PHOTO: PAUL JONES

ASTRONOMY

# IT'S EAT OR BE EATEN IN our cosmic jungle

STORY BY Julian Cribb

**THE HEART** of a normal galaxy is a place of extreme astrophysical phenomena, where hapless stars can be devoured in a flash or fired across the universe at blinding speed.

Fresh insight into the engine rooms that drive galaxies, the main building blocks of our cosmos, has come about in the past few years thanks, in part, to the work of two Swinburne University of Technology astronomers, Associate Professor Alister Graham and Dr Lee Spitler.

Associate Professor Graham says that for many years it was recognised that giant galaxies had a "supermassive black hole at their heart". On the other hand, dwarf galaxies had a compact cluster of stars at their nucleus, he says. "It was a case of one or the other."

However, when the Swinburne team began to closely examine mid-range galaxies on images gathered by the Hubble Space Telescope they found, to their astonishment, that several and then many galaxies seemed to possess both types of core – a massive black hole and a dense, swirling inner body of stars: both predator and prey.

In this cosmic jungle, stars wandering too close to the ravenous gravitational forces of the black hole fall in, emitting a searing X-ray flare as their dying cry. Others are drawn in – although not close enough to be devoured – then hurled like a stone from a slingshot at speeds up to 500 kilometres per second, enough to eject them from the galaxy entirely.

Massive black holes offer an explanation both for the enigmatic X-ray flashes as stars are gravitationally stretched and torn apart just before crossing over the black hole's event horizon, and for the occasional single stars seen by astronomers hurtling at astounding speed out of galaxies.

Only three years ago it was commonly believed that the two sorts of nuclei did not coexist in a single galaxy. It was thought that galaxies either had a black hole surrounded by not very much, or a fairly peaceful, albeit highly compact, cloud of hundreds of thousands to tens of millions of stars. "Now, as a result of our survey, we believe that this double nucleus may be quite common, especially in galaxies of medium size, or with central bulge components comparable to our own Milky Way's bulge," Associate Professor Graham says. "We'd expect to find such double nuclei in many, if not all, galaxies of similar mass."

The finding is also a testament to the superb quality of the images from the Hubble Space Telescope, which continues to deliver astonishing new insights into the cosmos after the instrument was refurbished earlier this year. "It is extremely difficult to see, from ground-based telescopes, the nuclear star cluster in far off galaxies, which may explain why many remained undetected for so long," Associate Professor Graham says.

The team's observations not only call for a revision of prevailing ideas about galactic evolution, but have dramatically increased hope for a new avenue by which Einstein's General Theory of Relativity may be tested. Although the hunt for the hitherto-unseen 'gravitational waves' predicted by the theory remains extremely technologically challenging, the new finding suggests that searches are likely to detect far more events than previously thought.

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"In theory, gravitational waves can be emitted when a star, or stellar remnant, rapidly spirals in towards a black hole. But such emission has never actually been observed. Since we now expect that it will occur quite frequently in these types of galaxies with a dual core, this should make the hunt more fruitful, and greatly improves the prospects of validating Einstein's theory by this means," Associate Professor Graham says.

His Swinburne colleague Dr Lee Spitler is a man with a very unusual occupation – he weighs galaxies and the objects within them, including their star clusters, for a living. His key role in the research has been to measure the mass of the clouds of stars surrounding the black holes (whose masses had previously been measured with Hubble), to assemble the hard data that will expose the underlying processes that govern these galaxies.

The bulge of our Milky Way galaxy, which is encircled by a spiral-armed disc of stars and dust, has a mass in stars equivalent to 10 billion of our Suns. At the very heart of this bulge is a black hole of about four million solar masses. This, in turn, is surrounded by a dense cluster of stars of some 30 million solar masses.

By studying the ratios of the mass of the black hole to the mass of the star cluster and the host bulge in many galaxies, the team can begin to decipher the evolutionary pathways as stars in the core are either consumed or spat out. Eventually, as galaxies continue to grow by merging and accreting gas, the black holes fatten on their stellar and gaseous diet into a supermassive monster, while the surrounding star cloud is gradually depleted.

"This work has been very exciting," Dr Spitler says. "We've managed to quantify how galaxies transition, with increasing mass, from housing only a nuclear cluster, to a double nucleus and finally a supermassive black hole."

Working from this base, the new insights promise "a lot more action and excitement" as the Swinburne astronomers painstakingly disclose a new chapter in the history of galaxies and how they developed, and indeed continue to evolve.

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