



July 2010

ARMAGH PLANETARIUM

# ASTRONOTES

Incorporating **FRIENDS' NEWSLETTER**

The summer starts here!

Ireland's monster telescope

The sky this month

Gravity: Apples and comets

Target: Jupiter!

# The summer starts here!

By Julie Thompson, Digital Theatre Manager

Our planet has reached that special point in its orbit where we at Armagh Planetarium launch our new shows for the summer. What are we presenting for your edification and delight?



Image Credit: Evans and Sutherland

## Catastrophes of the cosmos Our latest exciting show.

How about the ultimate in disaster movies? We all love to watch massive destruction from a comfy chair, knowing the world is still going to be there when we leave the theatre. "Violent Universe: Catastrophes of the Cosmos" reveals the skies to be home to potential deadly dangers to us all. Comets, asteroids, and meteors hurtle through space and sometimes collide with planets, including Earth. Stars collapse under their own gravity and detonate as supernovae unleashing deadly radiation across light years. Even more alarming are the gamma ray bursts, infernos of nuclear energy spraying lethal beams through space. Our Universe can be a scary

place. Created by Evans & Sutherland, this thrilling show is narrated by Sir Patrick Stewart (no stranger to exciting space adventures, he appeared in "Dune", "Lifeorce" and an obscure sci-fi TV series some of you may remember 20 years ago). "Violent Universe" is an exciting introduction to some of the galaxy's most dramatic events, describing their causes and consequences with some gorgeous full-dome visuals. This show gives the audience front-row seats to witness the ways the world could end!

## "Join the Little Yellow Star on his adventures"

A much gentler but just as exciting experience can be had in our other all new show, "The Little Yellow Star". Specially produced by us at Armagh Planetarium, this is a live show aimed at pre-school aged children and their grown-ups. With the help of the presenter, the audience will join the Little Yellow Star on his adventure in the night sky, meeting many of the wonderful animals who make up the star patterns as he goes. This is a free show designed to introduce little people to the stars and constellations in a fun way. More details and trailers of these and our other shows can be found at <http://armagh-planetarium.com>



## Boldly going Balloon astronauts made by our visitors.

Image Credit: Julie Thompson, Digital theatre Managers

planet.com/html/shows\_now\_playing.html .  
(Remember pre-booking of shows is essential).

Apart from this summer's shows, there will be attractions including live presentations by the education staff and guided tours of the As-tropark. For younger visitors, why not celebrate

the Space age by making your own rocket or balloon astronaut or even recreate your favourite constellations like Cygnus or Cetus with your own balloon model? Whatever the weather this summer there will be adventure and excitement here at the Planetarium!

# The July night sky

by Mary Bulman, Education Support Officer

This is a wonderful time of the year to indulge in a bit of stargazing. You may have to stay up pretty late but your dedication will be rewarded with some beautiful star patterns. This is also the time of year to see our Milky Way galaxy at its best as it is almost directly over our heads. Four planets can be clearly seen this month. After sunset Venus, Mars and Saturn are visible in the western sky for a couple of hours, their presence getting shorter and shorter as the month progresses. Around the middle of the month Jupiter becomes visible in the east from 11pm and continues to grace our skies for a while. If you can't find Jupiter, at the end of the month it can be seen moving across the night sky in tandem with a waning gibbous moon and should be a very enjoyable spectacle. On 13 July you may just be lucky enough to get a look at Mercury at dusk, west of Castor and Pollox.

