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Postcards from Libya

Mike Frost popped over to Libya just before Christmas for a clear view of the Geminid metor shower, his report starts on page 9

Top, The prettiest desert oasis visited

Centre, The magnificent ruins of Leptis Magna

Right, The inevitable group shot

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Dropping a Clanger

By Mike Frost

Our intuition about how gravity works is hampered by the inconvenient fact that we live on a planet covered with a thick gaseous atmosphere. Admittedly, an atmosphere comes in useful for other reasons, like breathing. But for the purposes of understanding how objects fall freely under gravity, an atmosphere is lousy.

The problem is air resistance. Jump off the top of a cliff and you'll feel weightless – but only for a split second. Air resistance then kicks in, resisting acceleration and limiting downward velocity to a terminal value. Usually, jumping off a cliff, you don't have enough time to appreciate this effect before the ground rudely interrupts your experiment. But leap out of an airplane, and you'll have time to appreciate the effects of air resistance. Alternatively, you can simulate "free-fall" parachuting in a vertical wind-tunnel, where the force of the wind is enough to keep you suspended in the air. It may be fun, but it isn't free-fall.

There are ways to overcome terminal velocity, and experience true free-fall, but they are expensive. To give astronauts a few minutes of training in weightlessness, NASA's famous "vomit comet" punches its way through the atmosphere, forcing its way along the parabolic path that an object in true free-fall would follow.

Because of our inability to experience true weightlessness at Earth's surface, we have developed the idea that free-fall is something that happens "up there" in orbit. The popular press, without a clear idea of the science, will have you believe that as you leave behind the Earth's atmosphere, you also "escape Earth's gravity", and that is why you are weightless. But that isn't true.

Do you remember a rather silly show on Channel 4 in 2005, hosted by Johnny Vaughan, called *"Space Cadets"*? A number of hapless reality show contestants were persuaded that they were going to fly into orbit. In reality they were confined to a flight simulator. The show's producers had the interesting challenge of explaining to the contestants why they were still going to feel gravity. They were told that their flight was only into "Low Earth Orbit" and so, disappointingly, gravity would still be present. I don't know whether any of the contestants were suspicious of that, but they should have been. The International Space Station is also in Low Earth Orbit, only 220 miles up, barely above the top of the atmosphere, yet its inhabitants are completely weightless.

The reason why astronauts feel weightlessness is not that they have escaped gravity; on the contrary, gravity's pull is still present, but in orbit astronauts are able to fall freely under its influence, something we are unable to do on Earth for more than an instant. On a planet without an atmosphere, the distinction between weightlessness in orbit and weightlessness whilst falling disappears. Jump from any height on the Moon, and you will feel completely weightless all the way down, until the moment you hit the ground. The Apollo astronauts, for example, were weightless each time their bounding strides took their feet off the surface.

Conversely, a spacecraft could orbit the Moon only meters up, in perfect weightlessness. Douglas Adams was right when he said *"there is a knack to flying. The knack is learning how to throw yourself to the ground and miss"*. Indeed – and on the Moon, you can achieve this by falling to the ground, whilst simultaneously throwing yourself sideways at 2000 m/s. At this speed, as quick as you fall towards the lunar surface, it recedes from you at exactly the same rate because you are simultaneously heading tangentially away from the surface.

In essence an orbiting spacecraft is falling around the Moon. And because of the lack of atmosphere, the spacecraft could do this at a very low altitude indeed. You could orbit the Moon just a meter up, low enough to reach out and brush the surface as you flew past, yet you would still be perfectly weightless. The only problem is a minor geographic inconvenience - the Moon is not a perfect sphere. So a spacecraft orbiting at a height of one meter would soon crash into a hill.

This scenario is no longer purely a theoretical flight of fancy. The SMART-1 spacecraft, launched by ESA in September 2003, was designed to test new technologies, including an ion engine, which produced very low thrust, enabling the spacecraft to be gradually manoeuvred into a lunar orbit. Over the course of months, this orbit was lowered closer and closer to the lunar surface, before the spacecraft slammed into the Moon's surface on September 3rd 2006. SMART-1 landed at an extremely shallow angle, barely a degree above horizontal. For the last few minutes before it crashed into a hillside, it was falling freely, barely metres above the ground. Any astronaut who had

gone along for the ride on SMART-1 (there were none) could have exited the spacecraft and then pushed gradually away. With great care, they could then have positioned themselves just above the ground, perhaps brushing it with a finger as it hurtled past, all the time remaining completely weightless.

Moreover, you could have stood at the top of the hill that SMART-1 crashed into, and watched the spacecraft orbiting – beneath you – in weightlessness, whilst you yourself felt the lunar gravity. The difference is that SMART-1 was falling sideways, fast enough to avoid hitting the ground (until its luck ran out), whilst you, already standing on the ground, would have been unable to fall free.

Indeed, you could even have built an arch high enough to allow SMART-1 to pass beneath. This allows an intriguing experiment; a quick way of getting into orbit on airless planets. Simply pick a lunar satellite in a very low, stable orbit, and build an arch big enough to allow it to fly under. Then climb to the top of the arch, wait for the satellite to pass beneath, and, picking your moment carefully, jump off the arch, and land on the satellite. Provided the satellite is more massive than you, you won't deflect its path unduly. Suddenly you will find yourself in glorious weightless orbit!

