Covering page

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Comments or queries about *Sky-Guide 2010* are welcome. Do get in touch too if you would like additional details about any particular celestial event during 2010. Contact the author at southdublinastronomy@gmail.com

A quick round-up of sky guides

A number of other guides to the sky for the year ahead may be of interest.

Sky-High 2010 is an annual produced by the Irish Astronomical Society and describes celestial phenomena visible from Ireland for the year ahead. Priced €5, Easons stock it in their O'Connell Street Dublin branch or you can order it direct from www.irishastrosoc.org

Paul Money produces an A5-sized annual called *Nightscenes* which is specifically geared towards observers in the UK and Ireland. The publication has a set of monthly notes and a star chart for that month along with more detailed information on other pages. At a bargain £5 it's a valuable guide sprinkled with lovely photos taken by Paul. Order from http://www.astrospace.co.uk/nightscenes/nightscenes.htm

Philips publish the colourful *Stargazing 2010* written by well known astronomy popularisers Heather Couper and Nigel Henbest. The guide retails for £6.99 and is also pitched at observers in the UK and Ireland. Available in many bookstores or through online sellers.

The Astronomical Calendar produced by Guy Ottewell since 1974 is a large format soft-cover publication that is packed with an incredible amount of detail. The size also allows for each page to contain Ottewell's unique and informative diagrams. The 2010 edition of the calendar can be ordered through Universal Workshops web site http://www.universalworkshop.com/AC10.htm

Italian amateur astronomer Pier-Paolo Ricci produces a phenomenally detailed almanac each year which runs to 450 pages. The guide contains numerous useful tables on all sorts of astronomical phenomena besides the standard details about the planets for the year ahead. You can download Pier-Paolo's guide (25Mb in size) from http://www.pierpaoloricci.it/download/almanacco2010_eng.htm

Many, many other sky guides appear annually including calendars and books such as Sir Patrick Moore's venerable *Yearbook of Astronomy*. The two magazines *Astronomy* (US) and *The Sky at Night* (UK) usually have their yearly almanacs as inserts towards the end of the preceding year while *Sky and Telescope* (US) and *Astronomy Now* (UK) produce separate publications in the late-Autumn. Organisations such as the British Astronomical Association (BAA) and the Royal Astronomical Society of Canada (RASC) publish handbooks for members annually but these can be purchased by non-members too. I haven't even touched on the non-English publications, some examples of which I've accumulated over the years.

Finally, the *Astronomical Almanac* is the doyen of professional and amateur astronomers worldwide. Co-produced by H.M.'s Nautical Almanac Office and the US Naval Observatory, the detailed tables in the Almanac cover a whole range of astronomical phenomena. The accurate ephemerides are calculated with the latest adopted numerical theories.

