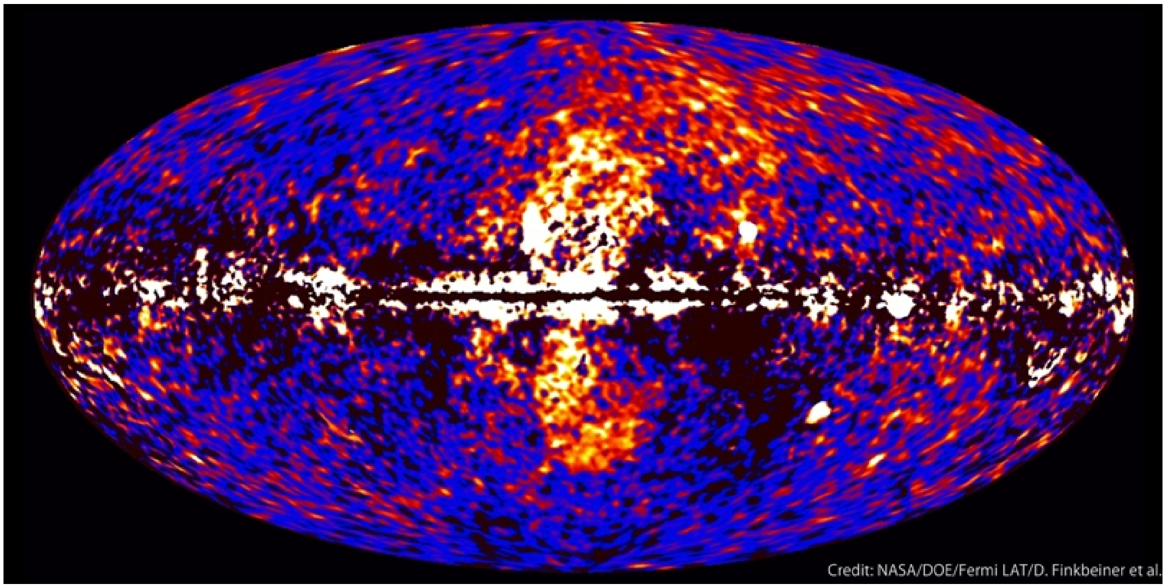

NASA's Fermi Gamma-ray Space Telescope has unveiled a previously unseen structure centered in the Milky Way. The feature spans 50,000 light-years and may be the remnant of an eruption from a supersized black hole at the center of our galaxy, or the gas ejected by a burst of star formation in the center of the galaxy several million years ago. The bubbles extend 25,000 light years above the plane of the Milky Way, and appear to be symmetric in shape.

Problem 1 - Approximate the volume of these two bubbles as two spheres with diameters of 25,000 light years. What is the total volume of the two bubbles in cubic light years?

Problem 2 - The average density of interstellar gas is about 1 hydrogen atom per cubic centimeter. If 1 light year = 9.5×10^{17} centimeters, and one hydrogen atom has a mass of 1.6×10^{-27} kg, how much mass may have been displaced by the formation of these bubbles A) in kilograms? B) in solar mass units if 1 SMU = 2.0×10^{30} kg?

Problem 3 - Suppose that the density of the gas ejected by the activity at the center of our Milky Way had a density of about 10% of the normal interstellar gas. If the process took 1,000,000 years to form the bubbles, at what rate would gas from the core of our Milky Way have to be produced in Earth mass units per year?

Problem 1 - Approximate the volume of these two bubbles as two spheres with diameters of 25,000 light years. What is the total volume of the two bubbles in cubic light years?

Answer: For one bubble: $V = 4/3 \pi R^3$ so

$V = 1.33 (3.14) (25,000/2)^3$ cubic light years

$V = 8.2 \times 10^{12}$ cubic light years.

For two bubbles $2V =$ **1.6×10^{13} cubic light years.**

Problem 2 - The average density of interstellar gas is about 1 hydrogen atom per cubic centimeter. If 1 light year = 9.5×10^{17} centimeters, and one hydrogen atom has a mass of 1.6×10^{-27} kg, how much mass may have been displaced by the formation of these bubbles A) in kilograms? B) in solar mass units if 1 SMU = 2.0×10^{30} kg?

Answer: A) Mass in one cubic light year = 1 atoms/cm^3 x 1.6×10^{-27} kg/atom x ($9.5e^{17}$ cm/light year)^3 = 1.4×10^{27} kg. The volume of the bubbles is 1.6×10^{13} ly^3, so the mass is $M=1.4 \times 10^{27} \times (1.6 \times 10^{13})$ and so M= **2.2×10^{40} kg**.

B) In solar mass units M= 1.4×10^{27} kg x (1 SMU/2.0×10^{30} kg)

= **1.1×10^{10} solar masses.**

Problem 3 - Suppose that the density of the gas ejected by the activity at the center of our Milky Way had a density of about 10% of the normal interstellar gas. If the process took 1,000,000 years to form the bubbles, at what rate would gas from the core of our Milky Way have to be produced in Earth mass units per year?

Answer: The density is 0.10 x the normal interstellar gas, so from Problem 2(B) the amount of material in the bubble volume would be 0.1 x 1.1×10^{10} solar masses = 1.1×10^9 solar masses. It took 1,000,000 years to inject this gas into the bubbles, so the rate is just

R =1.1×10^9 solar masses/1,000,000 years

= **1100 solar masses/year**.