The photo on the left shows what the universe may have looked like a few million years after the Big Bang: A clumpy soup of dimly glowing matter. The image on the right shows how one of those clumps may have evolved into a recognizable galaxy today. In Big Bang cosmology, the universe expands, and space stretches. An important consequence of this is that the density of matter in space is also decreasing!

Problem 1 - The volume of the Milky Way can be approximated by a disk with a thickness of 1000 light years and a radius of 50,000 light years. Compute the volume of the Milky Way in cubic centimeters. (1 light year = 9.5×10^{17} centimeters.)

Problem 2 - The mass of the Milky Way is approximately equal to 300 billion stars, each with the mass of the Sun: 2×10^{33} grams. Compute the total mass of the Milky Way.

Problem 3 - If you were to take all of the stars and gas in the Milky Way and spread them out throughout the entire volume of the Milky Way, about what would be the density of the Milky Way in: A) grams/cm^3 B) kilograms/m^3

Problem 4 - If the average density of the matter in the universe was at one time equal to that of the Milky Way (Problem 3), by what factor would the volume of the universe have to increase in order for it to be 4.6×10^{-31} grams/cm^3 today?

Problem 5 - By what factor would the size of the universe have had to expand by today, and how far apart would the Milky Way and the Andromeda galaxy have been at that time if their current separation is 2.2 million light years?

Problem 1 - The volume of the Milky Way can be approximated by a disk with a thickness of 1000 light years and a radius of 50,000 light years. Compute the volume of the Milky Way in cubic centimeters.

Answer: $V = \pi R^2 h = \pi (50{,}000)^2 (1000) = 7.9 \times 10^{12}$ cubic lightyears.

$= 7.9 \times 10^{12} \times (5.9 \times 10^{17}\ \text{cm/ly})^3 =$ **1.6×10^{66} cm^3**

Problem 2 - The mass of the Milky Way is approximately equal to 300 billion stars, each with the mass of our sun: 2×10^{33} grams. Compute the total mass of the Milky Way.

Answer: $M = 3 \times 10^9 \times 2 \times 10^{33}$ grams = **2×10^{42} grams**

Problem 3 - If you were to take all of the stars and gas in the Milky Way and spread them out throughout the entire volume of the Milky Way, about what would be the density of the Milky Way in: A) grams/cm^3 B) kilograms/m^3

Answer A) Density = M/V = 2×10^{42} grams / **1.6×10^{66} cm^3** = **1.3×10^{-24} grams/cm^3** . B) 1.3×10^{-24} grams/cm^3 x (1 kg/1000 gm) x (1000cm/1 meter)3 = **1.3×10^{-21} kilograms/meter^3**

Problem 4 - If the average density of the matter in the universe was at one time equal to that of the Milky Way (Problem 3), A) by what factor would the volume of the universe have to increase in order for it to be 4.6×10^{-31} grams/cm^3 today?

Answer: A) Density then / density now = 1.3×10^{-24} grams/cm^3 / 4.6×10^{-31} grams/cm^3 = **2.8 million times.**

Problem 5 - By what factor would the size of the universe have had to expand by today, and how far apart would the Milky Way and the Andromeda galaxy have been at that time if their current separation is 2.2 million light years?

Answer: Because volume is proportional to the cube of a length, the factor by which the universe would have to increase in size is S = (2.8 million times)1/3 = **140 times.** That means that the Milky Way and the Andromeda galaxy would have been at a distance of 2.2 million light years / 140 = **16,000 light years!**