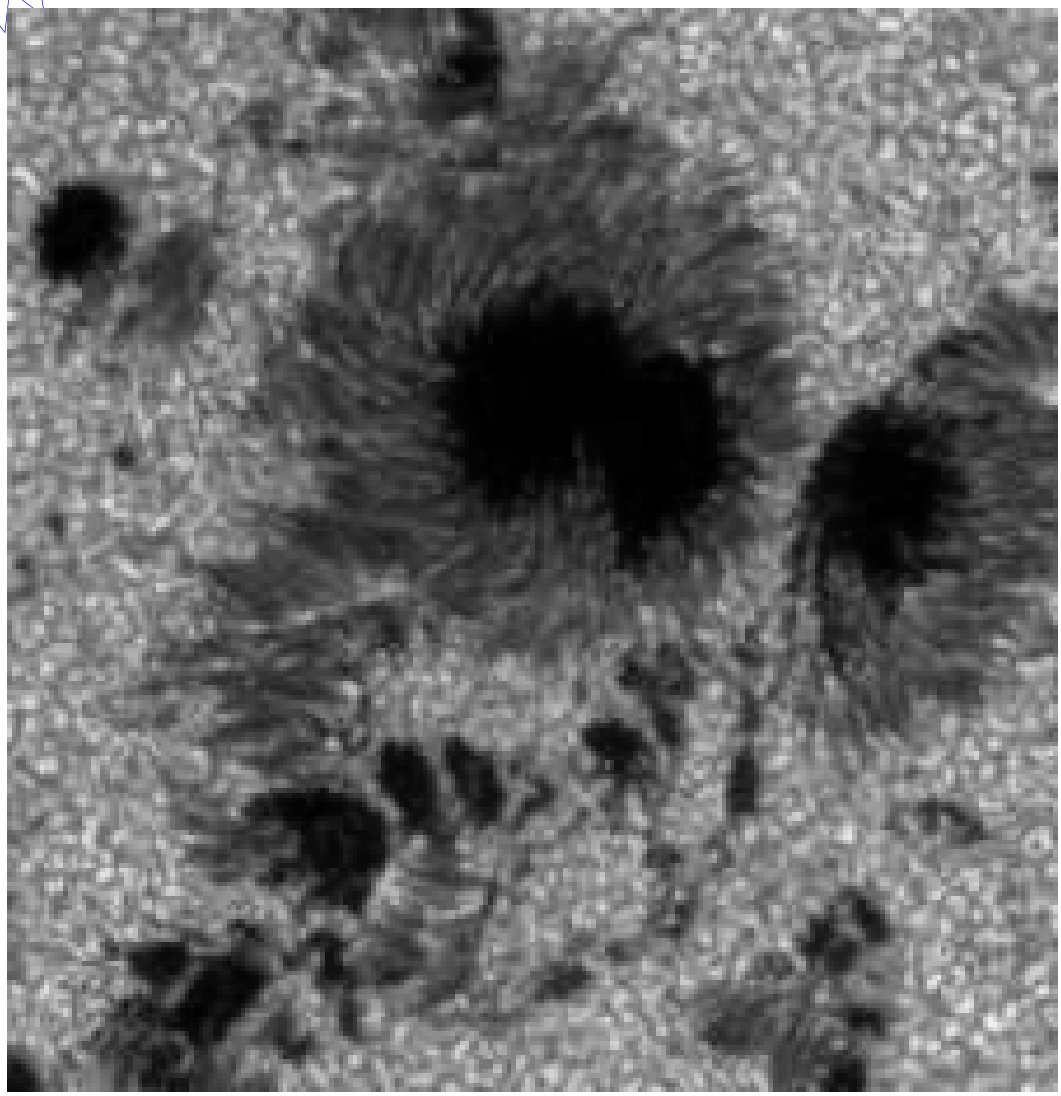
All in all this is just a quick flavour of the extensive selection of sky guides available for the amateur astronomer or casual sky-watcher curious about what's up for the year ahead.

John Flannery,

Dublin, Ireland
October 2009

SKY GUIDE 2010

Always free!



Where have all the sunspots gone?

Giving you the low down on what's up for the year ahead

Compiled by John Flannery, South Dublin Astronomical Society
southdublinastronomy@gmail.com

monthly phenomena … eclipses … comets and meteor showers … space missions … aspects of the Moon … detailed notes … and much more

Welcome!

Welcome to your free guide to what's up for 2010.

The monthly notes have been changed to calendar format for this year's booklet so the relevant page can be stuck on a wall to keep up-to-date with what is happening during that month. The main part of *Sky Guide 2010* has more in-depth information about a particular event. Subscribing to a monthly astronomy magazine will also keep you appraised of transient astronomical phenomena.

Mail us at southdublinastronomy@gmail.com if you have comments about *Sky Guide 2010* or spot errors that may have crept in. Ideas for future editions are welcome too.

The charts used in *Sky Guide 2010* were produced with Chris Marriot's *Sky Map Pro* astronomy software and labels added later. Other software used includes *Lunar Phase Pro* by Dublin-based Gary Nugent (www.nightskyobserver.com/LunarPhase/) and the *Multi-year Interactive Computer Almanac (MICA)* produced by the US Naval Observatory. Do also check out the web sites listed on page 40 which often carry more in depth information about future events.

Until next year's *Sky Guide 2011*, I bid you the astronomer's adieu. Clear skies!