Speaking of planets, in 1995, the first of over 460



**Satellite's eye view** Nobody really knew what the "Milky Way" was until around 300 years ago telescopes revealed it was made of thousands of stars. Nowadays we have telescopes in orbit. In this image the COBE satellite shows the plane of our Galaxy in infrared light .

known planets outside our Solar System was observed. The star 51 Pegasi is the first star that was found to have its own planet. Such planets are known as exoplanets and this one is unofficially called Bellerophon. It has half the mass of Jupiter and is so close to its parent star that the star almost grazes it. The planet's temperature must be very, very hot. This star, 51 Pegasi, as the name suggests, is to be found in the constellation of Pegasus, the Flying Horse of Greek mythology. This pattern can be seen in the east in the summertime. It is easily identified by the four bright stars which make up the Square of Pegasus, one of the delights of the night sky. Another summer favourite is Cygnus, the celestial swan. Cygnus is one of the constellations that does look like what it is supposed to represent. The bright star Deneb (of Summer Triangle fame), marks the tail of the swan and its outstretched wings and long neck are easily seen on a clear night. Cygnus can be found high in the sky in July.

**"In the northern hemisphere  
July to September is the  
best time to see the Milky  
Way"**

Flowing through Cygnus we can see something with the naked eye that is quite spectacular. It is the Milky Way galaxy. The densest part of the northern Milky Way runs along the swan's back. What we see with the naked eye is like a band of white dust strewn across the sky. In the northern hemisphere, July to September is the best time to see the Milky Way. Early astronomers were

puzzled by a region within the main band that is apparently devoid of stars, known as the Cygnus rift. We now know that rather than an absence of stars, this is a region where layers of dust block light from the distant stars reaching us. There is a similar dark region in the southern Milky Way known as the Emu in the sky (more on this in a future issue).

In fact everything we see in the sky with the naked eye is within the Milky Way, (apart from the Andromeda galaxy which is just visible with the naked eye). Because our Solar System is inside the Milky Way galaxy we cannot observe it from outside but only study it indirectly.

Structurally it is a barred spiral galaxy, a bit like a giant Catherine wheel firework with four main arms. It is at least 100 000 light years (about 31 kpc) in diameter (for more information on distances in space see my article in the April Astronotes). The spiral arms are called Cygnus, Perseus, Orion and Sagittarius. Our Solar System is situated on the edge of the Orion arm. The centre of our galaxy has a strong concentration of stars which form a 'bulge'. Astronomers think that this bulge surrounds an action packed, enormous black hole. Observations using radio telescopes provide us with information about the centre of our Solar System. Until the 1920's it was generally believed that there was only our own galaxy. Edwin Hubble (1889 – 1953) demolished that idea. We now know that there are thousands of galaxies in distant space. In 2004 the Hubble Space Telescope (named of course after Edwin himself) took a very important and impressive long exposure photograph, known as the Hubble Ultra Deep Field image. In this image at least 10,000 galaxies can be seen in a very small dark area of the sky in the southern hemisphere known as Fornax.

As I have been focusing on Aboriginal myths of the sky I cannot finish my article without telling you how the Aboriginal people view this band of light in the sky. Forget about milk squirting from a goddess's breast across the sky, think instead of a celestial river where the bright stars are fish and the dimmer ones are water lily bulbs. The legends and stories about the Milky Way are many and varied. The Kurna of South Australia and indeed many other groups see the Milky



Image Credit: NASA, ESA, SSC, OMC, and STScI

**Looking corewards** In this image infrared light and X-ray light see through the obscuring dust to reveal the turbulent heart of our Galaxy. The entire image width covers about one-half a degree, about the same angular width as the full Moon.

Way as a stellar river. They called it Wodliparri (wodli = hut, house, parri = river) and believe that positioned along the river are a number of dwellings. There is also a Loch Ness monsterish tale of a dangerous creature known as a yura lurking in the dark patches. The Kurna call these patches Yurakauwe, which literally means "monster water." These areas represent waterholes and billabongs and according to tradition getting too close to or swimming in these places is a foolish thing to do as the yura would pull you down into the deep, dark, murky waters. This seems to me a good story to make children aware of the dangers of water.