There are a few technical difficulties to overcome, of course. Suddenly losing the vertical speed you gained during your jump may be a little painful. Mind you, it won't hurt half as much as acquiring the tangential speed of the spacecraft. Landing onto an orbiting spacecraft involves throwing yourself in the way of a spacecraft travelling at bullet speed, two kilometres a second. You'll need some way cushioning the blow. A net, perhaps, like the ones which used to catch the trackside post on a mail train.

So, before risking your own neck, you might be tempted to try the experiment with one of the woolen-based creatures known to exist on Moon-like planets. But that would be dropping a Clanger.

Monty Python's *The Meaning of Life* Film from 1983

The *"Galaxy Song"* by Eric Idle

A few months ago the Monty Python's film *The Meaning of Life* was broadcast on TV with the wonderful *Galaxy Song* by Eric Idle about half way through. Here are the words for you to sing along with . . .

Whenever life gets you down Mrs. Brown,
And things seem hard or tough,
And people are stupid, obnoxious or daft,
And you feel that you've had quite enough . . .

Just . . . , remember . . . , that you're standing on a planet that's evolving,
Revolving at 900 miles an hour,
It's orbiting at 19 miles a second, so it's reckoned,
The sun that's the source of all our power.

The sun, and you and me, and all the stars that we can see,
Are moving at a million miles a day.
In an outer spiral arm, at 40,000 miles an hour,
Of the galaxy we call the Milky Way.

Our galaxy itself contains a 100 billion stars,
It's a 100,000 light years side to side.
It bulges in the middle, 16,000 light years thick,
But out by us, its just 3,000 light years wide.

We're 30,000 light years from Galactic Central Point.
We go round every 200 million years,
And our galaxy is only one of millions of billions,
In this amazing and expanding universe.

The universe itself, keeps on expanding and expanding,
In all the directions it can whizz,
As fast as it can go, the speed of light you know.
12 million miles a minute, and that's the fastest speed there is.

So remember when you're feeling very small and insecure,
How amazingly unlikely is your birth.
And pray that there's intelligent life somewhere else in space,
Cos there's bugger all down here on Earth!

Into the Goldilocks Zone

By Ivor Clarke

If you read any old books on astronomy and the formation of our solar system they will assume that we live in a typical type of system around a fairly typical type of star. All the small rocky planets would have formed close-in near the star and all the gassy big ones far out in the cold dark outer reaches of the nebula cloud. And it all made perfect sense.

The planets coalescing nearer to the star would have a lot of their water and gasses evaporated off by the forming star as it ignited and started to burn. This would have prevented them from gathering up large amounts of hydrogen, ammonia and methane, keeping the mass of these bodies smaller by blowing these gasses further out; away from the newly formed sun. Even though the new sun would not be burning with its full intensity, it would still cause huge changes in the dust cloud from which it had formed. A new solar wind would quickly push away small smoke size particles of dust and let the heat reach further out into the cloud. The time from the star forming to establishment of a solar system is still uncertain, but must be several hundred million years.

Further out from the heat of the new sun, the gasses and water molecules would not be heated into such an excited state that would cause the hydrogen, water, ammonia and methane ices to boil off the surfaces of the forming planets so that they could escape into space. So the outer planets would have formed from lots of gasses which couldn't have stayed for long on a hotter body. As their size grew, their greater mass would have attracted more and more gasses and dust to add to their bulk until they had cleared out their area around their orbit.

So depending on the stars size and heat, at a certain distance large gas planets would form out in the cold outer reaches and nearer in, all the small rocky ones. Great idea.

But now this seems all wrong. All of the above ideas have been chucked out and discarded with the discovery of so many gas giants in close orbits to their stars. At the moment we know of just over 400 extra solar planets, with the number rising quickly. The first to be discovered was in 1995 orbiting a normal sun like star, 51 Pegasi. Since then the list has grown, see graph page 7, with more being added almost daily. Nearly all of these have been discovered by the radial velocity method as shown by the dark blue colour in the graph.

There are now around 85 extra solar planets for which their mass has been estimated, this can only be done if a determination can be made of their size as they eclipse the star. An estimate can be made of the orbit by timing the light dip of the star when an eclipse happens. This gives a proximation of the size of the body if the distance is known, from this a mass can be determined. Spectra can show whether the planet has an atmosphere or not by comparing the spectrum of the star with the planet eclipsed and then when it's without and on the other side of the star. This will only be possible at the moment with very large Jupiter+ type gas giants with thick atmospheres. Even so, only the most sensitive instruments will show any difference in the spectra.

For the radial velocity method to work at present requires a very large body to orbit close to its parent body. The radial velocity method employed measures the wobble of a star as the centre of mass changes as the planet orbits the star. The amount of change is only a few meters a second. In our solar system only Jupiter has enough mass to have a centre of gravity outside of the sun's volume, with smaller planets like Earth the centre of mass is well inside the star. So heavy large planets close to the star cause more wobble as the C of G moves with respect to us around the star with each orbit of the planet. So they are easier to detect. It will take years to detect planets with orbital periods such as the orbital time periods of our solar systems

