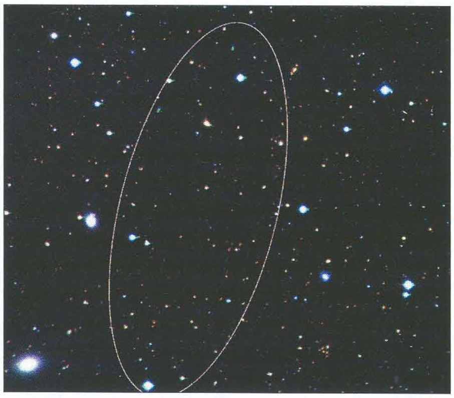
Have we seen the first 'dark galaxy'?

Radio astronomers may have found the first ever galaxy that is composed almost entirely of dark matter. The "dark galaxy", which lies in the Virgo cluster about 50 million light-years away, rotates in the same way as an ordinary galaxy but does not contain any stars (*Astrophys. J.* **622** L21–L24).

Dark matter was originally proposed to explain why galaxies rotate much faster than can be explained by the amount of visible matter they contain. However, since this mysterious material does not emit or absorb electromagnetic radiation, it can only be detected by its gravitational influence on ordinary matter.

Recent advances in radio astronomy have enabled researchers to search for dark matter by measuring the amount of hydrogen in different parts of the universe. Astrophysical structures can then be detected by their gas content alone, opening up the possibility of finding isolated clouds of intergalactic gas with no stars.

Last year a team led by astronomers at Cardiff University in the UK used the Lovell telescope at Jodrell Bank Observatory to detect a new galaxy called VIRGOHI21 that contained a cloud of hydrogen atoms 10^8 times heavier than the Sun. Now, Robert Minchin and colleagues at Cardiff, together with co-workers in Italy, France and Australia, have studied this galaxy in more detail.

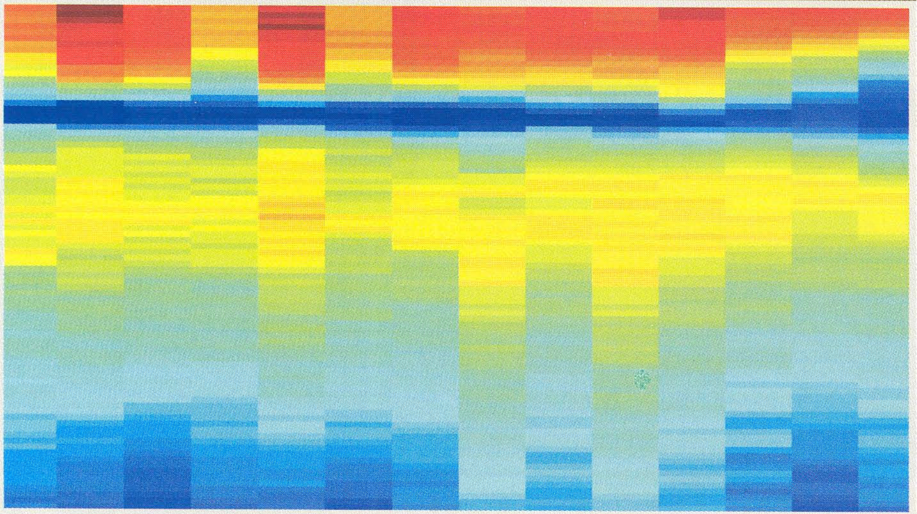


No stars – astronomers expected to see a spiral galaxy in the elliptical region indicated.

Based on the speed at which it is rotating, they calculate that VIRGOHI21 is 1000 times more massive than can be accounted for by the amount of hydrogen it contains. Moreover, if it was an ordinary galaxy, it should be bright enough to be detected at optical wavelengths.

Although similar dark objects have been detected before, these were later found to contain stars or debris from nearby visible galaxies. In contrast, VIRGOHI21 contains no stars, as confirmed by observations with the Isaac Newton telescope in La Palma. The team says that the most likely explanation for this is that the galaxy is made of dark matter.

Photonic crystal plays new tricks with light



Researchers in the US have succeeded in reducing the group velocity of light by a factor of more than 100 in a novel 2D photonic crystal. This image shows the transmission spectrum of the crystal, which consists of an array of 3600 microcavities in a slab of silicon, after it has been illuminated with a laser pulse. The vertical axis shows the wavelength of the transmitted light, while the horizontal axis shows the angle of tilt of the crystal (each column represents one degree with respect to the direction of the incident pulse). Halice Altug and Jelena Vuckovic of Stanford University found a clear signal at a wavelength of 1565 nm over a range of tilt angles (blue band), corresponding to a photonic band gap in the 2D crystal (*Appl. Phys. Lett.* **86** 111102). They also found that the group velocity of the incident pulse was reduced to 0.008*c*, where *c* is the speed of light in a vacuum. This shows that as well as channelling light along certain paths, photonic-crystal arrays can also be used to produce "slow light". Moreover, the fact that this effect was observed over several tilt angles should make it easier to couple the 2D crystal to other components such as lasers or optical interconnects for high-speed computing.

Total reflection doubles up

As we were all taught in high school, a ray of light that is travelling through a piece of glass changes direction when it strikes the interface between the glass and the air, in accordance with Snell's law. If the angle of incidence is less than a critical angle, which is determined by the refractive indices of the glass and the air, the ray is refracted and leaves the glass. However, if the angle of incidence is greater than this critical angle, the ray undergoes total internal reflection and remains in the glass. This mechanism allows light to be transmitted over long distances inside optical fibres, but it is not quite as straightforward as our teachers might have led us to believe.

In his classic book on optics, Newton suggested that such a light ray should be slightly delayed in the second medium before re-entering the first. Some 250 years later, Eugene Wigner predicted the value of this delay, but now Albert Le Floch and colleagues at the University of Rennes in France have measured it in an experiment for the first time. Furthermore, the researchers found that there are in fact two "Wigner delays", and not just one as first suggested by Newton (D Chauvat *et al.* 2005 *Phys. Lett.* A **336** 271).

Le Floch and colleagues began by placing a container filled with mercury along the hypotenuse of a glass prism. They then passed a femtosecond laser beam, which was polarized in a direction perpendicular to the plane of incidence, through the prism onto the surface of the mercury. Wigner delays are extremely short, so they can only be measured using ultrashort light pulses.

Next, the physicists measured how long it took the light beam to be reflected back through the prism using an autocorrelator. Since reflection from a metal does not involve a time delay, this measurement defines the "absolute zero" in the experiment. By repeating the measurement without the mercury, the team was therefore able to work out the difference between the two results and obtain a value for the delay from the glass–air interface.

Le Floch's group found that the delay increased to a maximum of 28 fs as the angle of incidence approached the critical angle of 43.48°. Moreover, when the experiment was repeated with light that was polarized parallel to the incident plane, the delay reached 57 fs. This implies that two Wigner delays must take place when unpolarized light undergoes total internal reflection, which has implications for the recently discovered "left-handed" materials and for materials with photonic band gaps. The team also says that the double Wigner delays should exist for beams of particles such as neutrons.