“...the stars began to dance and arrange themselves in time to Priepriggie’s song”

Every culture has its heroes and in Queensland we come across the Aboriginal celebrity Priepriggie famed for his songs and music. When he sang, the people danced to the rhythm until they dropped with exhaustion. Everyone said that he could even make the stars dance. One morning when he speared a flying fox, its companions attacked him and carried him up to the sky. When his friends missed him they decided to perform his dance hoping for his return. However they could not capture the rhythm. Suddenly they heard the sound of singing in the sky. As the rhythm grew louder and louder the stars began to dance and arrange themselves in time to Priepriggie’s song. Thus the Milky Way was cre-

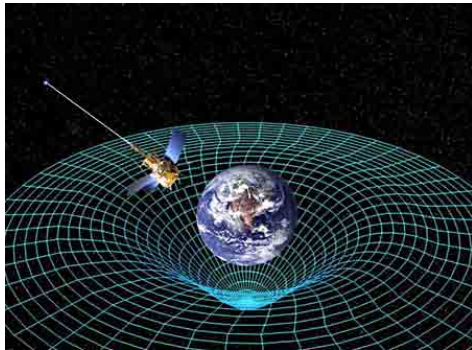


of gravity. In Newton's definition, gravity acts instantaneously between two points, however Einstein's Special Relativity says that nothing can travel between two points faster than the speed of light, which we know is not instantaneous (see later in this issue).

Einstein later came up with the General Theory of Relativity (1915) which says that matter and energy, change the shape of space and time, and the distortion is experienced as gravity. In lay-mans terms, mass curves space. In all honesty Einstein's relativity theories would need an entire article themselves to explain them. For more information see <http://www.einstein-online.info/>

“travelling to space...results in a very different experience of gravity ”

What we are used to feeling here on Earth is taken as being a standard measurement of gravity called 1g, this is the acceleration towards the ground due to gravity which is approximately  $9.8 \text{ m/s}^2$ . We measure all other forces of gravity in



**A warp in space-time** The Gravity Probe B is a Joint Project between NASA and Stanford University, which was launched 20 April 2004. The probe's gyroscopes measure two effects predicted by Einstein. One is the geodetic effect, which says the Earth's mass warps local time and space like the weight of a bowling ball would dent a rubber sheet. For more information go to [http://www.nasa.gov/mission\\_pages/gpb/index.html](http://www.nasa.gov/mission_pages/gpb/index.html).



Image Credit: NASA

**Oranges in orbit** Astronaut Edward M. (Mike) Fincke, NASA science officer aboard the International Space Station, juggles fresh fruit in the Destiny laboratory. The microgravity environment of space proves to be an ideal location for some tasks not so easily accomplished in Earth's gravity.

this unit, g. The force of gravity on the moon, for example, is about  $1/6g$ .

Astronauts experience gravity very differently to other people. When on Earth they experience the standard 1g but travelling to space and living in space result in very different experiences of gravity. In a Space Shuttle, the engines must reach a thrust that allows them to overcome the force of gravity and then continue into orbit. This means that during lift-off, astronauts experience 3g (1g is that of gravity).

In space, and when living on the Space Station, an astronaut's experience of gravity changes again. At this greater distance, the pull of gravity from the Earth is weakened, but his lesser amount of gravity is still pulling the astronauts towards the Earth, at the same rate as the Space Station. This leads to a situation similar to someone in a dropping lift. While the lift is falling at the same rate as gravity, any person inside the lift would then appear to no longer experience the force of gravity, and the person will float in the air. The advantage of the Space Station is that it is so far from the Earth that as it falls the Earth rotates away from it at the same time, meaning that it never gets any closer to the surface. The Space Station will stay in a stable orbit around the planet without any extra thrust at all.

# Target: Jupiter!

By Martina Redpath, Education Support Officer

On 3 June 2010, Jupiter, the largest planet in our Solar System, was struck by... something. This impact created a bright flash of light that was detected by amateur astronomers Anthony Wesley from Australia and Christopher Go from the Philippines. So what was this flash of light and why didn't the professionals notice it?

