

Can invading black holes explain GRBs?

X-ray observations of gamma-ray bursts (GRBs) by the Swift satellite suggest that the central engine can be active for up to a few hours. A new theoretical study shows that this is difficult to explain in the standard scenario of jet formation and instead proposes a different mechanism that would work not only for collapsing stars but also for stars invaded by a black hole companion in a binary system.

The collection of hundreds of GRB afterglows by NASA's Swift satellite since its launch in November 2004 is an observational breakthrough in the characterization of these powerful stellar explosions. The typical X-ray-afterglow emission is characterized by a rapid fading in the first minutes followed by a shallow decay lasting up to a few hours and a somewhat steeper decay afterwards. In addition, many GRB afterglows show X-ray flares superimposed on this general trend (*CERN Courier* October 2005 p11). While those features are consistent with the cannonball model, they were unexpected in the frame of the standard fireball model (*CERN Courier* December 2005 p20). Despite these difficulties, the latter remains the favoured model for long GRBs.

In this context, the intermediate shallow decay and the presence of X-ray flares are interpreted as evidence of ongoing activity of the central engine for several hours after the prompt GRB. This is a problem for models in which the ultra-relativistic jet at the origin of the GRB phenomenon is powered by the annihilation of neutrinos in a disc of matter



Rendering of a black hole powering a relativistic jet from within a star resulting in a gamma-ray burst. (Courtesy Dana Berry, SkyWorks Digital/NASA.)

that forms around a nascent black hole at the heart of a collapsing star. Indeed, the neutrino-heating mechanism requires a high mass-accretion rate onto a rapidly spinning black hole – a process that cannot be sustained for more than a few minutes.

A new theoretical study by Maxim V Barkov and Serguei S Komissarov from the Department of Applied Mathematics at the University of Leeds proposes an alternative to the prolonged neutrino-heating problem in the standard “collapsar” model. They demonstrate that jets of long GRBs can

also be powered via a magnetic process, such as the Blandford–Znajek mechanism. This mechanism, proposed in 1977, uses the rotational energy of the spinning black hole to power the jet. Compared with the neutrino-driven GRB model it has the advantage that it can account for the prolonged jet activity with a somewhat lower constraint on the spin of the black hole; but on the other hand, it requires a strong magnetic field at the black-hole horizon. One way to reduce the magnetic constraint is to start with a neutrino-driven supernova explosion that opens jet channels for the subsequent magnetically driven GRB.

A particularly interesting possibility discussed by Barkov and Komissarov is the case of a close binary system composed of a Wolf-Rayet star – a massive, dense star that has blown away its outer layer of hydrogen – and a black hole. The black hole could lose momentum in the wind of the companion star and ultimately spiral into the star's centre, devouring it from the inside. In the Milky Way, there is luckily only one such binary system, Cyg X-3, which has an orbital period of about 5 hours. The black hole might eventually parasite on the Wolf-Rayet star, disrupt it and produce a GRB to be observed in billions of years' time in a remote galaxy.

Further reading

MV Barkov and SS Komissarov 2009.
Submitted to *MNRAS*.
<http://arxiv.org/abs/0908.0695>.

Picture of the month



The 19-year-old Hubble Space Telescope has undergone a rebirth youth. This image by the Wide Field Camera 3 is one example that shows the power of the observatory after the fourth servicing mission in May 2009. The group of five galaxies is known as Stephan's Quintet. The name is a bit of a misnomer because the bottom-left galaxy actually lies seven times closer to Earth than the rest of the group. Three galaxies have elongated spiral arms and long, gaseous tidal tails that contain new-born star clusters – proof of the galaxies' close encounters. The broad coverage of the new camera from visible to near-infrared light results in unprecedented colours that depict the various ages of the stars. Star-forming regions are blue or pink, while older stars trace the shape of the galaxies with an orange haze. (Courtesy NASA, ESA and the Hubble SM4 ERO Team.)