Asteroids, Impacts and Craters

Sun and the Planets

When you sit down and think about the Solar System it truly is a remarkable system. The Sun is the largest body in the Solar System with a surface temperature of about 5,500 ^{o}C beneath which hydrogen undergoes nuclear fusion leading to helium. For almost 5 billion years, this fusion process has produced energy in the form of sunlight upon which the Earth is dependant. All other Solar System objects orbit this colossal energy source. Some of these objects are planets which can be categorised as either the inner or rocky planets (Mercury, Venus, Earth and Mars) or the outer or "Gas Giant" planets (Jupiter, Saturn, Neptune and Uranus). The planets, with the exception of Mercury and Venus, have their own natural rocky satellites that are in orbit around them. For example Jupiter has 64 moons or natural satellites and may have many more that are waiting to be discovered.

Asteroid Belt and Comets

The inner and outer Solar System planets are separated by a region containing a large number of rocky objects, know as asteroids, that are too small to be defined as planets. This region is referred to as the *Asteroid Belt*. Like the planets, these asteroids are in orbit around the Sun. For example the largest asteroid in the Asteroid Belt is Ceres which has a diameter of approximately 1,000 km. In fact like Pluto, Ceres is classified as a dwarf planet. These orbits are generally stable but they can be disturbed through collisions with each other or with objects entering the Asteroid Belt such as rogue asteroids or event comets. The main difference between comets and asteroids is that comets develop a tail when they orbit close to the Sun. This tail is produced when ice in the comet melts releasing water vapour and dust. Most comets tend to be on highly elliptical orbits around the Sun. The most famous comet in the Solar System is probably Halley's comet which has such an elliptical orbit that it visits the inner Solar System planets once every 76 years! The next time it will pass near the Earth will be sometime in 2061.

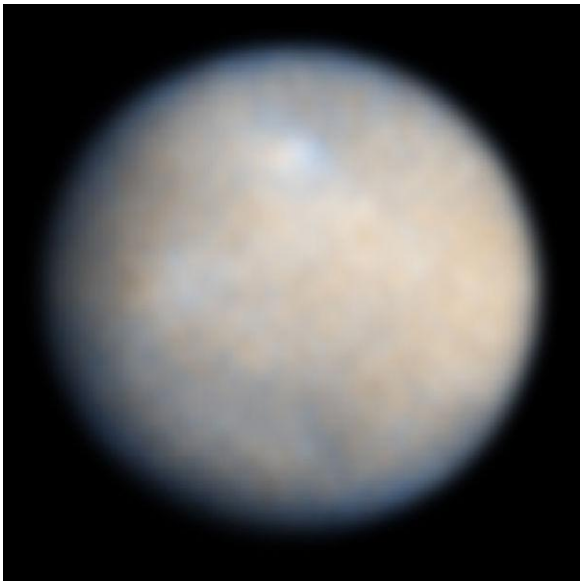

Figure 1: Ceres as seen from the Hubble Space Telescope (from Wikipedia page)

Asteroid or Fragment Impacts

The collisional history of asteroids within the Asteroid Belt has produced a varied distribution of asteroid sizes (Durda, Greenberg, & Jedicke, 1998). Scientists have catalogued nearly all asteroids whose diameters are greater than 10 km (Gladman et al., 2009). Unsurprisingly, there are more smaller asteroids than larger asteroids in the Asteroid Belt. In the Solar System, asteroids are not only found in the Asteroid Belt but like comets they can also be in highly elliptical orbits. It is impossible for scientists and astronomers to say for certain how many asteroids are in orbit around the Sun, but modern astronomical devices are being used increasingly to try to answer this question. Astronomers are most concerned with identifying near-Earth asteroids (NEAs) which are asteroids that could cross the Earth's orbit at one time or another. Of course, if they cross the Earth's orbit there is the chance that they could impact the Earth!

Using telescopes alone would make the task of identifying asteroids with a diameter less than 10 km very difficult. But why are astronomers so interested in identifying objects less than 10 km in diameter? The most recent catastrophic asteroid impact occurred about 65 million years ago when a 10 km asteroid impacted near Mexico. The result of this impact was the extinction of the dinosaurs, an impact referred to as the K-T or Cretaceous-Tertiary extinction event (Ward & Asphaug, 2000). An asteroid impact like the K-T impact occurs very infrequently though. However as there are likely to be more potential moderate scale asteroids that may impact (60 – 1000 m in radius), astronomers have turned their attention

towards cataloguing as many of these objects as possible. Modern technology has been used to develop automated search systems that incorporate CCD (Charge Coupled Devices) sensors which form the basis for modern digital cameras. One such automated system is the LINEAR (Lincoln Near-Earth Asteroid Research) project. The project has detected 226,193 new objects of which 2,019 are NEAs. Figure shows the breakdown of the number of near-Earth asteroids identified by all automated search systems since this method for asteroid identification was first used in 1995.

