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NEWS & VIEWS

SOLAR SYSTEM

A planet more, a planet less?

Scott S. Sheppard

Further observations of an object dubbed 2003 UB_{313}, which lies beyond Neptune, show that its diameter is around 3,100 kilometres. This makes it larger than Pluto, the smallest 'traditional' Solar System planet.

The number of objects detected in the Solar System beyond the orbit of Neptune — so-called trans-neptunian objects — is increasing rapidly. This is mainly due to large, sensitive digital detectors on telescopes and sophisticated software, running on high-speed computers, that can detect moving objects. More than 1,000 of these objects have been discovered since the first one — other than Pluto — was detected in 1992. On page 563 of this issue, Bertoldi *et al.*[1] describe observations of the brightest such object, known as 2003 UB_{313}. They find that it has a diameter of about 3,100 kilometres, making it the largest Solar System object discovered since Neptune, and the first known trans-neptunian object larger than Pluto (Fig. 1).

Determining the size of distant objects such as 2003 UB_{313}, which is 97 times farther from the Sun than is Earth, is not straightforward. Pluto was discovered in 1930, but it took decades to get a handle on its diameter: initial estimates put its size at similar to that of Earth, but now it seems that it is smaller than the Moon. As 2003 UB_{313} is about three times farther from the Sun than is Pluto, modern technology cannot resolve it: it appears as just a point of light even in images of the highest resolution.

There are, however, indirect methods for measuring the size of an unresolved object[2]. When sunlight strikes the surface of an object, a fraction of the incident light is reflected back into space. This fraction is known as the albedo of an object and can be observed in the visible region of the electromagnetic spectrum. An object is therefore optically bright either simply because it has a large diameter (and so more surface area from which to reflect light), or because it has a high albedo. To determine the albedo and diameter of an object separately, we need to determine what proportion of the incident light it reflects and what proportion it absorbs. This can be done by measuring the object's thermal radiation, because absorbed incident light warms a body's surface and is re-radiated back into space as heat. At its distance from the Sun, 2003 UB_{313} should receive enough sunlight to have a temperature of about 25 kelvin (−248 °C), the exact value depending on its albedo. At that temperature, a perfectly absorbing and emitting object would emit peak 'black body' radiation at a radio wavelength of around 0.1 millimetre.

Bertoldi and colleagues[1] used the radio telescope operated by the Institute for Millimetre Radio Astronomy (IRAM) in the Sierra Nevada mountain range of southern Spain to make observations at the requisite wavelength, and thus detect for the first time the thermal radiation of 2003 UB_{313}. Combining these observations with observations at visible wavelengths[3], they find that 2003 UB_{313} has a very high albedo, with about 60% of the sunlight that strikes it being reflected back into space. The authors also determined that the diameter of 2003 UB_{313} is 3,100 kilometres (to within 300 km). Pluto's diameter, by comparison, is around 2,300 km.

The diameters and albedos of only about a dozen trans-neptunian objects have so far been measured accurately. Most of these results stem from thermal measurements at millimetre and submillimetre radio wavelengths, or still smaller far-infrared wavelengths, using NASA's Spitzer Space Telescope. The albedos measured range from around 3% to 60%, possibly with slight systematic variations because of modelling uncertainties in the degree to which the objects' surfaces emit thermal radiation in the different wavelength regimes[4–6]. Although the data are sparse, it seems that the largest objects have the highest albedos. This could be because gravity on these objects is large enough for them to have active atmospheres and so be able to retain volatile gaseous substances that could brighten their surfaces.

The trans-neptunian object 2003 UB_{313} is not unique. It is typical of many of the icy

