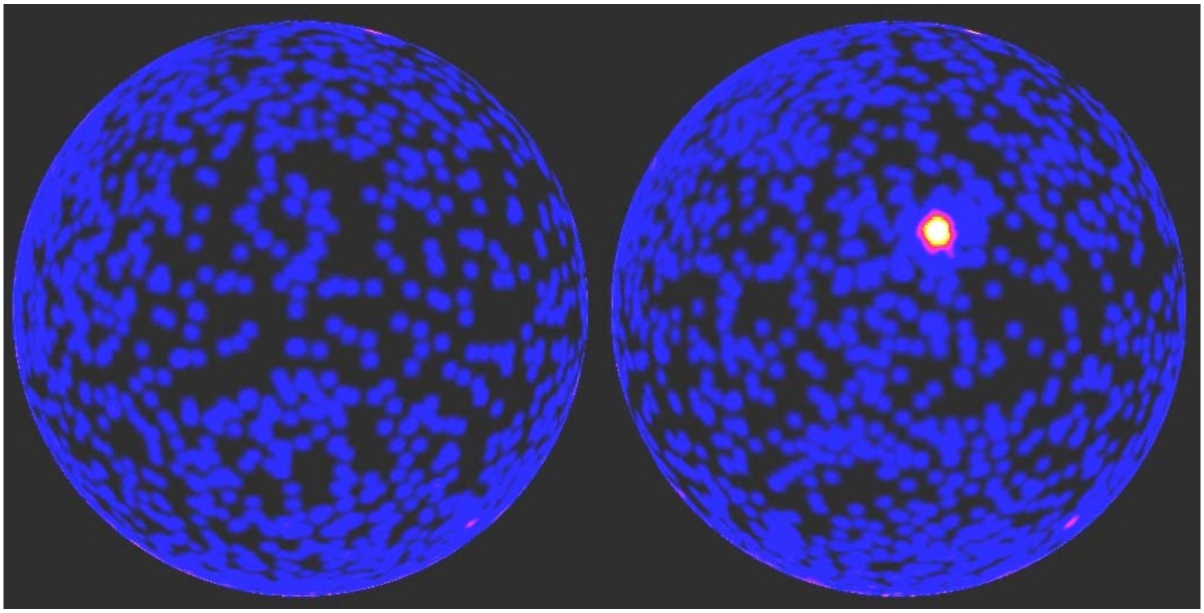
The Remarkable Gamma-Ray Burst GRB 130427A



In April, 2013, a record-setting blast of gamma rays from a dying star in a distant galaxy wowed astronomers around the world. The eruption, which was classified as a gamma-ray burst, or GRB, and designated GRB 130427A, produced the highest-energy light ever detected from such an event. Fermi's Large Area Telescope (LAT) detected the gamma-ray emission from the burst, which lasted for hours, and it remained detectable for the better part of a day, setting a new record for the longest gamma-ray emission from a GRB. The event occurred 3.6 billion light years from Earth in the direction of the constellation Leo. The estimated energy flux from this event at the location of Earth was about F = 2.0×10^{-8} watts/meter^2.

Problem 1 – Although instruments at Earth can measure how many watts of energy were detected over an area of 1 square meter, called the radiant flux, they would really like to know how much energy in watts, was released by the source of the event. Suppose that the same flux of energy flowed through every square meter of surface, of a sphere whose radius equaled the distance to the source of 3.6 billion light years (1 light year = 9.5×10^{15} meters). What was the total power emitted by the source into space in A) watts, B) solar units where 1 solar unit = 4.0×10^{26} watts)?

Problem 2 - Instead of the energy emitted across the entire sky like our sun does, astronomers think that the energy from a gamma-ray burst is emitted in two narrow beams that come from the core of the star as it becomes a supernova. If the area of each beam on the sky is only 1 square degree, and the full area of the sky is 42,000 square degrees, what will be the estimated total power of the source in watts and in solar units?

NASA's Fermi, Swift See 'Shockingly Bright' Burst
May 3, 2013
http://www.nasa.gov/topics/universe/features/shocking-burst.html

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Answer: The surface area of a sphere with a radius of 3.6 billion light years is
R = 3.6 billion ly x (9.5×10^{15} meters/ly) = 3.4×10^{25} meters.

Then S = 4 (3.141) $(3.4 \times 10^{25})^2$ = 1.45×10^{52} meters^2.

A) The total power = 2.0×10^{-8} watts/m^2 x 1.45×10^{52} m^2 = **2.9×10^{44} watts**.

B) 2.9×10^{44} watts x (1 solar unit / 4.0×10^{26} watts) = **7.3×10^{17} solar units**.

Note: If the source radiation was emitted over the entire surface of the sphere, it would equal the energy produced each second by 730 thousand trillion stars like our sun!

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Answer: Each beam only emits energy into 1/42,000 of the full sky, so the area on the spherical surface for each beam is only 1/42000 x 1.45×10^{52} meters^2 or 3.5×10^{47} meters^2. For both beams the total area is 2 x 3.5×10^{47} meters^2 or 7.0×10^{47} meters^2. The total power from the gamma-ray source is then 2.0×10^{-8} watts/meter^2 x 7.0×10^{47} meters^2 = **1.4×10^{40} watts**. This equals the power from **35 trillion suns**!