John Flannery, Dublin, October 2009

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Reading the monthly calendar

The magnitude of an object (planet or star) is given in brackets. *AM* or *PM* indicates an event in the morning or evening sky. Standard symbols are used for the lunar phases such as a solid circle for New Moon or an open circle for Full. Times are in Universal Time (see note on page 4.)

Join your local group

Ireland has a vibrant amateur astronomy community and many people are members of clubs. There, they meet others interested in sharing the camaraderie of our hobby. You are sure to find a warm welcome at each of the groups listed here.

National bodies

IFAS (www.irishastronomy.org) — The Irish Federation of Astronomical Societies is an umbrella group for astronomy clubs countrywide. The IFAS web site has a vibrant forum where you can get tons of advice about the hobby.

Astronomy Ireland (www.astronomy.ie) — Ireland's largest astronomy club publish a monthly full-colour magazine, organise lectures by world-renowned scientists, and bring astronomy to the general public.

ILPAC (www.irishastronomy.org/ilpac) — The Irish Light Pollution Awareness Campaign works hard at educating people about the environmental impact of light pollution, bane of astronomers everywhere.

IAA (www.irishastro.org/) — The Irish Astronomical Association meet in Queen's University Belfast. Members are drawn from around Ireland and are active observers.

IAS (www.irishastrosoc.org) — The Irish Astronomical Society are Ireland's longest established astronomy club. Membership is countrywide and monthly meetings are held at Dunsink Observatory in Dublin. Also publish *Sky-High*.

Local groups

I was unable to find details for some clubs due to their web sites being unavailable. Apologies to all concerned. However, do post a message to the IFAS forum or check with Astronomy Ireland for a club that might be near you.

Cork Astronomy Club — hold monthly meetings and organise observing sessions. Outreach work is done locally too. Check www.corkastronomyclub.com for more details.

Deise Astronomy Society are based in County Waterford. Details of monthly meetings and observing nights can be found at www.deiseastronomy.com

Galway Astronomy Club — another very active club who have monthly lectures in the Claddagh Hall, Nimmo's Pier, Claddagh Quay — check out galwayastronomyclub.ie

Kerry Astronomy Club — meet in the Tralee Institute of Technology. Home page is www.kerryastronomyclub.com

Midlands Astronomy Society — meet in Tullamore, Co. Offaly and host the annual Cosmos event in the Spring. More details about them at www.tullamoreastronomy.com

North Dublin Astronomical Society — based in Balbriggan, Co. Dublin, the NDAS are just getting started so post a message to the IFAS forum if you would like to know more.

Northern Ireland Amateur Astronomy Society — a number of active observers are amongst their members. Lectures are held monthly — more details at www.eaas.co.uk

Shannonside Astronomy Club — host the Whirlpool Star Party and meet monthly. A number of active observers are in the club — www.shannonsideastronomyclub.com

South Dublin Astronomical Society — the SDAS meet monthly. Details at www.southdublinastronomy.org

Discover Ireland's Scientific Heritage

From standing stones to the latest planetarium projection technology, there's a 6,000-year span of places to visit countrywide to learn more about Ireland's contributions to astronomy. This is only a small selection of the science centres that will delight and entertain.

Birr Castle and the Earls of Rosse are synonymous with great strides made in astronomy. The grounds are site of what was once the world's largest telescope for 75 years that was built by the Third Earl in the mid-1800s. The telescope was restored a number of years ago and a science centre completed adjacent to the Castle (www.birrcastleireland.com).

Dunsink Observatory in Castleknock in Dublin runs a fine outreach programme and public observing nights throughout the Winter months (www.dunsink.dias.ie). The Observatory has a 12-inch refractor which has had an interesting history — James South, who donated the lens, got embroiled in a famously fierce controversy with the original lens maker. Armagh Observatory is a leading research centre and also holds open nights for the public.

Other public observatories include Blackrock Castle Observatory in Cork city. It has been beautifully restored and a Solar System walk leads from Cork city centre along by the Lee to end at the gates of the Observatory (www.bco.ie). Ireland's second city also has the Crawford Observatory on the grounds of University College Cork (astro.ucc.ie/obs/).

