Matter Flashed at Ultra Speed

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Using a robotic telescope at the ESO La Silla Observatory, astronomers have for the first time measured the velocity of the explosions known as gamma-ray bursts. The material is travelling at the extraordinary speed of more than 99.999% of the velocity of light, the maximum speed limit in the Universe.

"With the development of fast-slewing ground-based telescopes such as the 0.6-m REM telescope at ESO La Silla, we can now study in great detail the very first moments following these cosmic catastrophes," says Emilio Molinari, leader of the team that made the discovery.

Gamma-ray bursts (GRBs) are powerful explosions occurring in distant galaxies, that often signal the death of stars. They are so bright that, for a brief moment, they almost rival the whole Universe in luminosity. They last, however, for only a very short time, from less than a second to a few minutes. Astronomers have long known that, in order to emit such incredible power in so little time, the exploding material must be moving at a speed comparable with that of light, namely 300 000 km per second. By studying the temporal evolution of the burst luminosity, it has now been possible for the first time to precisely measure this velocity.

Gamma-ray bursts, which are unseen by our eyes, are discovered by artificial satellites. The collision of the gamma-ray burst jets into the surrounding gas generates an afterglow visible in the optical and near-infrared that can radiate for several weeks. An array of robotic telescopes were built on the ground, ready to catch this vanishing emission.

On 18 April and 7 June 2006, the NASA/PPARC/ASI Swift satellite detected two bright gamma-ray bursts. In a matter of a few seconds, their position was transmitted to the ground, and the REM telescope began automatically to observe the two GRB fields, detecting the near-infrared afterglows, and monitored the evolution of their luminosity as a function of time (the light curve). The small size of the telescope is compensated by its rapidity of slewing, which allowed astronomers to begin observations very soon after each GRB's detection (39 and 41 seconds after the alert, respectively), and to monitor the very early stages of their light curve.

The two gamma-ray bursts were located 9.3 and 11.5 billion light-years away, respectively.

For both events, the afterglow light curve initially rose, then reached a peak, and eventually started to decline, as is typical of GRB afterglows. The peak is, however, only rarely detected. Its determination is very important, since it allows a direct measurement of the expansion velocity of the explosion of the material. For both bursts, the velocity turns out to be very close to the speed of light, precisely 99.9997% of this value. Scientists use a special number, called the Lorentz factor, to express these high velocities. Objects moving much slower than light have a Lorentz factor of about 1, while for the two GRBs it is about 400.

"Matter is thus moving with a speed that is only different from that of light by three parts in a million," says Stefano Covino, co-author of the study. "While single particles in the Universe can be accelerated to still larger velocities - i.e. much larger Lorentz factors - one has to realise that in the present cases, it is the equivalent of about 200 times the mass of the Earth that acquired this incredible speed."

"You certainly wouldn't like to be in the way," adds team member Susanna Vergani.

The measurement of the Lorentz factor is an important step in understanding gamma-ray burst explosions. This is in fact one of the fundamental parameters of the theory which tries to explain these gigantic explosions, and up to now it was only poorly determined.

"The next question is which kind of 'engine' can accelerate matter to such enormous speeds," says Covino.

Source: European Southern Observatory