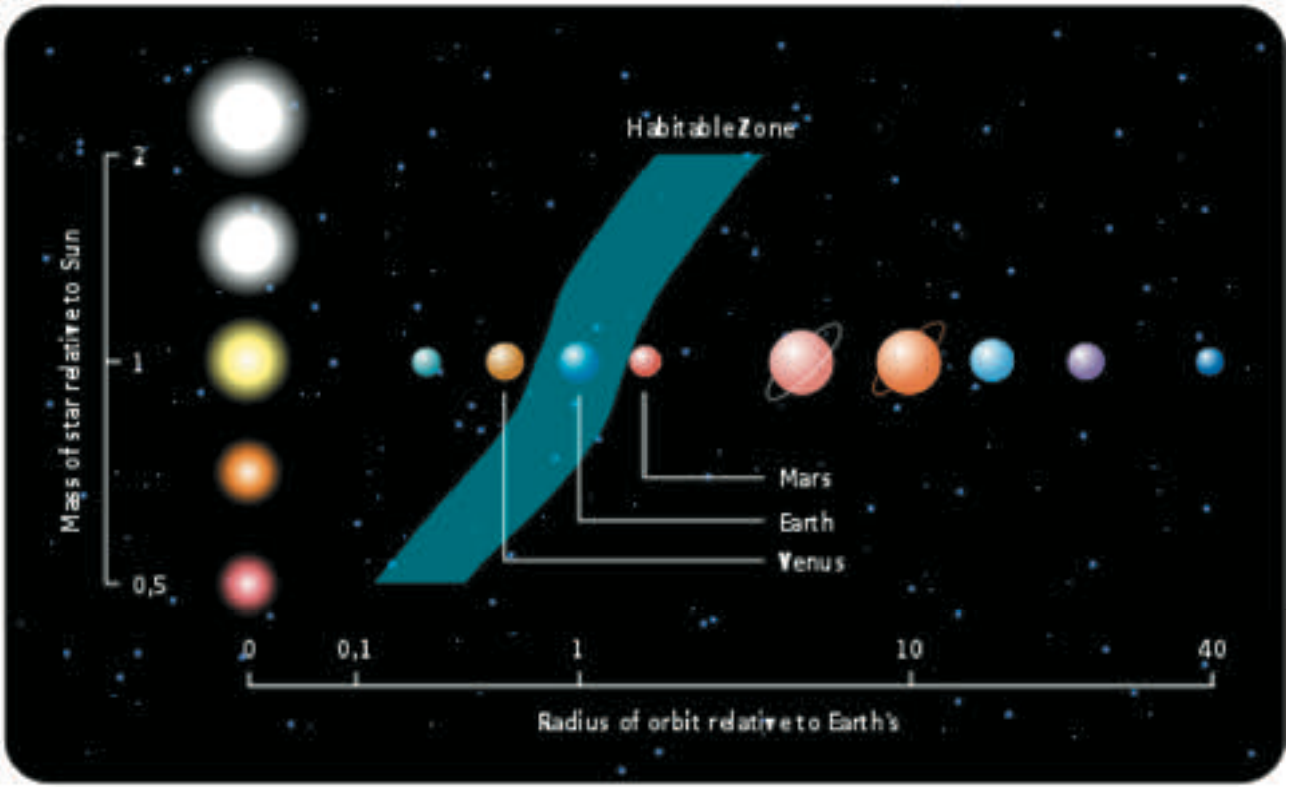
outer planets, with Jupiter at 12 years and Saturn's 29. But of cause all of these techniques will improves in the future as telescope detection systems improve and new space born telescopes come on line.

The Goldilocks Band

Around all the stars is an area called the Goldilocks Band. This is an area of space without extremes of heat or cold, which is known as the habitable zone. Mostly this is an area of space around a star in which water can be a liquid on the surface. With water you can get life, this may not mean large deep oceans and seas, just as long as there is a ready supply which can last long enough for life to start. It is believed that simple life started on Earth soon after the Moon was formed and the surface had cooled enough for water to collect and cool down the molten rocks caused from impact of the two bodies. It seems that most of this water would have arrived in comets hitting the planet during the heavy bombardment period which lasted millions of years. Several hundred million years would have passed from the Moon's formation with this bombardment continuing until about 3.9 billion years ago.

In our solar system the Goldilocks zone, which obversely includes the Earth extends inwards about 5—10 million miles and outwards almost to the orbit of Mars. So we are getting close to the innermost edge of the zone. Venus is not in this band as it orbits too close to the Sun at 66 million miles. And we all know how hot Venus is! This band is not fixed for all time, but slowly moves out from the star as it ages. Since our star lit up 4.65 billion years ago, it has increased in brightness by about 20%, so this has moved the Goldilocks Band outwards, away from the orbit of Venus where it was when the sun lit-up, into our region. Now the band starts about 85 million miles from the sun and extends almost into the orbit of Mars at about 120 million miles (Mars orbit varies between 128 and 155 million miles from the Sun). If Mars was 50% larger with a stronger gravity and thicker atmosphere it would almost be in the habitable zone now. As it is Mars with only 30% of Earth's gravity as let slip its atmosphere and lies cold and barren.

As most of the extra solar planets found have been gas giants, it is not expected that they would harbour life anyway: *"not as we know it Jim"*. The big surprise was how close to the star they were orbiting. Most are going round in just a few days, only a few million miles from the star, with one, CoRoT 7b in just 20.5 hours! The planets atmosphere temperature so close to the star must be in the hundreds of degrees Celsius and this would cause large amounts to boil off



into space. So the life time of these planets atmospheres must be a lot shorter than the planets in our system. All would be tidily locked with one face always turned towards the star with furious winds of hundreds of miles an hour whipping round the planet.

