The Economist

Black holes

Win some, lose some

The more they are understood, the more mysterious they become

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THE black holes that get the most press these days are the microscopic sort expected to pop out of the Large Hadron Collider in Geneva and, some misguidedly fear, gobble up the Earth in the process. But not every black-hole buff's gaze has turned to the collider. Plenty of physicists still look to the skies in search for clues to the nature of what is now believed to be as humdrum a cosmic occurrence as stars and planets. Some of what they see poses more questions than it answers.

Apart from the as-yet-unobserved microscopic variety, physicists have spotted numerous telltale signs of black holes that weigh several times the mass of the sun. These are believed to be the remnants of stars that have run out of nuclear fuel and thus collapsed through the pull of their own gravity. There are also signs of the even-more-massive brethren of these star-sized black holes—monsters which are thought to weigh between 100,000 and 50 billion solar masses and found at the centres of galaxies.

Theory suggests that the black holes which form from stars should have a minimum mass 25 times that of the sun. Such a huge amount of matter is needed for them to collapse into a point of infinite density, known as a singularity, that is surrounded by a boundary (called an event horizon) through which only a one-way trip inward is possible. Smaller stars, those between eight and 25 times the mass of the sun, will eventually collapse too. But they rebound as supernovae and then settle down as neutron stars in which the protons and electrons of the original star have merged to form additional neutrons to the ones that were already present. Stars smaller than eight solar masses simply expand into red giants and then dwindle away into white dwarfs.

The black hole that isn't

Recently, however, a team of astronomers working at the European Southern Observatory in Chile, led by Simon Clark, spotted a fly in the cosmic ointment. Or, more precisely, a magnetar. Magnetars are a type of neutron star which has a magnetic field a million billion times stronger than the Earth's. Though they are rare, finding one would not normally cause much of a stir. What got Dr Clark and his colleagues excited is that, if their calculations are correct, the magnetar in question should have been a black hole.

They stumbled on it in a star cluster called Westerlund 1, which is located 16,000 light-years from Earth. Previous studies have shown that this is the closest of the so-called super star clusters. These are collections of hundreds of bright, massive stars, all of which were born at the same time. In the case of Westerlund 1, that birthday is reckoned to have been between 3.5m and 5m years ago.

Only one of Westerlund 1's stars has so far formed a magnetar, which suggests it was the heaviest of the bunch because a star's lifespan is linked inversely to its mass. So, if Dr Clark could determine the mass of another star in the cluster he would know that the mass of the star that begat the magnetar must have been bigger.

Luckily for him, Westerlund 1 also contains a double star named W13. This system is known as an eclipsing binary, in which the two stars pass alternately in front of each other when viewed from Earth. That allows their masses to be calculated and, based on this information, Dr Clark's team have concluded that the magnetar-begetting star must have weighed at least 40 times as much as the sun—more than enough to form a black hole.

So why is it not a black hole? The only explanation Dr Clark can think of is that the star must have somehow shed nine-tenths of its mass before it exploded as a supernova. Unfortunately, that does not make astrophysical sense.

Dr Clark's magnetar is, at least, a lone anomaly. The supermassive black holes at the centres of galaxies (and around which those galaxies are assumed to have accreted in the first place) are much more disturbing, for there are a lot more of them. They must have formed early in the history of the universe, too. The evidence suggests that black holes more than a billion times heavier than the sun were around less than 1 billion years after the Big Bang.

Astrophysicists try to explain them as being the result of the collapse of huge clouds of gas. But that works only with the assumption that very special conditions were in place to prevent the gas from turning into stars before a black hole had a chance to spring to life. And no one has been able to say why these conditions would have been likely.

Lucio Mayer, of the University of Zurich, and his colleagues are now offering an alternative explanation, which they published in a recent issue of *Nature*. Dr Mayer knew from previous research that the early universe was awash with massive protogalaxies that would occasionally merge with each other. When his team used a computer to simulate such a merger, the model spat out an unstable, spinning disc of gas that funnelled more than 100m solar-masses-worth of matter into its centre in 100,000 years—a trice in cosmic terms. As that gas collapsed to a black hole, it pulled in more gas and dust from the disc, bulking up to a billion solar masses. Crucially, all this would have taken just 100m years, a pace brisk enough to dovetail nicely with the observed data.

If this model holds up to further scrutiny, then, at least one cosmic mystery may be resolved. Until, that is, astronomers like Dr Clark find with their telescopes something else that is amiss.

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