

U3A Astronomy meeting – 25th September 2009

THE MOON

Brief introduction

Until c.1600 AD people could watch the Moon only with the naked eye. What they saw was a bright disk with variable forms, dotted with large dark spots, supposed to be seas or oceans. Shortly after 1600 telescopes began to be used, showing the Moon to be a sphere with a rugged surface full of craters, mountains etc. – and no oceans!

What did the ever improving telescopes learn us about the Moon?

1. About the Moon's size and distance:

Diameter = 3476 km = 27% of the Earth. The Moon's volume is 2% and its mass only 1% of that of the Earth. The distance between Earth and Moon varies as the Moon follows an elliptical orbit. At *Perigee* the distance is 356,400 km, at *Apogee* 406,700 km, average: 384,000 km. As a result the apparent size of the Moon as seen from the Earth varies by 14% (different duration of solar eclipses!).

2. About the Moon's movements:

The Moon orbits the Earth in 27 days, 7 hrs., 43 mins. It does not fall towards the Earth as it moves around at a speed of 3700 km/h. There is a very subtle gravitational balance between Earth and Moon, they revolve around a common centre of gravity. As a result the Moon always turns the same side towards the Earth. In other words: the Moon's rotation period is also exactly 27 days, 7 hrs., 43 mins (no coincidence!). As a result of the gravitational balance, Earth and Moon keep each other in a stable course. Without the Moon – a relatively very large satellite – the Earth would have a far more wobbly course, and, apart from that, there would be no tides on Earth.

3. About the Moon's surface:

The better the telescopes became, the more craters etc. became visible. They are all the result of asteroid-impacts, subsequently filled with lava. Most mountains on the Moon are ring walls around these impact sites. The asteroid bombardments in the young Solar System ended c. 3.8 bn years ago and the Moon's own geological activity died out c. 3 bn years ago. Since then the Moon is geologically dead.

4. About the Moon's formation:

Most popular theory: impact of a Mars-sized object with the Earth c. 4.5 bn years ago, shortly after the birth of the SS. Moon was formed out of the debris, both from the Earth's crust and from the meteorite.

Which new elements brought the Space Travel Era (since c. 1960)?

- We could finally observe the 'back' of the Moon
- We could get a proper impression of what the 'moonscape' really looked like
- We could map the Moon in much greater detail than before
- We could bring rocks from the Moon to Earth and study them in laboratories.

Apollo 11

On 21st July 1969 astronauts landed on the Moon for the first time. The astronauts Armstrong and Aldrin took enormous risks. One important point was that it was impossible to have proper tests with the moon lander, as you could never simulate lunar gravity on Earth. And a second point was that nobody knew exactly what the lunar surface was made of. If the *Eagle* had landed and been trapped in a thick layer of dust, it might never have escaped. Also we shouldn't forget that the computer age had only just started 40 years ago. So the risks were far greater than they are with all manned space flight at the moment.

After these two, ten more astronauts walked on the Moon during five further missions. Nobody expected at the time that no new trips would be made during the next 40 years. However, five years ago, President Bush announced plans for new manned space flight, in 2020 to the Moon and by 2030 to Mars – without indicating where the money would have to come from. It is called the *Constellation Project*. But recently President Obama reduced the NASA budget and thus made it uncertain if, or when the project may be carried out.

Over the past 40 years we have learned a lot more about the Moon thanks to several unmanned missions – not only from America, but also from Russia, China and India.

The most recent one was NASA's *Lunar Reconnaissance Orbiter* – or LRO, launched last June. By the end of June the first pictures, of an astonishing quality, were received.

News

Shuttle missions towards the International Space Station

On Wednesday 15/07 the shuttle *Endeavour* finally started its journey to the ISS, on its 6th try! The mission was very special as it was the first time that 7 astronauts joined a Space Station crew of 6! So for about two weeks there were 13 people up there. They carried out a very full program of work, because, with the shuttle program ending next year, NASA has tried to pack as many things as possible into this mission.

Then, on 28/08 the shuttle *Discovery* was launched towards the ISS. Once again, a lot of work was carried out at the Space Station, after which the shuttle landed safely after its return into Earth's atmosphere, not in Florida – because of stormy weather - but in California. This means that, again, the shuttle had to be transported to Florida on the roof of a special Boeing 747.

First Japanese supply ship arrives at the ISS

Some weeks ago an unmanned Japanese cargo spacecraft arrived at the ISS. This sort of 'space trucks' from American and Russian origin have been in use for some time already, but this was the first time that a Japanese one was used. The new thing about it was that it did not dock with the Space Station – as the others do – but that it was plucked from its orbit at about 30 feet from the SS by a Space Station astronaut using a robot arm.

Solar eclipse

The full solar eclipse which took place on the 22nd of July in a band running from India towards China and Japan was very special because of its long duration, not the usual 2-3 minutes, but a full 6 minutes. This was because the size of the Moon as we see it from Earth varies up to 14% (with the varying distance between Earth and Moon) and was almost at its largest in July.

Comet hits Jupiter

On the 20th of July – the anniversary of the Moon landing – a huge comet or asteroid hit Jupiter. It had a diameter of about a mile and a quarter and it vaporised on impact. As the outer layers of Jupiter (1300 times larger than Earth) are made of gas (H and He), the object 'only' caused huge waves in the atmosphere, visible as a big dark smear, which was blown away in about a week's time. The huge collision was first discovered by an amateur in Australia.

Jupiter at opposition

The last two months were a very good time to observe the Solar System's largest planet, as it was 'at opposition' on 14/08. Jupiter was, and still is a very bright object, low in the southern evening sky.

Saturn's equinox

On 11th August Saturn had its 'equinox', when the Sun stood directly above Saturn's equator, thus illuminating only the c. 10 metre thick edge of the rings. This happens once every 15 years, twice during the 30 year orbit around the Sun. This, however, was the first time that a spacecraft – *Cassini* - was present to observe the event from nearby. The biggest surprise was the discovery that there are ridges and bumps of icy particles extending above and under the rings for up to 3-4,000 metres.

New telescope breaks world record

On the 24th of July, King Juan Carlos of Spain opened a new huge telescope on La Palma in the Canary Islands. The diameter of its mirror, which consists of 36 hexagonal segments, measures 10.4 metres, its surface is 75 sq. m. (the biggest mirrors until then, of the Keck telescopes in Hawaiï, measure 10 metres). This new big one on La Palma will certainly not be the last. A new generation of even much larger telescopes is under way. In 2018 a 30-metre telescope is set to be completed in Hawaiï, and the ESA have plans for a 42-metre telescope.

Life building material in comet dust?

In February 1999 the *Stardust* spacecraft was sent towards a comet in the SS with the aim to bring back to Earth some of the material from the comet's tail. The spacecraft reached the comet in 2004, and flew through its tail, collecting dust particles on tennis racket-like structures covered with aerogel. These instruments were put into a capsule that detached from the spacecraft and returned to Earth, to land in the Utah desert in January 2006. Last month came the news that glycine, an amino acid, had been discovered in it, which is a fundamental building block of life.

This discovery supports the theory that some of life's ingredients formed in space and were delivered to Earth long ago by meteorite and comet impacts. And if that could happen on Earth, why not then also on other planets within or outside the SS?