

A masing new ruler

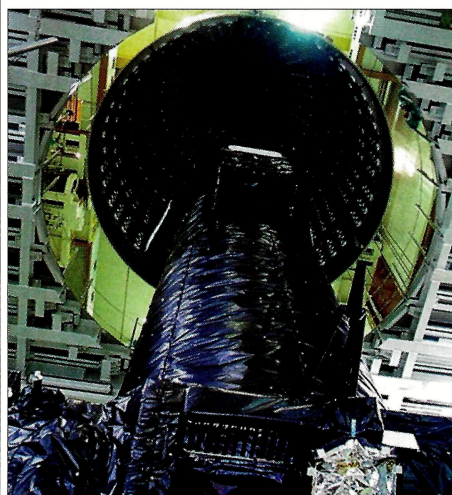
Observations of astronomical water masers have provided us with a new measure of distance in space.

Maser emission was detected by a team using the US Very Long Baseline Array (VLBA), from material rotating around a black hole in the centre of galaxy NGC 4258. With the rotation disk very nearly edge on, both the maser's angular velocity and acceleration could be measured. Then, using geometry, its distance from the galaxy could be calculated.

Uncertainties in the value of the Hubble constant, and thus the age of the universe, are mainly caused by errors in measuring large distances. "Standard candles" – Cepheid variable stars and type 1 supernova remnants – used for distance measurements, sometimes give wildly differing results. Errors occur because of "blending", where the stars appear to be brighter than they actually are because their image is mixed with that of nearby stars.

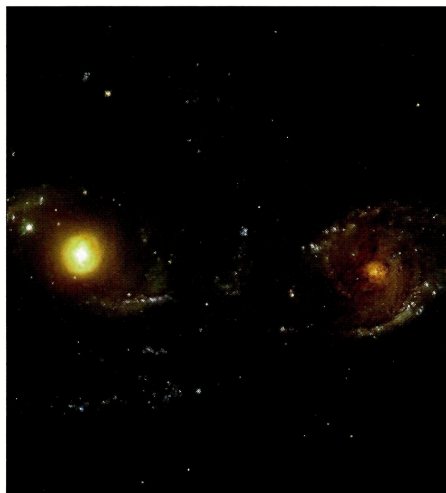
XMM is launched

On 10 December 1999, an Ariane 5 rocket launched the European Space Agency's X-ray multi-mirror satellite (XMM). XMM is Europe's largest scientific satellite. It is 10 m tall and has 120 m² of mirrors, which are coated in a 0.5 µm thickness of gold. The telescope will be the most sensitive in the world. It is set to revolutionize the study of X-ray sources including black holes, exploding stars and gamma-ray bursters (*CERN Courier* July 1999 p13).



XMM prepares for take-off. (ESA.)

The Hubble century



The spectacular universe is revealed by the Hubble Space Telescope: an interaction between 2 spiral galaxies NGC 2207 and IC 2163. (NASA/ESA.)

The name of Hubble will be eternally linked with 20th-century astronomy. At the beginning of the 20th century astronomers knew of planets and stars, and anything else was called a nebula (derived from the German word for fog). US astronomer Edwin Hubble was to change all that.

In his 1936 book *The Realm of the Nebulae*, Hubble said, "They are scattered throughout space as far as telescopes can penetrate. We see a few that are large and bright. These are the nearer nebulae. Then we find them smaller and fainter, in constantly increasing numbers, and we know we are reaching out into space... until, with the faintest nebulae that can be detected with the largest telescope, we arrive at the frontiers of the known universe. This last horizon... is a vast sphere, perhaps a thousand million light-years in diameter."

Until Hubble applied his eye to the new 100-inch telescope at Mount Wilson in 1919, we thought that the universe consisted only of the Milky Way – our galaxy. Although a few bold astronomers talked of remote "island universes", the nebulae were merely clouds on the astronomical horizon. By harnessing the power of the world's largest telescope, Hubble saw a star in the Andromeda nebula that was about a million light-years away, more than



