BLACK HOLES

Star ripped to shreds

When a star wanders too close to a giant black hole, it can be pulled apart by the black hole's tidal force. One such event offers insight into the properties of both the black hole and the star. SEE LETTER P.217

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Astronomers have strong evidence that supermassive black holes, with masses between a million and a billion times that of the Sun, reside in the centre of most galaxies. The evidence comes from observations of the copious amount of radiation that is emitted when these objects pull gas from their immediate vicinity. However, if a black hole's close environment is poor in gas, gas accretion proceeds at a low rate and is not accompanied by significant emission of radiation. Probing such 'dormant' black holes is therefore difficult — unless a tidal-disruption event occurs. Such an event takes place when a star comes close enough to the black hole to be ripped apart by its tidal force. The ensuing stellar debris is accreted by the black hole and produces a characteristic flare. On page 217 of this issue, Gezari *et al.*[1] describe how detailed observations of a tidal-disruption event have allowed them to determine the properties of not only the black hole, but also the disrupted star*.

Tidal-disruption events are rare. They are expected to occur once every 10,000 years per galaxy. To find them, it is therefore necessary to use large astronomical surveys in which thousands of galaxies are regularly observed. Gezari and colleagues' discovery comes from one such survey, which is expected to detect roughly one event every two years[2].

The main significance of this study probably lies in the accurate determination of the properties of the tidal-disruption event, which the authors based on a well-sampled ultraviolet–optical light curve for the flare (a plot that shows the evolution of the flare's brightness over time) and spectroscopic measurements of the system. They find that the supermassive black hole is hosted by a galaxy at redshift 0.17 (corresponding to a distance of approximately 2 billion light years from Earth), and has a mass of about 3 million solar masses. Moreover, on the basis of the shape of the light curve[3] and the absence of hydrogen lines in the spectra of the stellar debris, Gezari *et al.* conclude that the disrupted star was the helium-rich core of a red giant whose hydrogen outer shell had been previously stripped off, possibly by the same tidal force that eventually led to its complete disruption (Fig. 1).

Gezari and colleagues' observations also imply that the orbit of the star around the black hole was exceptionally tight, with the point of closest approach being only six times the black hole's Schwarzschild radius, which, for a non-rotating black hole, corresponds to its event horizon — the boundary beyond which nothing, not even light, can escape. After the point of closest approach, part of the debris was expelled from the system and part was launched into highly eccentric orbits, falling onto the black hole after approximately two months from closest approach, and producing the observed ultraviolet–optical flare.

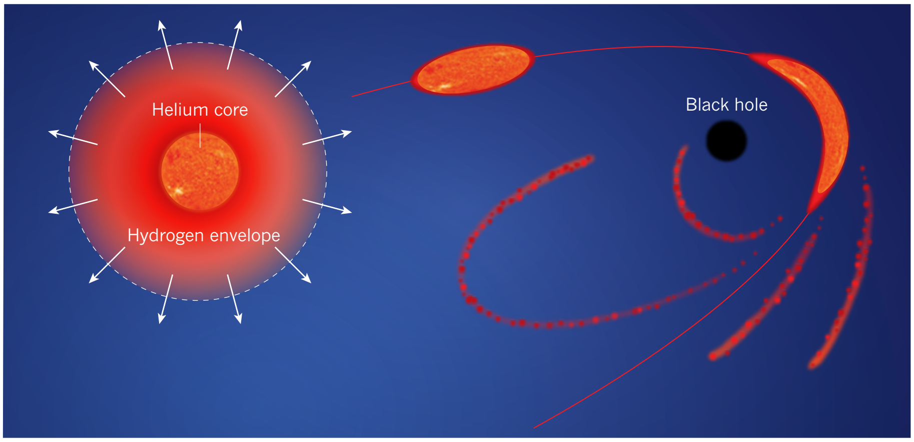

Figure 1 | Tidal disruption of a star. The helium-rich core of a red-giant star that had previously lost its hydrogen envelope moves on an almost parabolic orbit (red) towards a supermassive black hole. The sequence of blobs illustrates the progressive distortion of the star's core due to the tidal pull of the black hole. After the point of closest approach to the black hole, the core is completely disrupted, with part of the resulting debris being expelled from the system and part being launched into highly eccentric orbits, eventually falling onto the black hole. Accretion of this debris gives rise to the intense ultraviolet–optical flare that has been observed by Gezari and colleagues[1].

During the past year, two other tidal-disruption events caused by supermassive black holes have been detected[4–7]. In those cases, the emission occurred over a wide range of the electromagnetic spectrum, from X-rays to radio waves, because it was produced by a high-energy jet of particles that happened to point almost exactly in our line of sight; such jets are expected to be associated with tidal-disruption events. By contrast, the ultraviolet–optical radiation of tidal-disruption events is usually associated with thermal emission from an accretion disk of stellar debris that forms around the black hole. However, somewhat surprisingly, in the present case Gezari and colleagues find that the ultraviolet–optical emission does not seem to be caused by an accretion disk, because its emission would have fallen off with time[8] at a different rate from that observed. This finding will provide food for thought for subsequent investigations of these events.

Finally, the observation that the star's closest approach to the black hole corresponds to a distance of only six times the Schwarzschild radius suggests that effects of the general theory of relativity might need to be invoked to describe the system. Would the shape of the light curve be modified by such effects? Current models, including those used by Gezari *et al.*, are generally based on Newtonian dynamics, and hence do not include the effects of general relativity. As a result, the models cannot distinguish between a rotating and a non-rotating black hole. Tidal-disruption events can probe deeply into the gravitational field of the black hole, and so offer the means to test the effects of general relativity and black-hole rotation. The fact that we are now in a position to characterize the light curve and spectra of such events so accurately, and that the rate of discovery seems to be in line with expectations, means that we should soon be able to answer these fascinating questions. ■

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