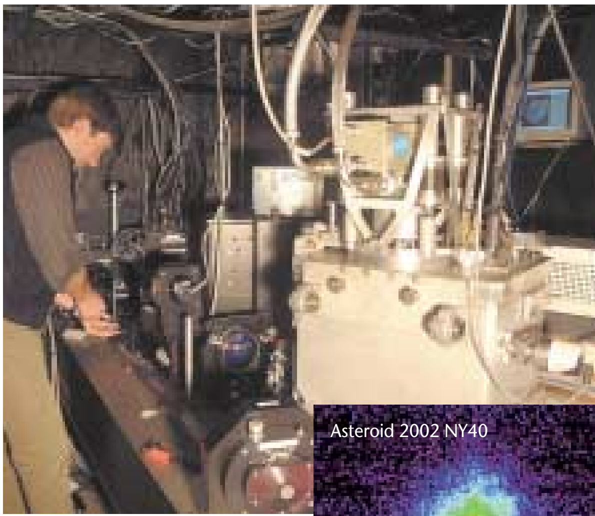
NAOMI focuses on a near Earth asteroid

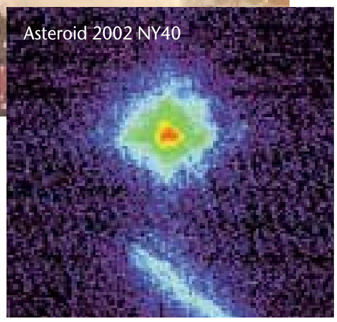
The adaptive optics system NAOMI on the William Herschel Telescope (WHT) in La Palma was recently used to take a remarkable image of a near Earth asteroid. Adaptive optics (AO), whereby an optical system compensates for the blurring effect of the atmosphere to give much clearer images, is revolutionising observational optical/infrared astronomy (*Frontiers* 10, p.5). NAOMI is the first AO system on a UK telescope, and was built by a team from the University of Durham and the UK Astronomy Technology Centre. In good conditions, it can deliver images as sharp as those from the Hubble Space Telescope.

The asteroid 2002 NY40 was observed last August when it was 750,000 kilometres away, twice the distance to the Moon, and moving rapidly across the sky at 65,000 kilometres per hour. Despite the technical difficulties this caused, the astronomers using the WHT obtained very high quality images in the near-infrared with a resolution of 0.11 arcseconds. This resolution is close to the theoretical limit of the telescope, and sets an upper limit to the size of the asteroid, which is only 400 metres across.

Near Earth asteroids are those that periodically approach or cross the orbit of our planet, and there is a very small probability that one could collide with the Earth.



The NAOMI adaptive optics system on the William Herschel Telescope



Asteroid 2002 NY40

Measuring the size of asteroids helps astronomers understand their nature and how they formed, as well as the potential threat they pose. Variations in the brightness of 2002 NY40 suggest that it is highly elongated and is tumbling. Further monitoring of these variations will tell us whether the asteroid was viewed end-on or side-on, thus allowing us to determine the size and shape more precisely.

Physics beyond the Standard Model

Measuring the magnetic moment of the muon is exciting particle theorists

Usually we think that major discoveries in particle physics come from experiments using accelerators that collide particles at the highest energies. Sometimes, however, very high precision measurements at low energies – where new physics may reveal itself as a tiny deviation from the expected value – can be just as powerful. Such is the case for the recent measurement of a subtle parameter, *g-2*, of an elementary particle called the muon, which is a heavier version of the electron, having 200 times the mass. This experiment, carried out at the Brookhaven National Laboratory (BNL) in the US, has revealed hints of physics that go beyond the famous Standard Model of Particle Physics which is the current description of all the elementary matter particles we know of, and three of the four fundamental forces between them – the electromagnetic, weak and strong forces.

The Dirac equation, introduced in the 1920s (*Frontiers* 13, p.17), enabled the electron to be described using quantum theory. A triumph of the equation is that it predicted that the magnetic moment of the electron is proportional to its spin, with a proportionality constant *g*, equal to 2, in units of e/2*m* where *e* is the electric charge and *m* is the mass of the particle. The constant *g* is known as the gyromagnetic ratio.

Later, theorists, Julian Schwinger, Richard Feynman and others, improved the description of the electron, developing a theory in which 'virtual' photons carry the electromagnetic force (quantum electrodynamics). This more developed theory predicts that the gyromagnetic ratio is a little more than 2. To represent the deviation from Dirac's value of 2, it is usual to quote the value of (*g*-2)/2 and call it the 'anomalous magnetic moment'. In fact, the anomalous moment of the electron has now been measured to a few parts per billion and is found, after an heroic calculation, to be completely described by quantum electrodynamics. This is the most precisely tested agreement between experiment and theory that exists in science.

Similar arguments also apply to the muon, but because it is some 200 times heavier than the electron, its anomalous magnetic moment is sensitive to the additional interactions due to the strong and weak forces, felt over only very small distances. Since the quantum field theory description of the electromagnetic, weak and strong interactions is the bedrock of the Standard Model,

The *g*-2 experiment