

Polarization brings to light the accretion discs inside quasars

The extreme luminosity of quasars is thought to be generated by supermassive black holes accreting surrounding material at the heart of galaxies. If the accretion has a preferred rotation axis, the infalling gas and dust should eventually form an accretion disc round the black hole. An accretion disc is far too small for such distant objects to be seen in an image, but even its expected spectral characteristics have hitherto not been identified. A new study can now disentangle accretion-disc emission from that of dust, using infrared polarization measurements.

Quasars are the most luminous persistent sources of radiation in the universe. They radiate about 1000 times as much energy as all of the stars in their host galaxy. Such extreme luminosities can be achieved by the accretion of matter by a supermassive black hole. Gravitational accretion is indeed much more effective in radiating energy – typically about 10% of the accreted mass-energy – than the modest 0.7% yields of hydrogen fusion in stars. The accretion could be chaotic with no preferred direction, but the presence of jets stretching over millions of light-years in some quasars indicates a preferred direction, defined by the spin axis of the black hole and/or the rotation axis of an accretion disc



Looking at sunset on Mauna Kea through the infrared polarimeter. (Courtesy UKIRT.)

(CERN Courier July/August 2006 p10).

Nikolay Shakura and Rashid Sunyaev derived the expected emission from an optically thick accretion disc back in 1973. The temperature gradient from the hot inner disc regions to the cooler external parts is expected to emit a spectrum characterized by a spectral index of $+1/3$ ($F_\nu \propto \nu^{+1/3}$), whereas the optical-ultraviolet spectra of quasars have an observed slope in the -0.2 and -1.0 range. This excess of emission in the red part of quasar spectra remained a puzzle for 35 years. Although it was usually ascribed to additional dust emission, it prevented astronomers from finding evidence for the accretion-disc origin of the dominant optical-ultraviolet emission of quasars.

An international team of astronomers led by Makoto Kishimoto from the Max-Planck-Institut für Radioastronomie in Bonn and the Royal Observatory of the University of Edinburgh, has now found the characteristic spectral signature of an accretion disc in six quasars. It discovered a spectral slope consistent with the expected $+1/3$ index in the polarized near-infrared emission of these quasars. The team argues that the emission of the accretion-disc is revealed in polarized light because it is scattered by free electrons in the near vicinity of the black hole, whereas the emission of surrounding dust clouds is not scattered and thus not polarized. The infrared polarization observations have been made with the infrared polarimeter mounted on the UK Infrared Telescope on Mauna Kea in Hawaii.

These results provide evidence that the controversial accretion disc is truly there in quasars and has the expected properties in its outer regions where the observed infrared emission is thought to originate. The optical-ultraviolet emission from the inner regions of the disc closer to the black hole is, however, not yet well understood.

Further reading

M Kishimoto *et al.* 2008 *Nature* **454** 492.

Picture of the month



Does Mars have a moon? Yes, actually two moons, called Phobos and Deimos. However, they are tiny compared with our Moon and are more than likely objects from the asteroid belt extending between the orbit of Mars and Jupiter that ventured too close to the red planet and became trapped in its gravitational potential well. This new image captured by ESA's Mars Express mission shows the surface of Phobos in unprecedented detail. It was acquired by the high resolution stereo camera on 23 July 2008 at a distance of only 97 km. The irregular shape of this moon, which measures less than 30 km in any direction, is further altered by craters and grooves. The latter could be produced by ejecta thrown up from impacts on Mars or by soil slipping into internal fissures. (Courtesy ESA/DLR/FU Berlin (G Neukum).)