As we have just seen, most of the ex-solar planets are very close to their star. This bias is properly caused by our searching methods in that we have found the easy ones first. The interesting ones will be the ones in much longer orbits further from the star and well into the Goldilocks Band, so have very small wobbles and much harder to detect. Small rocky planets like ours will only show up with far more sensitive instruments than we have at present. Gas giants are far easier to spot. And we have found lots of them.

Large Gas Giants in the Zone

But suppose a gas giant lies in the Goldilocks zone; and has a supply of large moons like our Jupiter or Saturn have. What would conditions on the surface of them be like? In the new James Cameron film *Avatar*, the Earth like planet / moon Pandora orbits a blue gas giant planet orbiting around the Alpha Centaui star system. In the film most of Pandora seems to be nice and warm with lots of life with a huge bio-sphere to equal our tropical rain forests. As the Alpha Centaui stars form a three star system with A having about 10% more mass than our sun and B about 10% less. C, Proxima is a small sub-dwarf star with a mass of about 12% of the Sun lying 0.2 Light Years away from the main pair. A and B orbit in just under 80 years at a distance of 11AU, similar to the distance of Saturn. This would give the possibility of planets orbiting each star out to the orbit of Mars. So maybe Pandora exits? As yet we have not detected any.

It is most likely that all planets above the size of say Neptune will have strong magnetic fields which can capture radiation and particles from the solar wind. It is safe to assume that the larger they are the more powerful will be the magnetic field and amount of radiation in the belts surrounding the planet. Let us also suppose the moons are like Jupiter's four Galiliean satellites, Io, Europa, Ganymede and Callisto at about the same size and distance. So lets give Jupiter a big heave and plonk him down in a Goldilocks zone. What would it look like?

A Goldilocks Jupiter System?

So to start with Io the nearest one in, forget it. Not only would the same problems exist as on Io now, with multiple volcanos erupting everywhere, all caused by the internal heat generated by the gravitational pushing and pulling of Jupiter and Europa on each orbit. But the biggest problem is that Io lies within the Jupiter radiation belts, orbiting just 262,000 miles from Jupiter. These radiation belts would be lethal to all types of life with intensity levels 10,000 times Earth's Van Allen belts. Up to 200,000 rads was recorded by Pioneer 10; only 500 rads will kill a human. We must assume that all large gas giants will have large radiation belts associated with them, trapped in their magnetosphere, so it won't be a good idea to get too close to them.

Io is pulled by the gravity of Jupiter and Europa and Ganymede which are in a 1 - 2 - 4 orbital resonance. Every time Ganymede goes round Jupiter once, Europa orbits twice and Io 4 times. This causes stress on these moons as they are pulled first by the gravity of Jupiter one way and the other way by the outer moons. All this stress on the moon causes friction by the flexing of the body due to the gravitational pulls of the moons on each other and friction makes heat. In the case of Io this causes the extreme volcanic surface with a molten sea of larva over large parts of its surface.

Next outwards lies Europa around 416,000 miles from Jupiter and looks like a cracked icy world. At 1,900 miles in diameter it is smaller than our Moon but has a greater density and has a similar escape velocity of 1.5 miles per second. By putting Jupiter into the Goldilocks zone, the heat from the sun would cause all the ice to melt so it would have a deep ocean covering all the surface with large tides washing around it. Europa also experiences gravitational flexing as it passes the other moons in orbit and this must cause heating in the interior rocks, heat that would build up and must be released. Would large underwater volcanoes shed black smokers into the ocean and push up volcanos to the surface like the Hawaiian Islands on Earth? One characteristic it shares with Io and the other three moons is that it is tidily locked with the same face always facing Jupiter. With an orbital period of 3.5 days all of the surface of Europa would receive plenty of warm sunlight during an orbit as the moon revolves around Jupiter.

