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Abstractions

FIRST AUTHOR

Most, if not all, galaxies are believed to have a huge black hole residing at their centre. When matter falls into one of these galactic black holes, large amounts of radiation are released, producing a quasar — an object that looks like a star but is 10 billion times brighter. Todd Boroson of the National Optical Astronomy Observatory in Tucson, Arizona, has been studying quasars for more than 25 years. During an analysis of data from the Sloan Digital Sky Survey, he and his colleague Tod Lauer uncovered evidence of a binary black-hole system: that is, the presence of two black holes at a galaxy's centre (see page 53). Many scientists agree that such systems, produced by the merging of two large galaxies that each harbour a black hole, ought to be common throughout the Universe. But few have been identified, possibly because they are very distant from us. Out of the hundreds of billions of galaxies in the Universe, only the four dozen or so nearest to our own can be studied closely enough for black holes to be directly detected. Boroson tells *Nature* more.

What is the Sloan Digital Sky Survey?

It's a massive astronomical survey managed by the Astrophysical Research Consortium and scheduled for completion in 2014. It covers more than a quarter of the sky and has been used to create three-dimensional maps containing more than 930,000 galaxies and 120,000 quasars. We looked at an analysis of spectra from 17,500 of these.

Were you looking for a binary black-hole system?

No. We were studying quasar characteristics when this popped up. We found something that I had never seen before — two very distinct sets of emission lines in one spectrum. This indicated the presence of two different objects, each travelling at a different velocity. In a normal quasar spectrum you would see only one. We deduced that there are two velocities because two black holes are orbiting each other.

Can you be sure?

The object has two sets of broad emission lines, which indicates that material is falling into the black holes. We can't rule out the possibility that these black holes aren't orbiting each other. But finding out should be fairly straightforward because if they are then we should see changes in the emission lines in as little as one year. We're also planning to get good images from the Hubble Space Telescope. Using the two velocities and the assumption that the black holes are orbiting each other, we can estimate the distance between them. That distance is so small that, even with Hubble, this object should look like a single point of light, not two. ■

MAKING THE PAPER

Benjamin Van Mooy

Ocean microbes use 'substitute' nutrients when phosphorus is low.

They might seem minuscule and insignificant, but marine microorganisms have a massive effect on global nutrient cycles. Phytoplankton form the basis of marine food chains and, from them, nutrients are transported through the system. Phosphorus is an essential nutrient for all organisms — it is a component of both DNA and cell membranes — so shortages can limit microbial growth. But recent studies have found that some species can thrive even when phosphorus is scarce. The mystery was how.

Benjamin Van Mooy, a marine chemist at Woods Hole Oceanographic Institution in Massachusetts, became interested in phosphorus cycling as a graduate student, when he discovered that 15–20% of marine phosphorus taken up by microbes in the South Pacific winds up in phospholipids, the fatty molecules that are a major component of cell membranes. He wondered whether the same was true in regions where phosphorus availability is much lower.

Unlike those for nitrogen and iron, the oceanic phosphorus cycle is a 'closed' system, meaning that there is never any addition of phosphorus from outside the system. Previous work suggested that phosphorus cycling in the Atlantic Ocean might provide an interesting contrast to that in the Pacific, so Van Mooy and his group headed for the Sargasso Sea. This elliptical stretch of water in the middle of the North Atlantic is Earth's only shoreless sea. It is bounded by ocean currents and known for its floating masses of seaweed. It was once considered a 'dead zone' owing to its lack of larger sea life, but the discovery of rich microbial diversity has prompted numerous studies, including a metagenomic survey by genomics pioneer Craig Venter. "The Sargasso Sea has become Mecca for many scientists," says Van Mooy.

By incubating sea-water samples with a radioactive phosphorus isotope, the team established that only about 1–2% of the phosphorus taken up in the Sargasso is used to make lipids. "At first, I thought we'd made a mistake," Van Mooy says. When the findings were confirmed, he knew they needed to culture these plankton in the lab to determine how they were able to thrive on so little phosphorus.

Unfortunately, Van Mooy has a brown thumb. "I'm a chemist. Everything I've ever tried to grow in culture has died within a week," he says. So he turned to friends in the related field of marine lipid research. Together, they sought to test a hypothesis that had been lingering in the literature — that some plankton species can use non-phosphorus 'substitute' molecules in their membranes.

On page 69, Van Mooy and his colleagues show that sulphur- and nitrogen-containing 'substitute' lipids, which in microbial membranes function similarly to phospholipids, are more abundant than phospholipids in some Sargasso Sea species. In fact, a survey of individual species in culture found that some species of algae, and photosynthetic bacteria called cyanobacteria, can use substitute lipids to reduce their phosphorus requirements by 10–30%.

The biggest challenge, Van Mooy says, was substantiating that theirs were the first descriptions of nitrogen-containing substitute lipids in the ocean. "Our work provides an example of how much remains to be discovered about the biochemicals that are present in marine organisms — and puts a biochemical face on the idea that all cells are not created equal." ■

FROM THE BLOGOSPHERE

If writing review papers and polishing manuscripts has worn you down, maybe it's time to turn to your musical talents to explain your science. For more than a year, *Nature* reporter Daniel Cressey has been cataloguing songs about science on The Great Beyond blog. The fourteenth installment features songs that are not only entertaining and educational, but are also easy on the ears (http://tinyurl.com/ac4aox).

The Nano Song is a Sesame-Street-esque rundown of how small 'nano-small' is — complete with dancing letters and a grouchy puppet. It's also the University of California, Berkeley's entry in the American Chemical Society's 'What is Nano?' contest (http://tinyurl.com/c97qug).

Meanwhile, Pennsylvania State University geoscientist Richard Alley pays homage to the subduction processes that drive earthquakes and volcanoes in his version of *Ring of Fire* (with apologies to Johnny Cash).

Both songs pack a science lesson into the span of three minutes and are sung in melodious voices. Check out the full series of songs the next time you need a writing break. ■

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