Ireland boasts a number of planetariums (planetaria?) and the best known is that in the historic City of Armagh. Sir Patrick Moore was its first Director and the centre now has the latest Digistar 3 projector which is leading-edge technology. An interesting exhibition area and beautiful grounds complement any visit. Check out their web site at www.armagh-planetarium.co.uk

Two further planetariums can be found in Greencastle, Co. Donegal (www.worldwidelasers.com), and in the Community College in the lovely West Cork village of Schull (www.schullcommunitycollege.com/planetarium.html).

The South Dome houses Dunsink Observatory's 12-inch refractor

The Science Gallery at Trinity College Dublin runs regular exhibitions of interest and more details of these can be found at www.sciencegallery.ie

Anthony Murphy, author of *Island of the Setting Sun*, runs the www.mythicalireland.com web site which is a comprehensive overview of archaeoastronomy in Ireland. Another interesting page is www.carrowkeel.com which features a section on the intriguing "Rolling Sun of Croagh Patrick". The varied designs of sundials can be quite beautiful and Michael J. Harley has catalogued some lovely examples around Ireland at homepage.ntlworld.com/michael.j.harley/index.html

Finally, Mary Mulvihill's book *Ingenious Ireland* is an extraordinary read that deservedly won a number of accolades. When you leaf through the pages you'll find yourself muttering "I didn't know that" as you are taken on a journey through the counties of Ireland, exploring the rich scientific heritage of each. In short, *Ingenious Ireland* is an essential purchase. You should also check Mary's science events listings at scienceculturebulletin.wordpress.com (updated frequently).

Star parties

The two-day Galway Star Party will be held by Galway Astronomy Club in the Westwood House Hotel, Clifden Road, Galway, on February 12th and 13th. Details of the packed and varied programme can be found at www.galwayastronomyclub.ie

The well-established Cosmos weekend hosted by Midlands Astronomy Club (www.tullamoreastronomy.com) takes place during a dark-of-the-Moon weekend from April 9th to 11th. Check the club web site nearer the time for the programme.

Shannonside Astronomy Club will hold the Burren Star Party on September 11th. The club formerly ran the Whirlpool Star Party in Birr, Co. Offaly but the event has now moved to take advantage of some of the darkest skies in Europe. More details of the weekend programme will be posted later at www.shannonsideastronomy.com

Cork Astronomy Club have started hosting a one-day astronomy lecture series at the beautifully restored Blackrock Castle Observatory in late Autumn. Keep an eye on their web site at www.corkastronomyclub.com for announcements.

Astro-Expo is Astronomy Ireland's annual celebration of astronomy. The day-long programme features lectures plus a chance to browse exhibits and purchase astronomy equipment, accessories, and books. Check www.astronomy.ie for details of the 2010 Expo.

Some terms to know

As with any hobby, astronomy seems to have it's own set of terminology designed to confuse. However, with a little patience you'll soon pick up the jargon and be well on the way to knowing your way around the sky. Sprinkled throughout this guide are a number of terms and concepts that might seem hard to grasp at first. Here we explain a few but do recommend a good beginner's guide.

One such book is the highly regarded *Backyard Astronomer's Guide* by Terence Dickinson and Alan Dyer. The 3rd edition was published in late-2008 and is a thorough guide to amateur astronomy and how to select equipment. The pictures of the night sky (all taken with fairly basic equipment) are wonderful to look too! Priced at about €40.

Practical Astronomy by Storm Dunlop is one of a range of excellent pocket-sized books produced by Philips. It costs less than €10 and others in the series give valuable advice on observing the Sun, Moon, Planets, Deep Sky Objects and binocular astronomy. A planisphere lets you "dial-in" the night sky for any time of the year and is also an essential purchase along with a good Moon map. The *Pocket Sky Atlas* (€15) from Sky & Telescope is a superb star atlas.

The ever-changing sky

When outside for a few hours observing on a clear evening you'll notice that the stars appear to wheel about a point in the sky. We know the heavens don't revolve but that the effect is due to the Earth's own rotation on it's axis. This causes the Sun and all the other celestial bodies to rise in the east and set in the west.