Like our Moon always turning the same

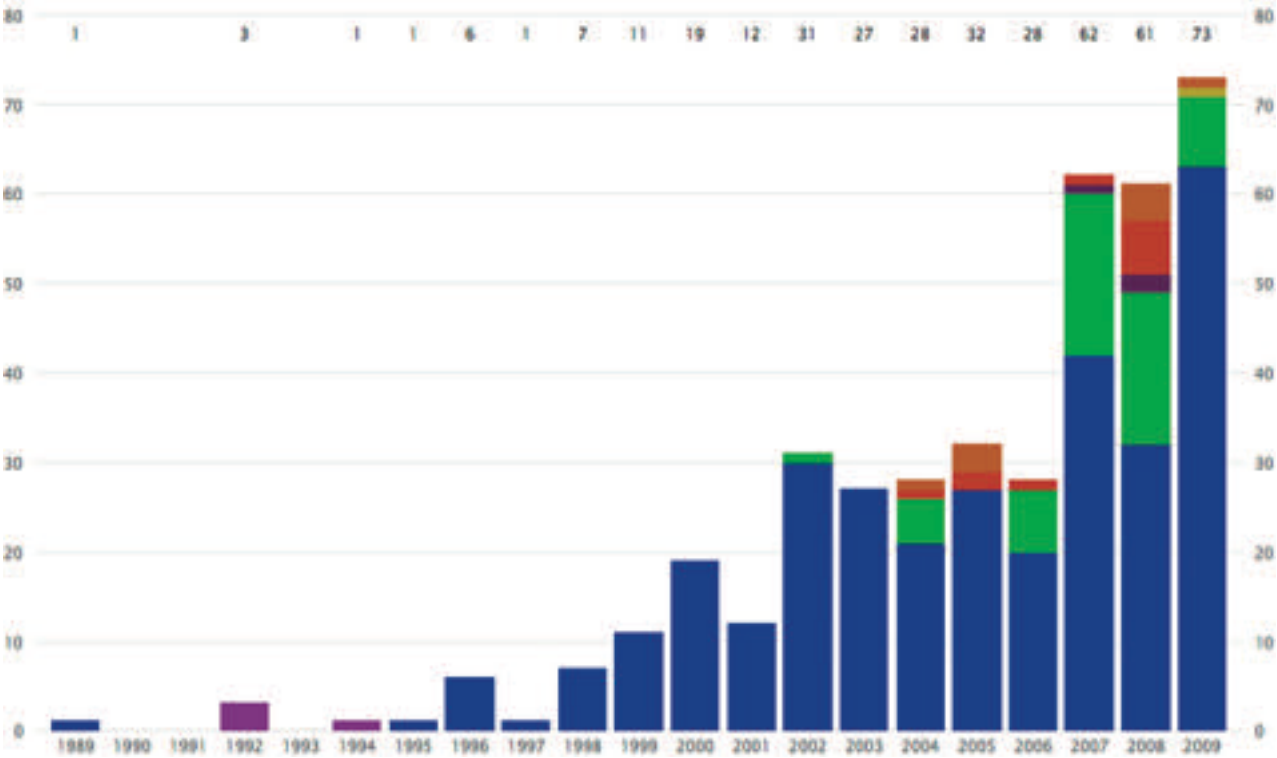
face towards us, all of the Moon gets lit by the sun during each 29 day orbit. As the facing side reaches mid-day there would be an eclipse of the sun as the moon passed through Jupiter's shadow. This only lasts for a short while and would not cool the moon to much before it returned into sunlight. Would there be any land exposed? Would there be an atmosphere?

Good questions. If the temperature was great enough to melt the ice and form an ocean, there would be an atmosphere of some type, however thin or thick, depending on its composition, to help stop the ocean evaporating away into space. Just because the moon has a weak gravitational pull may not necessarily mean a thin atmosphere. Titan, Saturn's largest moon has a dense nitrogen atmosphere filled with clouds of methane and ethane at a pressure of 1.5 bar. We don't know how much water and ice are on these moons but there is a lot, far more in proportion to their size than Earth. The small size of these moons means a low gravity, all of them not far off the same as the Moon. So the atmosphere would leak away into space slowly. Whether this would happen to quickly for life to evolve is difficult to say. It properly all depends on the surface temperature and the amount of liquid available.

Ganymede is the largest moon in the solar system, larger than Mercury and Pluto at 3,300 miles in diameter. It orbits at 665,115 miles from Jupiter well out of the deadly radiation zones in just over 7 days. This also is an ice covered moon; but in our new Jupiter II system, an ocean covered world. How deep would the water cover Ganymede? Current estimates based on the *Galileo* spacecraft flybys, put the thickness of the ice to be 500 to 600 miles thick!

All of the moons of the outer planets seem to be very ice rich, but not all of it would be water ice. Because the surface temperature now is around 140°K (-133°C) at Jupiter and 96°K (-177°C) at Saturn, at these temperatures many other gasses would be frozen solid. The pure gasses of Hydrogen freeze at 14.2°K (-259°C), Neon at 24.7°K (-248°C), Oxygen at 50.5°K (-222°C) and Nitrogen at 63.3°K (-210°C). The mixtures Methane, CH_4 freezes at 91°K (-182°C), Ammonia NH_3 and Carbon Dioxide CO_2 doesn't freeze until near 195°K (-77°C).

The last large outer moon is Callisto orbiting at 1,168,200 miles from our Jupiter. It is about the same size as Mercury, just under 3,000 miles in diameter but has only a third the mass, another watery moon taking nearly 17 days to complete an orbit. Even though it lies far from Jupiter it is still locked in a synchronous rotation period with Jupiter as are most moons orbiting their planets, always showing the same side to the primary. The surface of Callisto at present is



Number of extrasolar planet discoveries per year as of November 2009. Key: radial velocity = dark blue, transit = dark green, timing = dark purple, astrometry = dark yellow, direct imaging = dark red, microlensing = dark orange, pulsar timing = purple.

one of the oldest in the solar system with one of the most heavily cratered surfaces known. But this would quickly vanish in our Jupiter II setup, replaced by a deep ocean and thin atmosphere.

So we need to find larger moons, nearly Earth size to have a fighting chance of harbouring for a long time, a life giving bio-sphere that's got a chance to evolve above the blue/green algae level. This means a stable sun, a stable system and probably, a good deal of luck.

A New Earth?

If a Earth like moon was orbiting a gas giant in a suitably orbit lets look at what else is needed. First off the main star must be a stable one not much larger than ours so that it has a long life in the billions of years. This will give life a chance to evolve at the same pace as it did on Earth. Is this a typical time scale for life to develop? We have no idea as we have only Earth as a guide. Different environments may have a far greater rate of change on life evolving. If the star is a small M class or larger K type, its life time will be 10's of billions of years, plenty of time to spare, to evolve. This assumes that the star and planet remain fairly stable and don't suffer any effects from nearby nova or other stellar disasters! Our G type star has a lifetime of about 8 - 9 billion years before it puffs up into its red-giant stage which by then most of the solar system would be a no-go area for life. As it's only about half way through its life, it still gives lots of time for life to develop into many other ways.