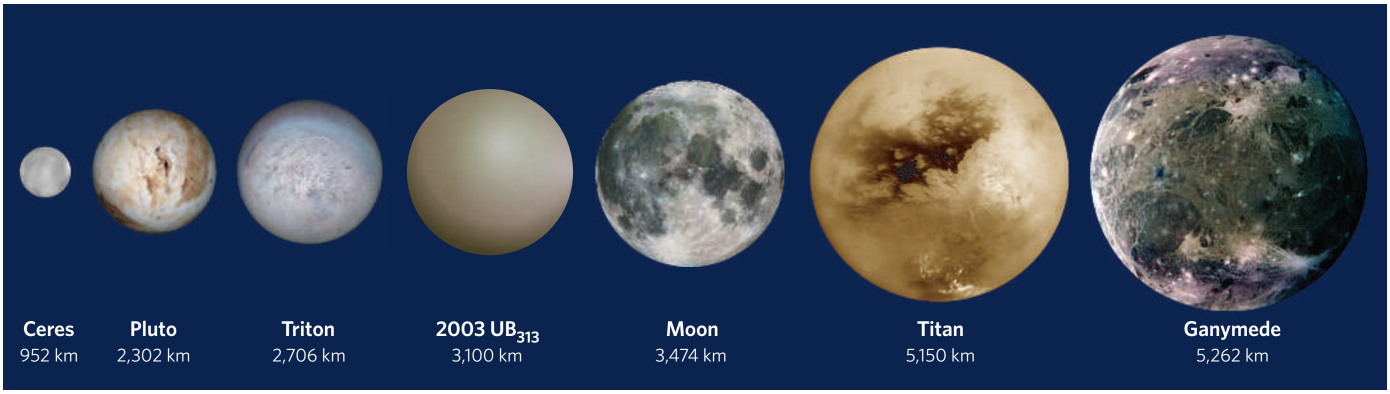

Figure 1 | Size matters. 2003 UB_{313} is currently the fifteenth-largest known Solar System object, with a diameter larger than those of Pluto and the neptunian moon Triton, but smaller than those of Earth's Moon and Titan, the largest of Saturn's satellites. Other objects, besides the eight undisputed major planets, that are larger than 2003 UB_{313} are Jupiter's satellites Callisto, Io, Europa (not pictured) and Ganymede (the largest moon in the Solar System). Behind Pluto, the next-largest known trans-neptunian objects are 2005 FY_9, with a diameter of about 1,800 km, and Sedna (1,700 km). A handful more are larger than Ceres, the largest asteroid in the main asteroid belt between Mars and Jupiter.

planetoids that populate this region of the Solar System — known as the scattered Kuiper disk — in that its orbit is highly elliptical, with a distance of closest approach to the Sun (perihelion) near the orbit of Neptune. This type of orbit is unlike that of Pluto or other objects in the nearer, classical Kuiper belt, but is common to many trans-neptunian objects. Such bodies keep to less-elliptical orbits just beyond Neptune, lying 35 to 50 times farther from the Sun than Earth is. Like Pluto, 2003 UB_{313} has a satellite. Physical observations[3] of the surface of 2003 UB_{313} have also shown it to be remarkably similar both to Pluto and to Neptune's satellite Triton (thought to be a captured Kuiper-belt object), both of which have high albedos and methane ice on their surface.

These observations lead inevitably to the question of whether 2003 UB_{313} itself qualifies as a planet. The minimum size required for this has never been strictly defined. Until the nineteenth century, the term 'planet' was uncontroversial: a planet was any object that had a fairly circular orbit around the Sun, and that did not show any cometary activity such as a coma or a tail. By 1807, the word encompassed Ceres, Pallas, Juno and Vesta, which are in the belt of objects between Mars and Jupiter. In the mid-nineteenth century, the growing number of such objects being discovered caused the term 'asteroid' or 'minor planet' to be coined. A similar situation is now looming with Pluto, 2003 UB_{313} and the rest of the trans-neptunian objects. Although the largest of these are much bigger than the largest main-belt asteroids, they also form an ensemble of bodies of probably very similar formation and evolutionary history.

Whichever way you care to count them, with the discovery and measurement of the size of 2003 UB_{313} there are no longer nine major planets in the Solar System. A committee has been formed by the International Astronomical Union to mull over several competing definitions of the term. One fairly simple solution is that anything orbiting the Sun and larger than a certain minimum size counts as a planet. The size is likely to be arbitrary: a round-number radius of 1,000 km, or perhaps the size of Pluto itself. These bounds stem from a perceived need to maintain Pluto's 'traditional' status as a planet, and would leave us with ten current planets, including 2003 UB_{313}.