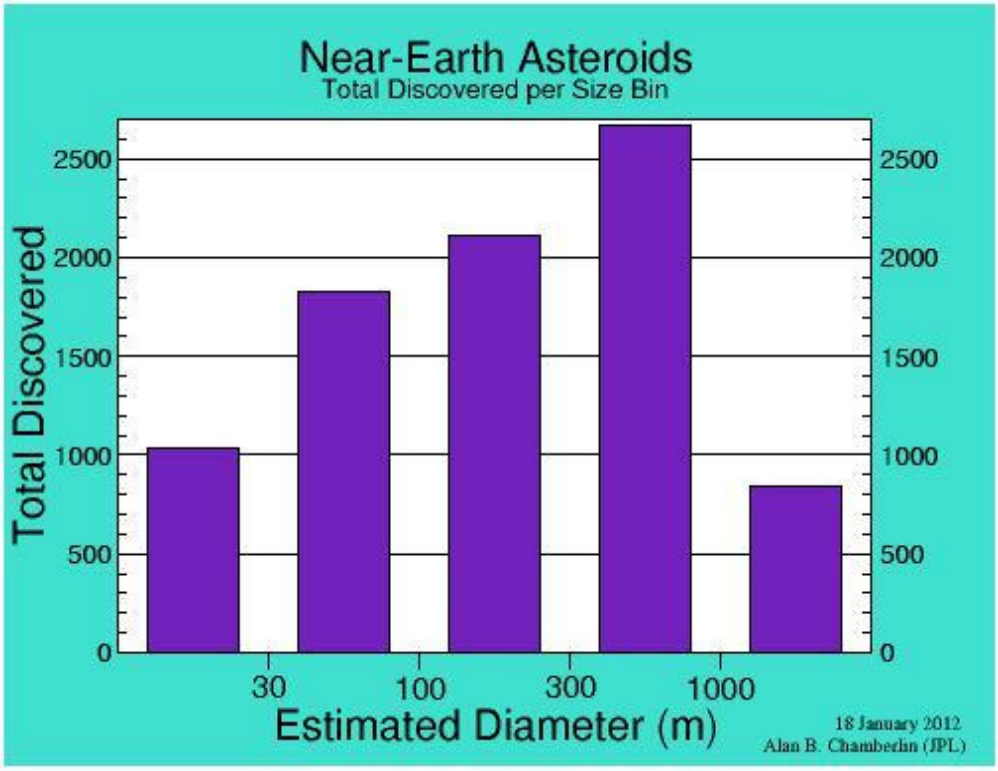

Figure 2: Total known near-Earth asteroids in a number of different bins; 0 m – 30 m; 30 m – 100 m; 100m – 300 m; 300 m to 1000 m and those greater than 1000 m. This figure has been generated by data from JPL and is available at the link http://neo.jpl.nasa.gov/stats/. This figure is updated regularly on the website. Note that this figure was last updated on the 18th January 2012.

Some computer simulations suggest that the probability of a 50 m asteroid impacting a region on the Earth during a 1000 year time period is about 0.0005% (Gladman et al., 2009). Of course this type of asteroids is quite small but it does not mean that we should not be prepared. An asteroid of 50 m could still have drastic effects for the Earth with the loss of life, buildings and roads, towns and cities over a region of approximately 20 km in diameter (Clark R, 2004). Of course if any NEA were to impact on land on the Earth, it would leave an remnant or a reminder of its impact in the form of a crater.

Craters

A crater is a bowl shaped depression or hollow in the surface of the Earth that marks an impact site for an asteroid or other astronomical body (Morgan et al., 1997). An impact crater is formed after the impact of a NEA on the surface of the Earth. However impact craters have also be observed on other Solar System bodies such as Mars, Mercury, the Moon and also on the moons of Jupiter. In the 1960s when the NASA Mariner missions were exploring the Solar System for the first time, scientists were genuinely shocked to observe impact craters on the surface of Mars (Clark R, 2004). The surface of the Moon is dominated by impact craters which are a reminder of a time in the history of the Solar System when impacts were quite frequent. Some of the most important characteristics of craters that interest scientists are their size, the shape and compaction as well as their age.

Figure 3: One of the most recognisable craters on the Earth is the Meteor crater in Arizona, United States.

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