A small M class star like Proxima Centauri or Gliese 581 would have a much smaller habitable zone than a brighter star. Its surface temperature are in the 2000°K to 3500°K range with its habitable zone inside where Mercury and Venus orbit. A planet orbiting in its Goldilocks zone has billions of years to develop. With the stars lifetimes thousands of times that of our sun, life could proceed very slowly indeed. No doubt creatures would evolve with senses more in tune with the red sunlight than we can image.

With K class stars like Epsilion Eridani the zone extends from inside Venus orbit out to ours, with the stars surface temperature of 3500°K to 4900°K. Our Sun is a G class with surface temperature of 4900°K to 6000°K. F class stars like Canopus or Procyon with 6000°K to 7400°K have a life of around 6 - 9 billion years depending on their mass so they are stable enough for life to develop. Also they have a larger habitable zone further from the star which will last a long time. All of this gives millions of stars in our galaxy the possibility of having life giving planets orbiting them. Just because a moon is orbiting another world should not discard it as one of the many places we can look for life. Until we can find other life on other planets or moons we are just guessing. We only have our planet as an example and we know that life started as soon as it was possible. As long as an environment can stay stable enough for life to respond to the challengers of climate change, ice ages, volcanos, earthquakes etc. it will survive and flourish.

But all of this assumes that life is similar to Earth based life, carbon, water based life. We may be in for a big surprise!

In a few hundred million years time the Earth will be getting to warm and be near to the inside edge of the Goldilocks zone, too close to our ever brightening sun for life to survive much longer. Mars will be, by then, into the habitable zone as the zone slowly moves outwards deeper into the solar system. Unless the good folk in the far distance future can move the Earth out nearer to Mars's orbit, the oceans on Earth will start to evaporate as the planet becomes to hot to support life. So is it possible to *move* a planet? To keep Earth at a constant temperature would require it to be moved every 5,000 or 10,000 years a few tens of thousand miles further out from the sun. This is where gravity assistance becomes useful in the opposite way to now. We use the Earth, Jupiter and other planets to accelerate spacecraft to reach targets by using their gravity to push the craft into a slightly different direction by using a close pass to transfer energy from the planet to the spacecraft, so adding speed. This adds to the spacecraft the energy lost by the planet. As the planet is trillions of times the mass of the spacecraft the net result is lots of speed for the craft and a tiny loss of speed for the planet. Thus balancing the books. By doing this in reverse, energy could be *given* to the planet by multiple passes of small bodies. This could be done easily by using a small moon or asteroid to make many close passes of the Earth so by importing extra orbital energy as in a gravity assist manoeuvre. Mass drivers on the small moon would deliver it into the correct orbit for it to make the necessary passes over many years. Always adding to the orbital energy of Earth while slowing down the small moon on each pass. By using the rocket motors on the moon to increase speed again for another close pass in a years time repeatedly for many years thus slowly nudging the Earth further outward, keeping our planet safely in the habitual zone.

Libyan Geminids

By Mike Frost

My bosses at work decreed that this year we couldn't carry over any holiday to 2010, so I had a few days to use up. What better than to go to Libya, on a trip organized by Astro-Expeditions, to see the Geminid meteors?

We flew from Gatwick to Tripoli with Afriqiyah Airways – no, I've never heard of them either - and then from Tripoli to Sebha, in central Libya, with Libyan Airways. We had a scheduled four-hour stopover at Tripoli, but one of our passengers had a dodgy passport and had to be removed from the flight, so we were late leaving Gatwick. In Tripoli, I was first through into arrivals to meet our guide, Hamid, who was resplendent in flowing Tuareg robes. He had arranged a meal for us in the airport restaurant, but time constraints meant that we took the meal as hand luggage on board the next flight. Our other attendant, considerably less flamboyant, was our security guard, Ahmed. We never did find out whose security he was guarding; ours or Libya's. Possibly both.

Sebha is a city of 130 000 in central Libya. The airport is overlooked by a fort built by the Italians on one of the few hills in the vicinity. We joined our drivers for the next few days, in a collection of land cruisers, and sped off into the night. Of course we were intrigued to see what the skies were like, and the first part of the journey was disappointing. For a desert road, the Sebha road was surprisingly well-populated, and the concept of appropriate lighting didn't seem to have percolated to the home and business owners, who illuminated the sky with bright lights. Nonetheless the roadside gradually seemed to become more agricultural and just after midnight we abruptly turned off the metalled road and shot off into the desert.

Our camp, Ubari, was a mile or two north of the road. Two rings of tents surrounded a central area, initially set up to serve us tea, but later used as our viewing location. My initial impression of the camp, as I sipped sweet tea, was disorienting – we seemed to be surrounded by two-storey blocks. But as we were taken to our accommodation the scale became clearer. The "blocks" were really large size tents, and what I thought were two rows of windows were simply decorations on the canvas. In reality our tents were comfortable en-suite dwellings, cool on entry but toasty once you had snuggled under a duvet.

Once settled in our tents, most people returned to the centre of the camp for an hour or two of observation. The Geminids do not peak sharply, so even though the main viewing night was expected to be twenty-four hours later, we enjoyed perhaps twenty shooting stars during the hour I observed. Our tour leader, Sheridan Williams, had brought along a laser pointer, and was able to give an impromptu tour of sky highlights. But we had had a long journey, and a busy day awaited, so I turned in at 1:30am.