A second possible definition is that anything with a high enough mass to be spherical is a planet. Although this is a physical criterion, determining whether or not an object meets it is complicated. It would also increase the number of known planets by several factors. A third alternative is that any object that has a unique orbit (which means that it is sufficiently far removed from other orbiting bodies), and that dominates its local environment gravitationally, should be known as a planet. This definition has the most solid scientific basis, as objects with similar formation and evolutionary histories would be grouped together. It would leave us with eight planets: Pluto would not fulfil the criteria.

A final proposal for what constitutes a planet takes into account the fact that the currently known major planets are themselves remarkably different, and can be split into subcategories. Mercury, Venus, Earth and Mars, for example, are terrestrial planets whose compositions are dominated by rock. Jupiter and Saturn are gas giant planets dominated by their hydrogen and helium envelopes. Uranus and Neptune are ice giant planets, dominated by gases other than hydrogen and helium. The trans-neptunian objects, or ice dwarf planets, are probably composed of large amounts of volatile solids such as methane ice and water ice.

So 'planet' is a term, seemingly, that can be bent to any number of uses. But whatever the planet-definition committee decides will be secondary to the naked fact of our rapidly expanding scientific knowledge and understanding of the Solar System. With further improvements in instrumentation and software, there may be further surprises in store. ■

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MOLECULAR BIOLOGY

Prime-time progress

Stephen D. Bell

DNA is duplicated within a complex macromolecular machine. Insights into how replication begins and how this is coordinated with progression of DNA synthesis come from a diverse range of sources.

DNA is replicated by unzipping the double helix to expose the bases that act as a template for copying the genetic material. Both strands of DNA serve as templates, and thus one double helix becomes two. Conceptually, this is a simple reaction, but the devil — as so often — is in the detail: the process is mediated by a multitude of proteins and turns out to be mechanically complex. A trio of papers in this issue[1–3] have made considerable headway in understanding the intricacies of replication.

One level of complexity in the replication reaction comes from the fact that DNA polymerase, the enzyme that synthesizes the new DNA, cannot begin a strand itself. Rather, it extends a short RNA 'primer' that is already bound to the template. This means that an additional enzyme, a primase, is required to generate the primer to start the polymerase reaction[4,5].

A second complexity lies in the fact that the two strands of the DNA double helix are arranged antiparallel to one another; the opposite directions are termed 5′ to 3′ and 3′ to 5′ (from the positions of carbon atoms in the sugars that make up the DNA backbone). However, DNA polymerase can synthesize DNA in only one direction: 5′ to 3′ (Fig. 1). So the 3′ to 5′ template strand — the 'leading' strand — can readily be replicated, but how is the other, 'lagging' strand copied? This dilemma was resolved by the discovery that the lagging strand is replicated discontinuously. It is synthesized in short pieces, called Okazaki fragments, that are then joined together — essentially, the polymerase takes two 'steps' forward and then synthesizes one back. The

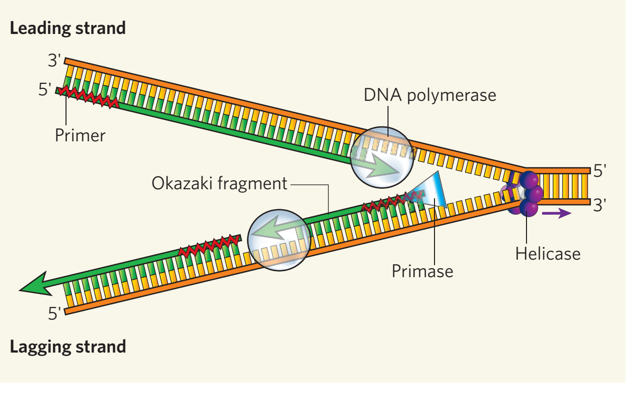

Figure 1 | DNA replication. The helicase unzips the double-stranded DNA for replication, making a forked structure. The primase generates short strands of RNA that bind to the single-stranded DNA to initiate DNA synthesis by the DNA polymerase. This enzyme can work only in the 5′ to 3′ direction, so it replicates the leading strand continuously. Lagging-strand replication is discontinuous, with short Okazaki fragments being formed that are later linked together.