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Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/23000143
Skygazing: Astronomy through the seasons, 2014-03-11

A HOLE IN THE MIDDLE

Ken Tapping, 11th March, 2014

At this time of the year, if you go outside in the last hour or two of darkness before dawn, you will see the red star Antares low in the southern sky, and to its left the Milky Way broadening and brightening as it dives down to the horizon. This is the sky we will see on summer evenings. Considering the weather we've been having, there is much to be said for waiting for those summer evenings.

If we look into the broad stream of the Milky Way a few degrees above the southern horizon, into the constellation of Sagittarius, we are looking in the direction of the core of our galaxy, which is just one of billions of spiral galaxies we see around us. The core lies some 30,000 light years from us – a light year is the distance light travels in a year, just under 10,000,000,000,000 km. However, we cannot see that core; its light is blocked by the great clouds of gas and dust.

Fortunately, the blocking and scattering by those clouds is much less at radio and infrared wavelengths. Early in the history of radio astronomy it became clear there is something odd in the centre of the Milky Way – a strong, but small source of radio emissions. Infrared images confirmed this, showing something star-like and very bright. The object became known as Sagittarius A-star, or "Sag A-star" for short. We know how far away the object is, so by measuring how much energy is reaching us, we can estimate how much energy Sag A-star is putting out. It turns out that its output is far too high for it to be a star. In addition, observations using X-ray telescopes show pulses and bursts of X-rays.

If we see an object orbiting around something else, we can measure how far apart those objects are and how long one complete orbit takes, and then calculate the masses of those objects. In galaxies we can measure how rapidly stars at various distances from the core are moving, and get an idea of how material is distributed. Measurements for our galaxy and many others suggest that they have very massive but small objects in their cores. Infrared observations show stars orbiting Sag A-star, so now we know its mass, which is equivalent to more than 4 million suns. The only object we know of that can be small enough while being that massive, and produce such a huge energy output is a black hole. A black hole's intense gravity pulls in dust clouds and any stars or planets that stray too close. As they spiral in and vanish they get very hot and radiate energy, mainly in the form of X-rays. By the time the material vanishes inside, the amount of energy radiated is close to what you would get if that material were totally converted into energy. By contrast a 10 billion watt power station converts less than ten grams of fuel into energy per day, the rest is wasted. Black holes like the one at the centre of our galaxy swallow entire stars and convert them into energy with almost 100% efficiency. The changes in brightness and X-ray bursts happen when the black hole swallows something particularly toothsome, like a large star.

Now we know that many galaxies have black holes in their cores. Most of them are fairly benign, like ours. However some galaxies have black holes that are larger and swallowing huge amounts of material from their inner parts. The cores of these galaxies shine exceptionally brightly. Far out in space there are galaxies where the black holes in their cores are even more vigorous, and shine enormously brighter than the remnants of their host galaxies. Through telescopes they look like bluish stars, which led them to be called "Quasi-Stellar Objects" or Quasars. The radiation levels in them would be so high that any form of life as we know it could exist there. Our black hole is docile by comparison, and has not done anything too bad since the Earth formed some 4.5 billion years ago.

Jupiter dominates the southern sky overnight. Mars rises about 11pm, and Saturn at 1am. Venus rises around 6 am. Mercury is low in the dawn twilight. The Moon will be Full on the 16th.

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