I was up not long after dawn the next day. There was still a rosy glow to the sky. I climbed up the nearest dune and took some photographs. The Ubari camp was on the edge of the desert. From height you could see signs of occupation in the distance, back where we had arrived from, but from the camp it appeared that we were completely surrounded by sand.

After breakfast, we set off on a land cruiser safari into the sea of sand. The desert extends north for hundreds of miles, and if you look at it on Google Earth, you'll see huge parallel dunes, miles apart. From ground level, you don't get such an impression of geographical order. There just seems to be sand everywhere! Our drivers, fortunately, knew where they were going and we headed off in convoy into the desolation. The sky was overcast and so warm clothing was necessary. After several miles we gradually dropped into a valley and vegetation began to appear, first an occasional bush, then a depression

filled with palm trees and date bushes. Finally, gloriously, we arrived at an oasis – a dash of green and brackish water in the middle of red desert. Half an hour later, a second lake, with steep dunes behind it. We took lunch here. The restaurant had snowboards available for hire.

In the afternoon the sun at last came out, and in short order we went from gloves and scarves to T-shirts and sunglasses. The convoy headed straight up to the top of the dunes and a hair-raising decent into the next valley. Here was the prettiest oasis, with a mirror like view of the dunes in the water – and the ugliest oasis, which was all but dry and so consisted of a square mile of dried-up mud.

On arrival back at camp, it was about 45 minutes before sunset. One of my ambitions for the holiday was to observe a sunset over the desert – to attempt to spot the elusive "green flash", the vivid green ray of light from the top segment of the setting sun, which can be seen over land in the right conditions. I persuaded five of my fellow travelers to join me on a dune overlooking the camp, with a clear western horizon. Unfortunately, and as usual, although we had a clear sunset, there was no green flash.

After an evening meal, we set up for the evening session observing the Geminids. We assembled in the centre of the camp. There was a ring of comfortable couches, on which we made ourselves at home. Within the ring a small number of observers set up telescopes and cameras. Sheridan, our tour leader, had a camera set up to take a wide-field shot every 10 seconds. Other photographers had specific targets to photograph in between watching for meteors.

I had two or three items on my to-do list. I had never before seen Neptune and I knew that it was in the same field of view as Jupiter (as it was when Galileo observed the moons of Jupiter in 1613, when he recorded the undiscovered planet as a background star). I was shown the field of view through a "birder" scope, and taken star-hopping to Neptune, although I wasn't able to distinguish it as a planet, either through its lack of twinkling, or showing a blue disk. Mars was also up in the sky, and some early birds spotted Mercury before it set.

I also wanted to identify the zodiacal light. Whilst watching for the Leonids in 1999, other observers the next day had remarked on how strong this was, and so I must have seen it but not registered it. This time, we seemed to be in luck. As the sky darkened, there was a definite glow to the west.

But of course the main show was the meteors. Even the photographers and telescope users spent the majority of their time watching the whole sky in anticipation of the next streak of light. Right from when we started observing, shooting stars could be seen at a rate of about one a minute. As we started, the radiant in Gemini was low in the east and rising; but of course meteors could be seen anywhere in the sky.

I observed for around four and a half hours, from after 9:30pm to just short of 2:00am. Throughout that time the meteor rate was steady; there was perhaps a gradual increase but not a sharp peak. There were a few bursts of two or three meteors in quick succession; also several brighter meteors, although nothing really outstanding. I wasn't counting but those who were had made it to 200 meteors by the time I gave up. With binoculars I was able to visit old friends like M31 and M42, and slightly more difficult targets like the Triangulum spiral. As we were further south, we could see a little lower in the celestial sky than usual, and so I took a look around Canis Minor, Lepus and Eridanus. Annoyingly, the glow in the west which we had taken to be the zodiacal light persisted throughout the night, and eventually we had to concede that it was probably light pollution from nearby villages. It's dispiriting that you

can't even escape this in the middle of the Sahara.

By popular demand, we had a lie-in the next morning, with breakfast around 9:30 and breaking camp at 11:00. We headed west to the nearby town of Gerba, where the museum was shut, and then to the archaeological site featuring burial pyramids of the Garamantians, a desert civilization who traded with the Romans. After lunch we headed back to Sebha, breaking our journey at a rather depressing zoo. In the evening we flew back to Tripoli and drove to the coastal town of El Khums – yet another late finish! – in preparation for our final day, visiting the magnificent ruins of Leptis Magna.

Many of my friends (including Tony & Geoffrey from this society) visited Leptis during the solar eclipse tour in 2006, and gave the site rave reviews. And Leptis lived up to its billing! At its highpoint it was one of the largest cities in the Roman Empire, a trading post with the nomads of Africa, but there was always a struggle with the sandstorms which eventually buried the city and preserved it until Italian archaeologists excavated it last century. Much of the city remains buried, but among the areas which have been restored are the amphitheatre, the forum, the baths and the basilica. What impressed me most was that I could explore on my own and not encounter anyone else for half an hour at a time.

After lunch of camel and couscous, we returned to Leptis to visit the stadium. Leptis Magna was constructed from stone hewn from a seaside quarry. The quarry was then turned into a huge stadium, comparable to the Colosseum in size, with a Ben-Hur style racetrack next to it. After climbing down to the racetrack you can pass beneath an arch, and then enter the central arena of the stadium through a tunnel, just as the gladiators would. I gave an impromptu rendition of Russell Crowe's "Husband to a murdered wife, father to murdered children" speech from Gladiator, but fortunately there was no-one to give thumbs-up (or down) to me.