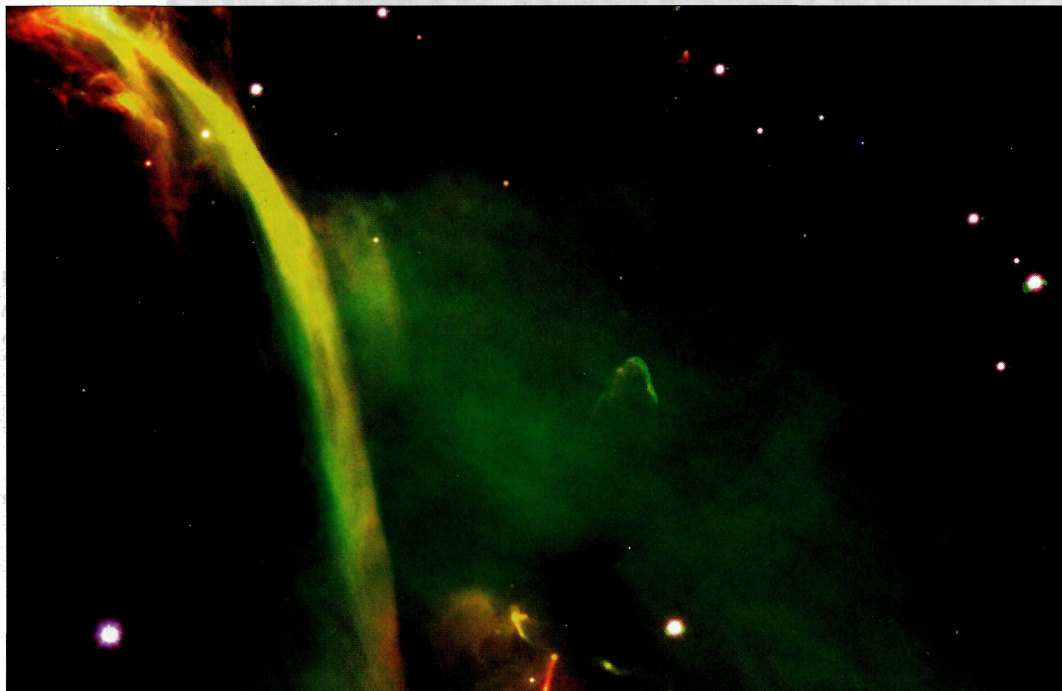
Finding one's place in the world – Edwin Hubble at the Mount Wilson telescope. (Space Telescope Science Institute.)

ten times the diameter of the Milky Way. A curtain had been lifted on a much larger universe. Nebulae – now known as galaxies – are clouds of distant stars beyond the Milky Way.

Having drawn back the curtain, Hubble's work went on to show that this larger universe is continually expanding. In what we now call the "Hubble flow", distant galaxies appear to be rushing away from us. Hubble's law states that the further away the galaxy, the faster it appears to recede. The constant of proportionality – the Hubble constant – fixes the age of the universe. Back in Hubble's day astronomers did not receive Nobel prizes.

The thick blanket of the Earth's atmosphere totally blocks the light from the faintest and furthest stars. In 1990, the first major astronomical satellite to be placed in orbit above this star-blocking layer was aptly named the Hubble Space Telescope. Initially hampered by faulty optics, this new eye on the universe has gone on to reveal images of unparalleled beauty and significance and it has revolutionized optical astronomy in a way that is worthy of its namesake. The Hubble Space Telescope has shown that the universe is about 12 thousand million light-years across. This is not that much bigger than Hubble had described in 1936, however, is far more spectacular than he could have imagined from the images obtained from the Mount Wilson telescope.

Picture of the month



This impressive millennium fireworks display was captured by the Very Large Telescope in November 1999. It is a Herbig-Haro object: a protostar with two jets shooting out gas into the surrounding interstellar medium at velocities of up to 250 km/s. The irregular appearance of the jets suggests that there are periodic outbursts where large chunks of material fall onto the protostar from a surrounding disk.

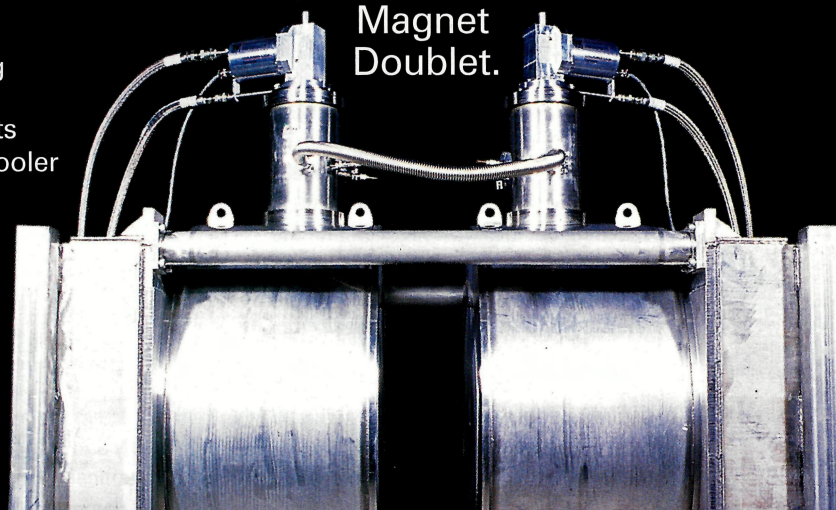
The Very Large Telescopes are run by the European Southern Observatories at the Paranal Observatory, based in Chile.

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