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Gamma Ray Burst and Afterglow

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Gamma-ray bursts (GRB's), short and intense pulses of low-energy γ rays, have fascinated astronomers and astrophysicists since their unexpected discovery in the late sixties. GRB's are accompanied by long-lasting afterglows, and that they are associated with core-collapse supernovae. The detection of delayed emission in X-ray, optical, and radio wavelength, or "afterglow," following a γ-ray burst can be described as the emission of a relativistic shell decelerating upon collision with the interstellar medium.
Several hundred afterglows have now been observed across the electromagnetic spectrum. While it is fair to say that there is strong diversity amongst the afterglow population, probably reflecting a diversity in energy, luminosity, shock efficiency, baryon loading, progenitor properties, circumstellar medium and more, the afterglows of GRBs do appear more similar than the bursts themselves, and it is possible to identify common features within afterglows that lead to some canonical expectations. After an initial flash of gamma rays, a longer-lived "afterglow" is usually emitted at longer wavelengths (X-ray, ultraviolet, optical, infrared, microwave and radio). It is a slowly fading emission at longer wavelengths created by collisions between the burst ejecta and interstellar gas.
In X-ray wavelengths, the GRB afterglow fades quickly at first, then transitions to a less-steep drop-off (it does other stuff after that, but we'll ignore that for now). During these early phases, the X-ray afterglow has a spectrum that looks like a power law. This kind of spectrum is characteristic of synchrotron emission, which is produced when charged particles spiral around magnetic field lines at close to the speed of light
In addition to the outgoing forward shock that ploughs into the interstellar medium, there is also a so-called reverse shock, which propagates backward through the ejecta. In many ways"reverse"shock can be misleading, this shock is still moving outward from the rest frame of the star at relativistic velocity, but is ploughing backward through the ejecta in their frame, and is slowing the expansion. This reverse shock can be dynamically important, as it can carry comparable energy to the forward shock.

In the early phases of the GRB afterglow still provides a good description even if the GRB is highly collimated since the individual emitting regions of the outflow are not in causal contact at large angles, and so behave as though they are expanding isotropically, If the emission from the GRB itself is confined into a relativistic jet with some half opening angle ∅⊠, then the true burst energy is not that observed by a GRB detector, but is modified by the fraction of the sky illuminated by the jet. This is only strictly true for a so-called top hat jet, where the energy per solid angle is the same for any observer, but is commonly assumed.
In this case, the correction from the measured energy of the burst ⊠⊠⊠⊠ to its true Energy.

At early times, individual elements within the relativistic outflow are not in causal contact, since they experience time dilation. However, the jet is slowing as it ploughs into the medium and the evolution of the Lorentz factor

The majority of afterglows, at times typically observed, fall in the slow cooling regime and the cooling break lies between the optical and the X-ray. Numerous observations support this broad picture for afterglows.
In the spectral energy distribution of the afterglow of the very bright GRB. The bluer light (optical and X-ray) appears to follow a typical synchrotron forward shock expectation (note that the apparent features in the X-ray and optical spectrum are due to the presence of dust within the host galaxy).
Gamma ray bursts are among the most energetic phenomena in the universe, we still don't fully understand the physical processes that drive them.
Science from studies of GRBs is now important across the bulk of astronomy, and even beyond fundamental physics. GRBs have been used to provide stringent limits on quantum gravity effects through differing speeds of light at different energies; have been proposed to explain mass extinction events in the geological history

of the Earth; have progenitors for short bursts that may create the majority of heavy elements throughout the Universe; are successfully used to probe the physical conditions in the early Universe; provide a route to mapping the build-up of stellar mass and metals across cosmic history; provide unique constraints on the processes of particle acceleration and the production of ultra- high energy cosmic rays and neutrinos; probe the stellar evolution of the most massive stars and have been demonstrated as route to enabling multi messenger astronomy.

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