After Leptis Magna, everything else was going to be an anti-climax. The coach went on to Tripoli, where we checked into an imposing luxury hotel on the sea-front. The hotel was an administrative nightmare – keys didn't work, allocated rooms were already occupied. A gale howled outside the windows. We paid the briefest of visits to the souk to shop for trinkets, and then dined in a fish restaurant overlooking Tripoli's Roman remains. And the next day we were on a flight back to Gatwick.

This was only the briefest of breaks, but I enjoyed it hugely. The meteors were about as good as I expected. The Land Cruiser safari was excellent, Leptis Magna outstanding. The company of my fellow travelers was very enjoyable and our guide entertaining. Not a bad way to spend a few days before Christmas!

Michael McNeil submitted the following report to "*The Astronomer*": -

Location was in the central Sahara in Libya, near Ubari, which is a two hour drive from Sebha. I was with a group of 20 people. On the night of maximum, skies were excellent, despite some local light pollution, with overhead limiting magnitude of around 6.25.

The night prior to maximum, I saw 15 meteors in a brief watch of 25 minutes commencing at 23.00UT.

On maximum night, 13/14th December, I watched from 19.30 until 01.00 UT or 5.50 hours including a brief 15 minute break. During this period, I counted 355 Geminids of varying brightness, a large number being fast faint meteors. There were a number of bright events, with trails, as bright as mag -2.5. Rates increased as the radiant rose, but I estimate a ZHR of 120 overall, taking into account the increasing elevation of the radiant and sightings missed by me, but seen by other observers. The incidence of bright events increased during the last hour of my period of observation, as did the frequency, I would estimate to ZHR 180. One bright event at mag -2.5 left a trail visible for 10 seconds and another bright turquoise teardrop was seen also at mag -2.5. 12 sporadics were witnessed, one at mag -3.0, breaking up into 6 identifiable pieces with a trail of 45 degrees.

Interesting sightings were made of Mercury (at sunset), Saturn, Mars and Jupiter and Neptune in same field of view with a small wildlife spotter scope. Zodiacal Light was suspected, but later put down by all to distant light pollution and there was a negative result for the Green Flash, despite ideal conditions.

I also conducted another ''Orion Star Count'' which I believe was a BAA initiative in January 2007. From my local area then, I only achieved a count of 25 stars, with a limiting magnitude of 5.25. In Libya, I managed a count of 38, despite a limiting magnitude of 6.25 which I must probably put down to slightly poorer eyesight over the past 3 years. Who knows?

Sheridan's automatic camera took 600 exposures during the observing, from which a grand total of 2 meteors could be seen. One of them is reproduced with his kind permission. Taken on a Canon EOS 450D with a 10 – 22mm lens, 30s at f4.5, at 1600ASA on 13/12/2009 at 20:07:18pm.

Alan Hancocks came across the following article when he looking back through his files to prepare his eulogy for John Pedrick at the January meeting. We thought the society might find the cutting entertaining.

The piece is a short newspaper article by the columnist Mandrake. This is probably the Mandrake column in the Daily Telegraph, but we don't know when it appeared; the late 60s or early 70s are most likely.

I am however quite happy to confirm that the Green Flash is a genuine, if elusive, phenomenon, and I invite anyone who want to know more to attend one of the lectures I give on the subject. The next one is to Chipping Norton AAG on June 21st.

Mike Frost

Watch for that Flash

By Pendrake

Does the Green Flash exist? There are men, particularly old Middle East Hands, who swear that if you watch the sun as it dips below the horizon there is a startling green flash when it finally disappears. There are others who swear it is all a figment of the imagination brought on by over-indulgence in duty-free Scotch.

Certainly there are two of Mandrake's colleagues who, when posted to Cairo, would take up their position every night on the balcony of their hotel overlooking the Nile. There, they would watch the boats drift downstream and discuss the events of the day while waiting for the Green Flash to flash.

The trouble was that they usually became so immersed in other things that they forgot to watch for the flash.

One of them has imported this practice to his English golf club and gathers his club members around him on the balcony to watch for the flash as the sun disappears over the brickworks.

Some people swear they see it. Others say it is all one great con job, and a third look at him pityingly while suggesting that long hours spent under the desert sun have addled his brains, and the only Green Flash he sees comes from behind, not in front of, his eyes.

But he is not shaken. It exists, he argues. He has seen it in Cairo, Tel Aviv, Beirut, Hongkong, and – on one never to be forgotten occasion – in Eastbourne.

But does it really exist? Is it a scientific fact? Can anybody resolve the mystery of the Green Flash?

Please ...

ON PLUMBING AND PHILOSOPHY

An excellent plumber is infinitely more admirable than an incompetent philosopher.
The society which scorns plumbing as a humble activity and tolerates shoddiness in philosophy because it is an exalted activity will have neither good plumbing nor good philosophy.
Neither its pipes nor its theories will hold water.

Excellence ---------- John W. Gardner

When I first read this little gem many years ago, the thought struck me that if the substitution 'astronomer' is made for 'philosopher' then it is even more relevant to our world. Since an astronomer are scientists -- and scientists were once called a natural philosophers -- and natural philosophers are a sub set of philosophers -- well, the cap fits!

Sent in by Dennis Spratley