This mysterious light captured in both photographs and video was most likely a meteor (like the shooting stars of the night sky), striking the clouds of Jupiter and thus producing this bright flash as it disintegrated. In an extraordinary coincidence, the same amateur astronomer Anthony Wesley also discovered a similar impact the year before, and the news confirming that an asteroid caused the 2009 impact was released on the same morning of this recent discovery. The bright flash of light was seen where the South Equatorial Belt (SEB) ought to be, but it disappeared several months ago under high level ammonia clouds. However, these are thought to be unrelated events. So what is going on out there with our largest planet?

**“It’s as if Jupiter just swallowed the whole thing”**

In July 2009, Wesley reported seeing a bright flash on Jupiter. After the impact, the Hubble Space Telescope (HST) took pictures of the aftermath of this event. The scar left on Jupiter by the 500m wide asteroid left a bruise the size of the Pacific Ocean which was monitored by the HST. The magnitude of this asteroid impact would have had catastrophic consequences had it happened on Earth. It would have been the equivalent of thousands of nuclear weapons exploding at once. In 1994, fragments of comet Shoemaker-Levy 9 (SL-9) struck Jupiter leaving behind murky, sooty bruises amongst Jupiter's



Image Credit: Anthony Wesley, Broken Hill, Australia

**Big Bang** Three colour composite image of Jupiter and the flash that occurred June 3rd 2010.

clouds. The magnitude of the SL-9 was similar to the 2009 impact observed by Wesley. Last month's event however was not as bright as these previous impacts.

Since this impact last month, many observers have had their attention directed to Jupiter to see if an impact blemish has been left behind. In the past, impacts such as the July 2009 impact, have left their mark scarring Jupiter, but as of yet no visible remnants of this impact can be seen. “It’s as if Jupiter just swallowed the whole thing,” describes Anthony Wesley. The July 2009 impact left a noticeable bruise on Jupiter’s cloud tops for up to four months after impact. However this recent impact has left no similar debris or mark behind. The most logical explanation behind this flash, is that it was a small meteoroid, big enough to produce a flash but still too small to leave any marks behind.

Four days after the flash on Jupiter, the Hubble Space Telescope turned its powerful Wide Field Camera 3 towards the planet, however there is still no sign of a black sooty cloud that has

been typical of previous impacts on this gaseous planet. To witness two impacts on Jupiter within a year is causing astronomers to reconsider how often our gas giant neighbours are hit by space debris. Don Yeoman, head of NASA's Near-Earth Object program, part of JPL (Jet Propulsion Laboratory) suggested back in the days of SL-9, an impact on Jupiter is likely to be seen "every hundred years or so". However, the same person Anthony Wesley has observed two impacts within the one year.

So how come the professional astronomers have not discovered these impacts yet the amateurs have? Well, it would be impossible to devote the Hubble Space Telescope to observe Jupiter and other planets regularly as well as looking into deep space. Also as amateur astronomy skills improve, their findings are adding to a huge database and contributing further to our knowledge about our planets and our Solar System.

For this spectacular event to have been captured on video from a backyard on Earth is amazing, Anthony Wesley and other amateur astronomers

### Scarface

Jupiter with an impact blemish caused by the 1994 comet SL-9. This sight reminds me of some of the final scenes of the novel "2010: Odyssey 2" (CJ)



Image Credit: H. Hammel, MIT and NASA

are making fantastic and important discoveries which are aiding our learning about the other planets in our Solar System. Jupiter is a strange planet that deserves the attention it receives, perhaps by the end of this year or next Jupiter's SEB will have reappeared and maybe another impact will have occurred. Watch this space!

