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Gamma Ray Bursts

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Many strange, incredible and explosive phenomena occur in the vast vacuum of space. Many forces are present in abundance that are more complex and powerful than imaginable; they could destroy life as we know it without leaving a trace of our existence. Since the dawn of humankind, we have looked at the stars trying to grasp the complexity of the cosmos. Some are more innocuous than others; gamma ray bursts are most certainly not of the innocent variety. Gamma rays are the highest energy form of electromagnetic radiation, and Gamma Ray Bursts are the brightest and most energetic phenomena in the galaxy.

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There are a number of objects that Gamma Ray Bursts may originate from. Because of the difficulty in studying them, and the somewhat recent discovery of their existence in 1973, (Higdon, James C., and Richard E. Lingenfelter) there is still much debate on where Gamma Ray Bursts come from. Their only recent discovery and classification has been largely because of two things: gamma ray bursts are both incredibly massive in scale and incredibly far from Earth. Not to mention a casual observer can't simply take an optical telescope, point it at the night sky, and see one. Because of this difficulty in both finding and studying these objects, It has only just recently come to light that the most common of the progenitor objects are Wolf-Rayet stars. A "progenitor object", for the purposes of gamma ray bursts, is the object from which a burst is born; an object of such potential energy, mass, and size that its very existence pushes the limits of what astrophysicists believe to be true. One such object is a Wolf-Rayet star. A larger and more energetic version of the sun, Wolf-Rayet stars are evolved, massive stars which are spinning off a large percentage of their mass due to incredibly fast solar winds. Winds of this speed are never seen on planet Earth; they can be as fast as 2000 kilometers a second propelling 1.988435×10^25 kilograms of mass from the star every year. This amount of mass is millions of times more than the sun ejects yearly. They are usually found in star forming regions of the universe as Wolf-Rayet stars are incredibly short lived. Their birth time in the cosmic scheme of things is not very far away from their death time. Some Wolf-Rayet stars only live for a small fraction of the sun's life, as little as hundreds of millions of years. If the life of the sun were this short, the human race would have never come into being.

A Wolf-Rayet star would not generate a Gamma Ray Burst on its own, however. A compact, massive companion star, usually a neutron star, is often found in binary formation with the Wolf-Rayet star. The orbit of the two stars around each other, in the aforementioned binary formation, is greatly accelerated by the tremendous mass of the neutron star, which is necessary, as the angular momentum of the Wolf-Rayet star is usually decreased by the aforementioned solar winds. This spinning results in a tidal effect between the two stars, which draws them closer to each other. This tidal effect is very similar to the tidal effect found on the earth between the moon; the gravities of the two objects cause stretching because of their proximity. Eventually, one of two possibilities occur. The most commonplace occurrence at this point is that the Wolf-Rayet star either loses too much mass or too little mass due to matter ejection from solar wind and spins off, away from its neutron star binary partner. The other option is that the change of mass conserves the angular momentum as

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the stars draw near, and eventually, they collide.

Usually a Gamma Ray Burst is not emitted. Astrophysicists have found that the most likely outcome is a supernova or some other variation of massive energy ejection that is not a Gamma Ray Burst. However, if the two stars in the binary system are spinning at matching angular momentums, then the stars can merge and form a collapsar. A collapsar is a massive rotating star core which has the potential to emit Gamma Ray Bursts. Jets of gamma rays are emitted along the rotational axis of these collapsars and expelled with incredible energy.

The energy of Gamma Ray Bursts vary, but they will always outshine even the brightest supernovae, sometimes by as much as 200 to 300 times.Their electromagnetic energy output during tens of seconds is comparable to that of the Sun over tens of billions of years. This amount is comparable to the output by the entirety of the milky way galaxy over a few years, and is so large that there is no practical way to compare it to anything created by humans. This led to the naming of such collapsing star events that lead to the propagation of Gamma Ray Bursts as Hypernovae since the prefix "hyper" supersedes the prefix "super" as in "Supernovae."

Scientists have long since tried to track and categorize gamma ray bursts. Up until recently, this has been largely unsuccessful because of a number of different factors differentiating bursts from one another. There is a large variability in the time that the burst lasts. Some have lasted as long as 1000 seconds while others have been as short as 30 milliseconds. This variability gives more merit to the theory that there is more than one way for gamma ray bursts to form. In addition to the difference in the amount of time that the Gamma Ray Burst lasts, there is also a large discrepancy in the pattern in the intensity of the burst. The pattern of the burst is known as burst morphology. Gamma ray bursts have been categorized in a number of ways based on their burst morphology. Categories include single pulse or spike events, smooth, single or multiple, well defined peaks, distinct well separated episodes of emission, and very erratic, chaotic, spiky bursts. These categories encompass every Gamma Ray Burst recorded. For example, the previously mentioned Wolf-Rayet star progenitor object would form a single, smooth pulse as the burst formed by a collapsar is singular and uniform.

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Gamma Ray Bursts are intense both in the energy of the actual burst and in the serendipitous circumstances required for them to propagate. They are only just beginning to be understood, and research into their many mysterious workings are underway by scientists across the globe. Understanding Gamma Ray Bursts can lend valuable insights into the nascency of the Universe and what led to its creation, as their energy is so intense that they can be detected billions of years after their origin. This provides an ethereal window through time; light only travels so fast, so by the time the rays reach us, we are seeing them as they were eons ago.

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Image Sources

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