

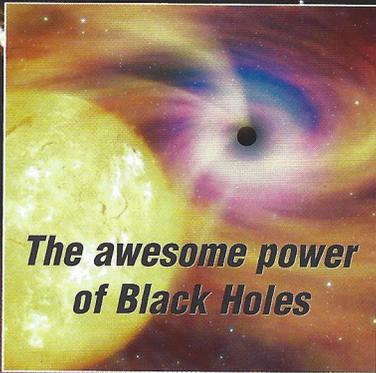
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New mysteries of

Black Holes

Scientists have made a new connection between supermassive black holes, and the galaxies in which they reside.

Three astronomers at the Instituto de Astrofísica de Canarias (IAC) in the Canary Islands — Alister Graham, Peter Erwin, Nicola Caon, and Ignacio Trujillo — have discovered a fundamental connection between supermassive black holes and the galaxies at whose centres these objects reside. This connection was found by studying the global distribution of stars within galaxies, the concentration of which is related to the mass of the central supermassive black hole

Supermassive black holes are the most massive singular objects in our Universe — one million to over a billion times more massive than our Sun. Even so, the 'event horizon' (the surface from which no light can escape because of the strength of the gravitational field) of a one million solar mass black hole is only about four times larger than our Sun — they are very dense objects. The Sun weighs 2×10^{30} kg (almost five hundred thousand times heavier than the Earth), and is 1.4 million kilometres in diameter. These supermassive black holes have been found in a large number of galaxies, including our own.

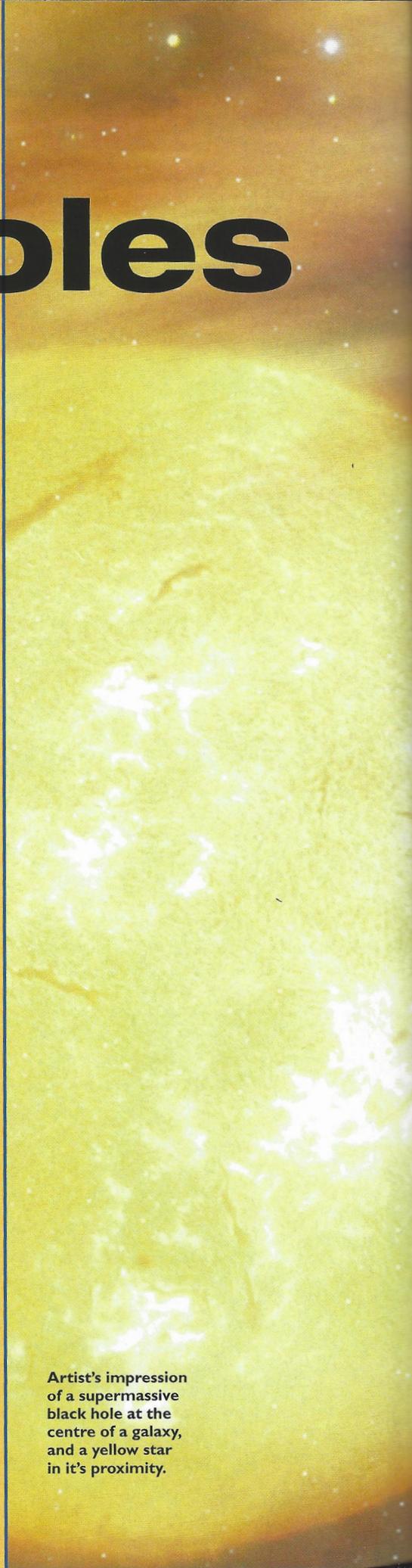
The overall distribution of stars within both elliptical galaxies and the bulges of spiral galaxies has been found to be directly related to the mass of a galaxy's central supermassive black hole. More massive galaxies are not simply bigger versions of less massive galaxies, as has been frequently assumed in the past. Their entire structure is different — more massive galaxies are more centrally concentrated. The precise degree of concentration has now been shown to correlate extremely well with the mass of the central supermassive black hole.

'This is an important realisation which provides further insight into the formation of both galaxies and their central black holes. We now know that any viable theory of supermassive black hole growth must be connected with the (eventual) global structure of the host galaxy,' according to project leader Dr Alister Graham, and Australian astronomer working at IAC.

It would appear quite natural that more centrally-concentrated galaxies can more efficiently supply gas and material to fuel their central black holes. The researchers note, however, that it is possible that the processes which shaped the galaxy and built the supermassive black hole operated in tandem. Whether or not smaller primordial black holes existed before galaxies formed around them remains an open question.

Observational implications

This discovery also has important practical advantages. The discovery last year of a relation between central black hole mass and galaxy velocity dispersion (a measure of average star motions within a galaxy) meant that it was possible to estimate a galaxy's central black hole mass from the galaxy's velocity dispersion. Unfortunately, this is a time-consuming process — to obtain a velocity dispersion measurement, the light from a galaxy must first be spread into its constituent wavelengths (colours). This dilutes



Artist's impression of a supermassive black hole at the centre of a galaxy, and a yellow star in its proximity.

the galaxy's light and thus requires long exposure times.

With this latest discovery, astronomers can now predict black hole masses directly from the images of galaxies, by measuring the fall-off in luminosity from the centre to the edge, and thus determining the concentration. This way, thousands of very distant galaxies can be studied cheaply and effectively. Astronomers hope to gain a deeper understanding of the evolution of these enigmatic objects, which appear prevalent throughout our Universe.

The work was based on archival data obtained with the NASA/ESA Hubble Space Telescope, and the Isaac Newton Group of Telescopes at the Spanish Observatorio del Roque de Los Muchachos (La Palma).



