Looking towards the constellation of Triangulum (The Triangle), in the northern sky we see two very similar galaxies, named PGC 9074 and PGC 9071 located about 490 million light years from Earth. Both are spiral galaxies, and are presented to our eyes face-on, so we are able to appreciate their distinctive shapes. After the collision, these two galaxies will eventually merge together into a new, larger galaxy.

The distance between the centers of these two galaxies is about 110,000 light years. The galaxy diameters are about 75,000 light years.

Problem 1 – Astronomers measure the speeds of stars and galaxies in units of kilometers/sec, but because of the scale of the universe, sometimes it is helpful to use the equivalent speed unit if 'parsecs per million years' to make certain calculations easier and faster. One parsec equals 3.26 light years and one light year equals 9.46×10^{12} kilometers. If there are 3.1×10^{7} seconds in one year, what is the equivalent speed unit for 1 kilometer/sec in pc/myr?

Problem 2 – The two galaxies in the above photo are currently about 110,000 light years apart, and are approaching each other at a speed of 500 km/sec. In about how many million years will the two galaxies have completely collided if they continued at the same speed?

Problem 3 – Like a ball falling to the ground, the gravity of each galaxy will cause the galaxies to move faster and faster as they get closer together. The following equation describes this accelerated motion:

$$D = d_0 - V_0T - 1/2aT^2$$

where T is the time in millions of years (myr) from the present, V_0 is the current speed in pc/myr, and a is the acceleration of gravity in pc/myr^2. If d_0 = 34,000 parsecs, V_0 = 500 pc/myr, and a = 0.4 pc/myr^2, in how millions of years will the galaxies have collided?

http://www.nasa.gov/content/inseparable-galactic-twins/
July2, 2013
Inseparable Galactic Twins

Problem 1 – Astronomers measure the speeds of stars and galaxies in units of kilometers/sec, but because of the scale of the universe, sometimes it is helpful to use the equivalent speed unit if 'parsecs per million years' to make certain calculations easier and faster. One parsec equals 3.26 light years and one light year equals 9.46×10^{12} kilometers. If there are 3.1×10^{7} seconds in one year, what is the equivalent speed unit for 1 kilometer/sec in pc/myr?

Answer: 1 km/sec x (1 ly/9.46×10^{12} km) x (1 pc/3.26 ly) x (3.1×10^{7} sec/1 year) x (10^{6} yr/1 myr) = **1.0 pc/myr**.

Problem 2 – The two galaxies in the above photo are currently about 110,000 light years apart, and are approaching each other at a speed of 500 km/sec. In about how many million years will the two galaxies have completely collided if they continued at the same speed?

Answer: The galaxies are 110,000 ly apart, which is 110,000 ly x 1pc/3.26 ly = 34,000 parsecs. They are traveling at 500 km/sec which is 500 pc/myr, so the time required is T = distance/speed = 34,000 pc/500 = **68 million years**.

Problem 3 – Like a ball falling to the ground, the gravity of each galaxy will cause the galaxies to move faster and faster as they get closer together. The following equation describes this accelerated motion:

$$D = d_0 - V_0T - 1/2aT^2$$

where T is the time in millions of years (myr) from the present, V_0 is the current speed in pc/myr, and a is the acceleration of gravity in pc/myr^2. If d_0 = 34,000 parsecs, V_0 = 500 pc/myr, and a = 0.4 pc/myr^2, in how millions of years will the galaxies have collided?

Answer: The formula will look like $D = 34000 - 500\,T - 0.2T^2$. We want the condition that D = 0 for the collision. The value for T can be found by graphing this equation and finding the point (T,0), or by using the quadratic roots formula.

Method 2: a = -0.2 b = -500 and c = 34000, then

$X = [-b +/- (b^2-4ac)^{1/2}] / 2a$

X = [500 +/- 526] / -0.4 so X1 = -2565 and X2 = +65
Only the solution '+65 million years' is a real solution about a future (positive) time so the required root is **65 million years**. This is only slightly smaller than the answer in Problem 2 which assumed constant collision speeds, so the gravitational acceleration between these two galaxies is not a significant factor.