## Ireland's monster telescope at Birr

By Sinead McNicholl, Education Support Officer

On a recent trip to County Offaly in Ireland, I passed by the town of Birr which I had heard mentioned many times at Armagh Planetarium in regards to astronomy. Curiosity got the better of me and I had to stop to see what made this town so special and headed towards the famous Birr Castle, home to the Earls of Rosse. On entering the huge gates at the castle you are transported back to a time when Birr Castle was the focal point of scientific discovery and innovation.

Located in the grounds of the castle is the "Great Telescope" which was built by William Parsons (1800-1867), the 3rd Earl of Rosse. Parsons was born in York in England and educated at

Trinity College Dublin graduating with first-class honours in mathematics in 1822. He inherited an Earldom and a large estate in County Offaly when his father died in 1841. Parsons was enthusiastic about astronomy which led to the planning and construction of a telescope on his estate. His wife Mary was heiress of the Fields of Heaton outside Bradford and it was with her enormous fortune that the third Earl was able to finance and build his dream telescope. As Birr is situated near the middle of Ireland, Parsons hoped that by using this instrument he would be able to study and record details of immensely distant stellar objects and provide evidence that many of these mysterious nebulae in space were actually galaxies located far outside our own Milky Way galaxy.



**Leviathan!** The monster telescope at Birr Castle. Sinead is standing beneath it.

The telescope itself was basically a 17 metre tube, suspended between two 15 metre high stone walls with a network of supports which enabled the tube to move in a vertical direction. The 72 inch (183 cm) mirror was cast in the grounds of the Castle using three large crucibles resulting in a mirror that weighed over three tons. Construction of the telescope and mountings took over two years but finally, on 15 February 1845, the weather cleared long enough for a short viewing of the double star Castor, in the constellation of Gemini, which confirmed the potential of the new telescope. The “Great Telescope” held the record as the largest telescope in the world for its day and provided the most magnified view of the sky possible at the time. In fact it held this record for just over seventy years until the construction of the Hooker telescope in 1917 at Mount Wilson in Los Angeles. However the Birr telescope mirror still remains the largest metal mirror in the world today!

“The Great Telescope held the record as the largest telescope in the world”

The Birr telescope could see objects that were at least 10 000 times too faint to detect with the unaided eye. The first object to be observed using the telescope was the Moon. Minute craters and rilles which had never been seen before were noted. Even features on the planets Mars, Jupiter and Saturn were seen in great detail. The telescope had proved to be of amazing optical quality and its light gathering capacity was

beyond the expectations of many.

The purpose of the telescope was then turned to study the stars and to re-visit the nebulae in the Messier Catalogue. The Messier catalogue was compiled by Charles Messier (1730–1817) after he became frustrated when he went comet hunting by all the fuzzy objects he seen in the sky which weren’t comets. Questions remained whether these fuzzy objects were unresolved star clusters or nebulous regions of space, and Parsons set about the answers. In April 1845, Parsons was able to deduce the spiral nature of the M51 nebulae, known today as the Whirlpool Galaxy. Although at the time he did not know that he was looking at a galaxy outside of our own Milky Way Galaxy he did enter the history books as the first person to sketch the spiral structure of a galaxy. By the end of 1850 the number of nebulae seen at Birr had reached fourteen including M1 which he named “the Crab Nebula”. Parsons had answered the intriguing question; nebulae were indeed composed of faint stars.

During this time in history, Birr became a hub of activity as other astronomers from all around the world flocked to the small Irish town to use its famous telescope as a tool to aid their study and exploration of the heavens. The astronomer J.L.E Dreyer (1852-1926) who researched the New General Catalogue of clusters and nebulae was one of many who made use of the powerful telescope. Its fame was such that it is actually mentioned in the Science Fiction novel “From the Earth to the Moon” by Jules Verne.