The stars appear to drift in such a way that any particular star is due south four minutes earlier each night. Multiply this by 365 (days) and you get something close to 24 hours. If a star is due south at 10pm then it will lie on the meridian four minutes earlier the following night. In a month it will be in the same position two hours earlier. A year from now and the star will be again due south the same time we see it tonight. The concept lets us understand why some constellations are seasonal.

Scale in the sky

A total solar eclipse is one of the most awe-inspiring sights in nature. The diameter of the Sun is 400 times that of the Moon. It is also 400 times further away. The happy circumstances that let us enjoy eclipses is due to the fact that the Sun and Moon have the same **apparent** (or angular) **diameter** in the sky of half a degree.

Degrees are further divided into 60 arcminutes (60') with each arcminute made up of 60 arcseconds (60"). This allows us measure angles in the sky or the apparent size of a celestial object. For example, the Full Moon measures an average of half a degree, or 30 arcminutes, in diameter.

Finding your way around

Knowing your way around the sky might not seem that important in the age of the computerised GoTo telescope but it is worth knowing how to locate stuff the old way.

Two systems exist. The first is altitude and azimuth. **Altitude** is measured in degrees from a point on the horizon straight up to the overhead point (the zenith) at 90°. **Azimuth** is measured three hundred and sixty degrees right around the horizon starting from true north equal to 0°. East is 90° azimuth and so on.

Astronomers also use a kind of celestial longitude and latitude called right ascension and declination to accurately plot the position of an object in the sky. Using these coordinates will let you track down that comet you've just read about or pick your way through the Messier catalogue.

Right ascension is expressed in hours (h), minutes (m) and seconds (s) running eastward from 0 to 24 hours right around the sky. The zero point of right ascension is taken as the vernal equinox — the point where the Sun crosses the celestial equator, moving from south to north.

Declination is how many degrees, minutes, and seconds north (+) or south (-) of the celestial equator an object is.

Some constellations are visible all year round and are known as **circumpolar**. A star is circumpolar if it's declination is greater than the 90° minus the observer's latitude.

To find how far south you can see subtract your latitude from 90° and make the result negative. From Dublin at 53°N the most southerly star seen will have a declination of -37°.

Star light, star bright

The **magnitude** of a star refers to its brightness, not to its size. The scale of magnitudes is a logarithmic one. A difference of one magnitude is a difference of 2.512 times in brightness. A difference of five magnitudes is a difference of 100 times in brightness. The lower the magnitude number, the greater the brightness.

The stars in the Plough range from about magnitude 2 to magnitude 3½. The faintest stars you can see with the naked eye on a really dark moonless night, away from city lights, are magnitude 6 or 7. Binoculars show stars two to four magnitudes fainter, while the most powerful telescopes in the world are able to show magnitudes approaching +30.

The apparent brightness of a star depends on its true brightness and its distance. The term magnitude if not qualified, refers to apparent brightness. The term **absolute magnitude** is the magnitude a star would show if it lay at a standard distance of 10 parsecs.

Times throughout the publication are given in Universal Time (UT). This is the 24-hours system starting at mean midnight as measured at Greenwich. It is the same as Greenwich Mean Time (GMT). To translate UT into Summer Time just add one hour.

Summer Time in 2010 begins on March 28th at 01:00 when the clocks go forward one hour. Summer Time ends on October 31st at 01:00 when clocks go back one hour (remember, "Spring forward, Fall back").

Some terms to know

Light-year leaps

Kilometres may be a convenient unit to measure distance on Earth but not so in space. Astronomers therefore use a more manageable metre-stick within the Solar System known as the **astronomical unit** (a.u.). One astronomical unit is simply the mean Earth-Sun distance, or roughly 149, 597, 870.691 kilometres — mind you, it would still take over 177 years continuous driving (at the national speed limit!) to reach the Sun!

