Astronomers have recently discovered a massive cluster of young galaxies that formed when the universe was only about 1 billion years old. The light from these galaxies has taken over 12 billion years to reach Earth. The growing galactic metropolis, called COSMOS-AzTEC3 is the most distant known massive "proto-cluster" of galaxies known today. The circled red smudges in the above image are the individual galaxies that are a part of the cluster. In the time since the light started on its journey, these galaxies have probably fallen together under the influence of gravity to form a large galaxy about the size of our Milky Way. At the distance of the galaxy cluster, the width of this photograph, which was taken by the Japanese Subaru Telescope on Mauna Kea, is about 25 million light years across. (Image Credit: Subaru/ NASA / JPL-Caltech)

Problem 1 - Assuming all of the galaxies lie in the same plane, and at the same distance, to two significant figures: A) What is the greatest distance between the galaxies in this photograph? B) What is the smallest distance between galaxies in this photograph?

Problem 2 - The Milky Way galaxy and the Andromeda galaxy are separated by about 2,200,000 light years in diameter. How many millimeters apart would they appear if they were viewed at the same distance as this cluster?

Problem 3 - If the average speed of a galaxy in this cluster is about 1000 light years in 1 million years, how many years will it take for all the galaxies to fall to the center of the cluster?

Problem 1 - Assuming all of the galaxies lie in the same plane, and at the same distance. To two significant figures: A) What is the greatest distance between the galaxies in this photograph? B) What is the smallest distance between galaxies in this photograph?

Answer: With a millimeter ruler, the width of the image is about 153 millimeters, which corresponds to an actual distance of 25 million light years. The scale of the image is then 25 million/153 mm = 160,000 light years /mm, then:

A) The farthest distance between the 11 identified galaxies is about 96 mm, for a distance of 96 mm x (160,000 ly/1 mm) = **15,000,000 light years**. B) The closest pair of galaxies are about 2 mm apart, or 2 x 160,000 = **320,000 light years**.

Problem 2 - The Milky Way galaxy and the Andromeda galaxy are separated by about 2,200,000 light years in diameter. How many millimeters apart would they appear if they were viewed at the same distance as this cluster?

Answer: 2,200,000 light years x (1 mm/160,000 light years) = **14 millimeters**.

Problem 3 - If the average speed of a galaxy in this cluster is about 1000 light years in 1 million years, how many years will it take for all the galaxies to fall to the center of the cluster?

Answer: For the two most distant galaxies to fall to the center, a point half way between them in the photograph, they must fall a distance of 7,500,000 light years. Since the speed is stated as 1000 light years / 1 million years, the time it would take is about

T = 7,500,000 light years x (1 million years / 1000 light years)

= 7,500 million years or **7.5 billion years**.

Note that galaxies closer together will have fallen together much sooner, so the most distant pair of galaxies defines the approximate free-fall age of this cluster. Since the universe is 13.7 billion years, and the free-fall age of this cluster is only 7.5 billion years, it must have had enough time to collapse into a smaller size long ago...perhaps even before our own Earth was formed!