Flares from the direction of the Black Hole in the Galactic Centre

In recent dramatic observations using NAOS-CONICA on the VLT, near-infrared flares from the direction of the the black hole at the Galactic centre have been detected. The signals, rapidly flickering on a scale of minutes, must come from hot gas falling into the black hole, just before it disappears below the "event horizon" of the monster. The new observations strongly suggest that the Galactic Centre black hole rotates rapidly. Never before have scientists been able to study phenomena in the immediate neighbourhood of a black hole in such a detail. These results were published recently by Reinhard Genzel and colleagues* in the journal *Nature***, and were presented in ESO Press release PR 26/03.

This flare, and several others like it, were coming from exactly the direction of the supermassive black hole at the heart of the Milky Way. The team members were certain that the black hole must be accreting matter from time to time. As this matter falls towards the surface of the black hole, it gets hotter and hotter and starts emitting infrared radiation. But no such infrared radiation had been seen until that night at the VLT.

A careful analysis of the new observational data, reported in the Nature article, has revealed that the infrared emission originates from within a few thousandths of an arcsecond from the position of the black hole (corresponding to a distance of a few light-hours) and that it varies on time scales of minutes. This proves that the infrared signals must come from just outside the so-called "event horizon" of the black hole, that is the "surface of no return" from which even light cannot escape. The most likely emission process of the infrared emission is synchrotron emission from relativistic electrons. The observed intensity of the infrared emission and its spectral energy distribution suggest that a significant fraction of the electrons near the event horizon are accelerated to energies much above the virial equilibrium, in a non-thermal distribution, perhaps through magnetic reconnection events as in solar flares. The rapid variability seen in all data obtained by the VLT clearly indicates that the region around the event horizon must have chaotic properties.

The team members have commented that the data give unprecedented information about what happens just outside the event horizon and let us test the predictions of General Relativity. The most striking result is an apparent 17-minute periodicity in the light curves of two of the detected flares. If this periodicity is caused by the motion of gas orbiting the black hole, the inevitable conclusion is that the black hole must be rotating rapidly.

It is known from theory that a black hole can only have mass, spin and electrical charge. Last year the team was able to unambiguously prove the existence and determine the mass of the Galactic Centre black hole (ESO Press Release 17/02). If their assumption is correct that the periodicity is the fundamental orbital time of the accreting gas, they now have also measured its spin for the first time. And that turns out to be about half of the maximum spin that General Relativity allows. As Reinhard Genzel comments, "the era of observational black hole physics has truly begun".

Variability on time scales of one hour to several days was also observed in late May/June 2003 at 3.8 microns at the Keck telescope by a team of observers lead by Andrea Ghez (UCLA, paper in press ApJ Letters). As in the case of the VLT data, the Keck observers find the variable *L*-band source to be coincident with the black hole position to within less than 10 mas.

(based on ESO Press Release 26/03)

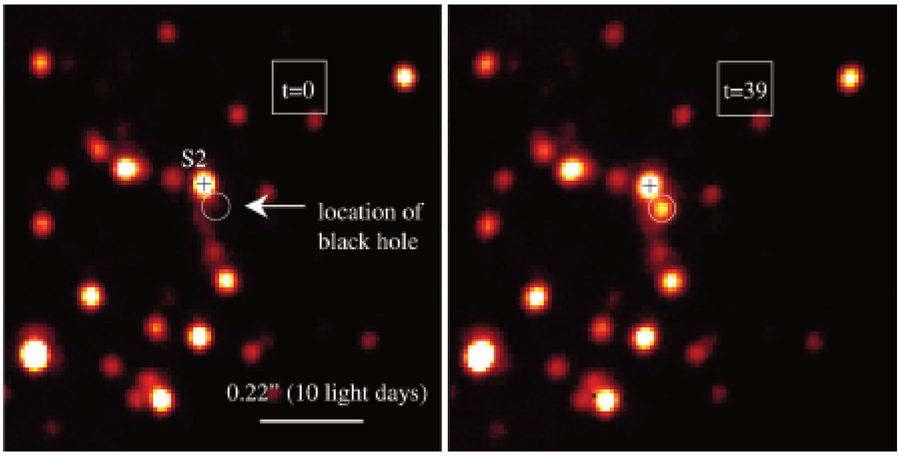

Figure 1 shows the detection of one of these flares, obtained with a resolution of 0.040 arcsec in the near-infrared H-band (λ=1.65 μm). The observations were made with the NACO imager on the 8.2-m VLT YEPUN telescope at Paranal on May 9, 2003. The image covers a sky area of about 1 x 1 arcsec, corresponding to about 45 light-days at the distance of the Galactic Centre. The time (in minutes from the beginning of the data set) is shown at the upper right of each image. North is up and East to the left. The position of the 15-year orbiting star S2 is marked by a cross and the astrometric location of the black hole is indicated by a circle.

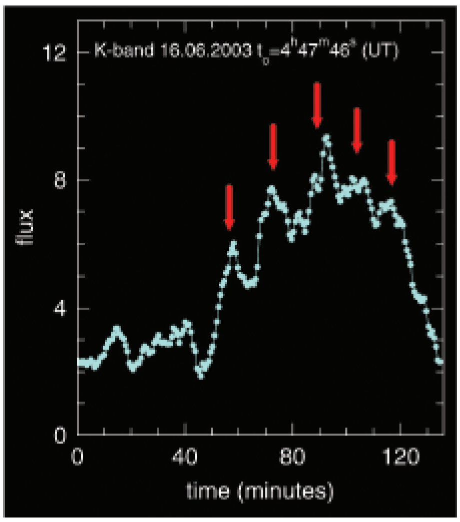

Figure 2 displays the "light curve" of a light flare from the Galactic Centre, as observed in the K-band (λ=2.2 μm) on June 16, 2003. This and a second flare discovered about 24 hours earlier show variability on a time scale of a few minutes and appear to show larger variations (arrows) with a 17-minute periodicity. The rapid variability implies that the infrared emission comes from just outside (the event horizon of) the black hole. If the periodicity is a fundamental property of the motion of gas orbiting the black hole, the Galactic Centre black hole must rotate with about half the maximum spin rate allowed by General Relativity. The present observations thus probe the space-time structure in the immediate vicinity of that event horizon.

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**R. Genzel et al. (2003) Nature 425, pp. 934-937: "Near-IR Flares from Accreting Gas around the Supermassive Black Hole in the Galactic Centre"