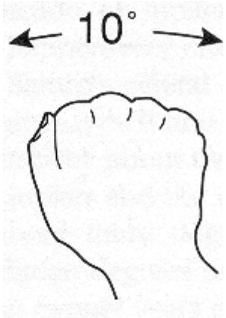
The void between the planets is measured in tens of millions of kilometres but to bridge the gap to even the nearest star requires kilometre-long leaps of mind-boggling proportions so we use the **light-year**. A light-year is simply the distance travelled by a ray of light in a year. We know light has a finite speed of approximately 300,000 km/s so a light year can be calculated as 300,000 * 60 seconds in a minute * 60 minutes in an hour * 24 hours in a day * 365.25 days in a year giving us a rough result of 9·46 trillion km! Put another way, if we were to drive our car from the Earth to the Galactic centre (this time at a speedy 160 km/h) it would take over 12 billion years!

Even a light-year doesn't suffice in many cases and so we sometimes use another unit called a **parsec**. This is simply the distance at which a star would show a *par*allax of one arc-*sec*ond and equates to 3.2616 light years.

By the way, a light-year is a measure of distance, not of time. However, looking at the night sky we genuinely are looking back in time and see celestial bodies as they were because of how long even light needs to cross the huge distances.

Once you get beyond the stars and into the realm of galaxies even the light-year becomes unwieldy when talking in large numbers. The term **mega-parsec** (one million parsecs) is freely banded about by cosmologists though even they are reduced to describing distances to objects at the edge of the observable Universe in terms of their recessional velocity, or red shift, with the quantity *z* used in equations.

All in all, space is a big place but within these pages we hope we can get you started on a voyage through the wonders of the Universe that will last a lifetime.



A "handy" way to measure scale in the sky. Your little finger at arm's length covers ½°; i.e. the apparent width of the Full Moon.

A good demonstration of the illusion that the Moon looks big is that it would take ten Full Moon's side-by-side to span the gap between the two "pointer" stars in the Plough — a distance of just five degrees!

The Greek alphabet is used to identify the brightest stars in each constellation. The sequence doesn't necessarily start with alpha being the brightest — 34 of the 88 constellations have at least one star more brilliant.

Exploring the sky

Whether new to the hobby or an advanced amateur astronomer you probably already own a pair of a binoculars, the ideal instrument to casually explore the wonders of the Universe at any time.

The fixed magnification of (most) binoculars will not allow you see the detail provided by telescopes but their wide field of view is perfect for appreciating the extensive star clouds of the Milky Way, the full extent of a comet's tail, or quickly completing a variable star programme in an evening. Their greatest asset though is their simplicity; at the drop of a hat, you can be up and observing without any fuss. Ideally, you should have them mounted on some form of tripod in order to steady the view.

Although binoculars are outclassed by telescopes when it comes to be able to study the Solar System family in great detail, you'd be surprised at just how much you can see in giant glasses. The rings of Saturn for example. Although the image is tiny, when the rings are wide open — as they were a few years ago — you can see them distinctly separate from the planet's globe. Even a low-power binocular will show the cratered surface of the Moon well and reveal it's smooth "seas" and jagged highlands.

Binoculars are also a great introduction to the realm far beyond the Solar System — what amateur astronomers call the "deep sky". This is the abode of galaxies, nebulae, and stars in many guises. It is here that we set sail from Earth and are transported across many light years of space to the wonderful and the exotic; dense glowing clouds of gas where new suns are being born, star-studded sections of the Milky Way, and the ghostly light of far-flung galaxies — all are within the grasp of an ordinary pair of binoculars. In recent years there have been good quality discounted 10x50mm instruments sold through chain stores in Ireland.

If you wish to explore further then I recommend you get copies of the observing handbooks produced by the Irish Federation of Astronomical Societies (IFAS). These handbooks can be downloaded at www.irishastronomy.org and are a tremendous resource for the beginning amateur astronomer. The IFAS forum is well worth joining too for advice and discussions on all aspects of the hobby.