After Parsons died in 1867 his son, the 4th Earl of Rosse, continued to use and maintain the telescope. However upon his death the Birr Telescope was not used as often and fell into disrepair. In 1994 the restoration process began and this was finally completed in 1999. You can now visit Birr and stand alongside this monster telescope which is a major tourist attraction. The present Earl (the sixth) has also established an astronomical museum



**William Parsons**  
3rd Earl of Rosse.

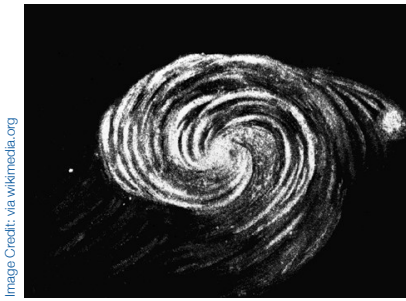


Image Credit: via Wikimedia.org

**M51** Sketch made by William Parsons of the Whirlpool galaxy as seen through the Birr Telescope.

at the castle. The science centre demonstrates how the extraordinary telescope was built in the castle workshops by the people of Birr. Scientific instruments are displayed, alongside interactive models to explain how they were used. Occasionally the Birr telescope is still used to take a peek at the stars and is arguably the largest historic scientific instrument still working today. It remains in the centre of the Demesne as Ireland's greatest scientific wonder and represents a masterpiece of human creative genius.

# Impossible, that's all!

By Colin Johnston, Science Communicator

Here are some predictions. We will never travel faster than the speed of light. We won't ever invent devices that transmit signals to enable us to communicate faster than light either. There will be no warp drives, stargates, jumpdrives, hyperspatial shunts and so on. If we ever go to Alpha Centauri we will have to do it the hard way; years or decades or centuries of proper space travel. Talking back to Earth from Far Centaurus will take years; 4.36 years from transmission to reception, same again for the reply.

I imagine some of you are already shaking your heads. Some will be despairing at my lack of imagination, others remembering all those 'experts' in the past who said that flying machines, supersonic flight, spaceships and so on were impossible (for example, "heavier-than-air flying machines are impossible" stated Lord Kelvin in 1895). I reject any charge that I'm unimaginative; I am a card-carrying science fiction geek. Heck, I've probably read more SF stories than I've had hot dinners.

Why do I think faster than light travel and communications are impossible? ("Faster than light" is a pain to have to type over and over again, from now on I'll just say FTL.) Don't blame me, it's all Albert Einstein's fault. When Albert Einstein (1879-1955) wasn't inventing improved fridges or

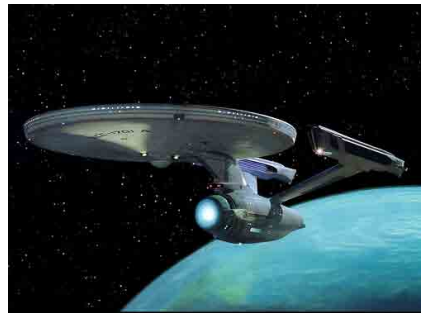


Image Credit: Paramount Pictures

**FTL starship** beloved by many...but it ain't gonna happen.

the chronosphere (little something for the video gamers there), he was an outstanding theorist, nowadays everyone has heard of his Theory of Relativity and can quote " $E=mc^2$ ". It is the theory of relativity that established the speed of light as the cosmic speed limit. Sort of... Einstein had two theories of relativity, it is the earlier one, 'special relativity' published in 1905 under the snappy title "On the electrodynamics of moving bodies", that lays down the problems with FTL.

Einstein's starting point was that the speed of light is fixed. It always travels at the same speed (roughly 300 000 km/s). Light cannot accelerate or slow down (in a vacuum that is, light does get slower travelling through a medium, say glass or water). Putting more power into a light bulb does

not give you a faster beam of light. This has a number of amazing (and to be honest, not easily predicted) consequences. Here are the ones most relevant to interstellar travel.

**ON A FAST MOVING VEHICLE TIME SLOWS DOWN** (according to outside observers). As the Tenth Doctor would have said "What?!" This is called Time Dilation; the crew of a spaceship travelling at near light speed (and everything around them) exist at a slower rate than outside observers. This affects everything, even their perception, so the space travellers do not notice anything even though they are moving in slow-motion. What?!

