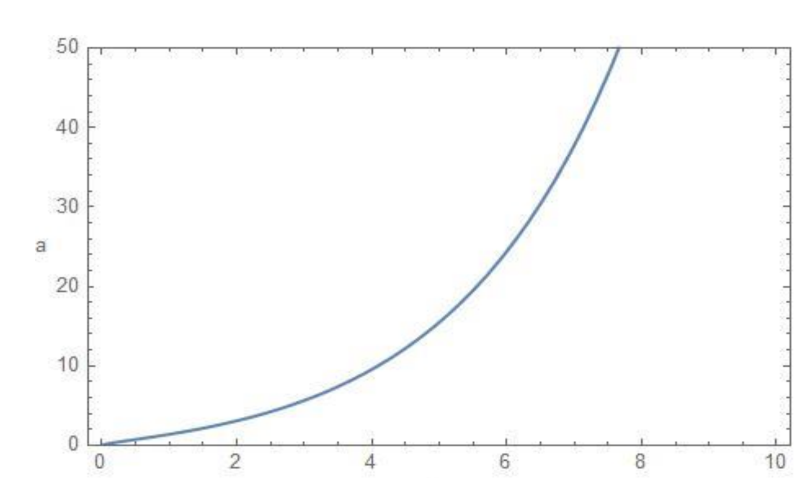
The model that was used for this research takes radiation pressure into account, and is in reference to the research paper from reference 1.

The pressure, P, is given by:

$$P = -3\rho^2$$

Using the Friedmann and Fluid equation with this value of pressure, leads us to a scale factor of:

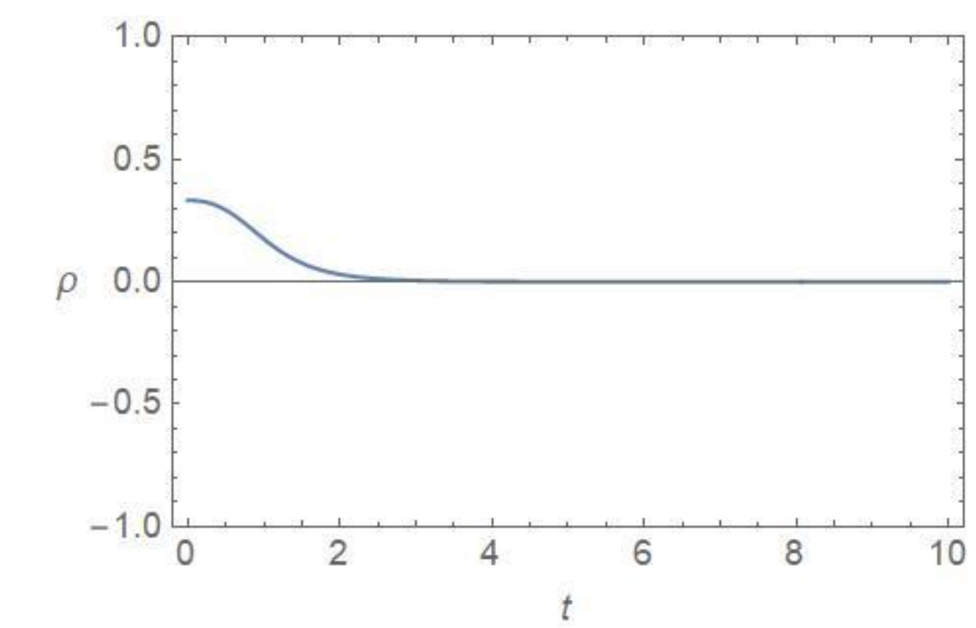
$$a[t] = Ae^{\frac{t}{3}}$$



The density is given by:

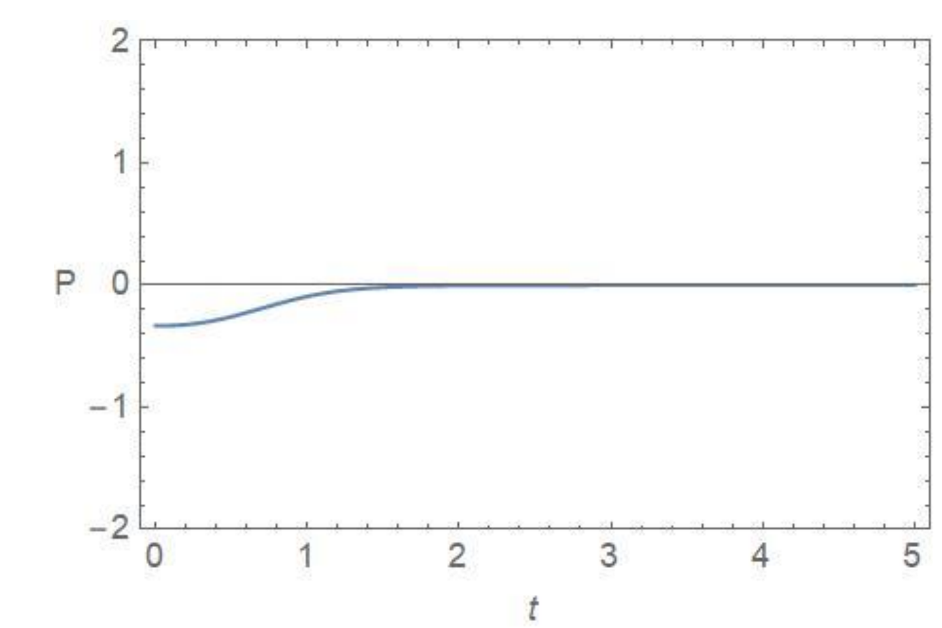
$$\rho = (C_0 a[t]^3 + 3)^{-1}\ [C_0 = 1]$$

$$\rho = (a[t]^3 + 3)^{-1}$$



Using the equation of state for pressure and density ,P $= -3\rho^2$, The pressure, P is found to be:

$$P = -3\rho = (a[t]^3 + 3)^{-2}$$



Conclusion:

The acceleration of the universe was once thought to have slowed down. However, the observations made in 1998 required a new model for describing the acceleration of the universe. Implementing the equations found from reference 1 gives us the expected results for all of the factors affecting the expansion. In the future, we are planning to do research working with other models involving expansion and acceleration.

References:

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