The formula for calculating how the time dilation varies with speed is actually remarkably easy to derive (alas there isn't the space here) and shows that as an object's speed approaches that of light, time moves slower for it as perceived by outsiders. At everyday speeds, this effect is utterly insignificant, but at high speeds its effects are dramatic. For example, this formula predicts that an observer watching events in spacecraft hurtling along at 99.5% of light speed will see them proceeding at a tenth of their normal rate. As speed increases, the dilation increases. At the speed of light time stops moving altogether for the space travellers, to outside observers they would appear frozen in place.

As you can image, being frozen in place raises practical difficulties (pressing the button to decelerate for example), but there are more odd consequences of relativistic travel. **A FAST MOVING VEHICLE GETS HEAVIER** (according to outside observers). What?! As the speed increases, time slows and mass increases. As a spaceship accelerates towards light speed to outside observers it and its contents get heavier. Again, the crew on board are oblivious to this, but for example at 99.5% of light speed they are effectively ten times as heavy as they were at rest. As they accelerate towards light speed this mass increase gets more and more extreme, to outsiders the ship weighs as much as a planet... a star... a galaxy... At light speed the ship achieves infinite mass which again leads to practical difficulties. It would be impossible to supply enough energy to attain light speed.

**Blame him!** Albert Einstein in his patent office days. There is a legend, which ought to be true even if it isn't, that says Einstein approved the shape of that honey and almond chocolate bar that comes in pentahedron-shaped packaging.



Image Credit: Via NASA

This description has been hugely simplified and may seem crazy, but it seems to be how the Universe works. Remember, reality has been around since long before we showed up. Experiments have proven relativity's predictions. Atomic clocks flown around the world on jet planes have been found on landing to have run slightly slower than identical clocks ticking away back home in the lab.

Other proofs come from particle physics. At labs like CERN and Black Mesa (another one for the computer gamers there), physicists experiment with subatomic particles such as kaons, pions, charmed B mesons and tau leptons (particle physics isn't as much fun as astronomy, making up weird names is as exciting as it gets). The physicists' experiments on short-lived particles called muons show that when they travel at 98% of lightspeed they live five times as long as stationary examples. Mass increase has been observed by the particle physicists too as they whirl protons and so on around in their accelerators, in fact it is essential that this is allowed for, when pushing particles to near light speeds (extra oomph is needed!)

It seems pretty certain that it is impossible to keep on accelerating until you're travelling at many times the speed of light (although the message doesn't seem to have got through to some of the early morning motorists on the Portadown Road) but surely I'm just an old stick in the mud? What about some outside the box thinking, what about tachyons, wormholes and short cuts through hyperspace? Patience, we'll look at them in the next part of this article.

# Image of the Month



Image Credit: CAHA, Descubre Foundation, DSA, OALV, Vicent Peris (OALV / Pdrinsight), Jack Harvey (SSRO), Steven Mazijn (SSRO), Carlos Sonnenstein (Valkanki), Juan Cortezero (Pdrinsight).

Following on from Sinead's article on astronomy at Birr, once you have enjoyed this false colour image, compare it to the one on page 10. William Parsons was clearly a great observer and drew fine sketches!

M51 is not an isolated island in the void: it has a small companion, the dwarf irregular galaxy NGC 5195. The duo are performing a cosmic dance together. During the last 500 million years NGC 5195 has passed twice through the disc of M51.

Now, the small galaxy is located slightly behind the disc of the Whirlpool, and moving away from us. As this goes on, tidal forces between them shape both galaxies. Stars are being ripped from the smaller galaxy in streams which extend over the right of the image as a fuzzy fog.

Millions of worlds are destined to be scattered from their parent galaxies into the emptiness of intergalactic space. What a lonely fate! (Caption by Colin Johnston, Science Communicator)



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