The Greek Alphabet

α	alpha	ι	iota	ρ	rho
β	beta	κ	kappa	σ	sigma
γ	gamma	λ	lambda	τ	tau
δ	delta	μ	mu	υ	upsilon
ε	epsilon	ν	nu	φ	phi
ζ	zeta	ξ	xi	χ	chi
η	eta	ο	omicron	ψ	psi
θ	theta	π	pi	ω	omega

January 2010

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Mars opens the year as a magnitude -0.8 ember retrograding in Leo. It crosses into Cancer the second week of January and ends it above the stellar swarm of the Beehive cluster M44. The planet reaches opposition on the 29th when it burns at magnitude -1.3 and the disk measures 14.1". Cream-coloured **Jupiter** shines at magnitude –2.1 in the south-western sky these evenings but sets just after 7pm by the end of the month. **Saturn** rises just before midnight on New Year's Day but is up two hours earlier by the 31st. The northern aspect of the rings are tipped just under 5° Earthward at the moment — a tight angle when seen in a scope. **Mercury** is in the pre-dawn from the second week and shining at magnitude 0 when 5° high mid-month as civil twilight begins. **Venus** is too close to the Sun to be seen.				**1** New Year's Day 1801: minor planet 1 Ceres discovered by Piazzi	**2** *PM*: Use binoculars to spy dim Neptune (8.0) just 2¼° from Jupiter (-2.1) — the gap is widening daily	**3** Moon 6½° from Mars (-0.8) Earth at perihelion (00h) Quadrantid meteor shower peaks tonight (ZHR 120)
4 Mercury is at inferior conjunction (not visible)	**5** Jupiter crosses from Capricornus into Aquarius	**6**	**7** 10h 39m 1942: birth of Stephen Hawking, UK astrophysicist	**8**	**9** Mars crosses from Leo into Cancer today	**10** 1946: radar bounced off the Moon for the first time
11 Venus is at superior conjunction (not visible)	**12** BT Young Scientists Exhibition at the RDS, Dublin starts today and runs until January 17th (www.btyoungscientist.ie)	**13** *AM*: Mercury 7° to upper left of a thin crescent Moon above ESE horizon	**14** Saturn stationary, begins to retrograde. It can be found near the star eta Virginis (3.89^{m}) tonight Uranus passes from Aquarius into Pisces today	**15** 07h 11m annular solar eclipse — not visible from Ireland. This is the longest 'til 3043 AD	**16**	**17** 252 BC: A first precise position for Mars is recorded in the annals
18 *PM*: Jupiter (-2.0^{m}) is 6½° below the 3 day old Moon	**19** *AM*: Mercury (0.1^{m}) at its best above ESE skyline for this apparition (5.3° up the beginning of civil twilight)	**20** 1930: Buzz Aldrin born	**21**	**22** 1978: Launch of Progress 1, the first automated resupply spacecraft, to *Salyut 6*	**23** 10h 53m	**24** 1986: *Voyager 2* encountered the planet Uranus
25 1983: *Infra-Red Astronomical Satellite* (*IRAS*) is launched	**26** Jupiter lies 1½' from a mag. 7.2 star tonight — don't confuse the star for a "moon" of the planet!	**27** Mercury greatest elongation west (24° 45') Mars closest approach to Earth — 99.33 million kms	**28**	**29** Mars (-1.1^{m}) at opposition in Cancer. The disk measures 14.09" in a telescope	**30** 06h 18m Closest Full Moon of 2010 (356,592 km distant)	**31** Minor planet 106 Dione is predicted to occult a magnitude 9.06 star (visible from the S coast of Ireland)

February 2010

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1 Mars (-1.3^{m}) passes 3¾° N of the Beehive star cluster over the next few nights	**2**	**3** Planned launch of the *Solar Dynamics Observatory*	**4** Planned launch of STS-130 *Endeavour* with components for the *International Space Station*	**5**  23h 48m	**6**	**7** 1999: Launch of the *Stardust* spacecraft which encountered comet 81P/Wild 2
8 1828: Author Jules Verne born	**9**	**10** Jupiter passes 20' from the star sigma Aquarii (4.82^{m}) tonight	**11** 1970: Japan becomes only the fourth nation to orbit its own satellite	**12** Galway Astronomy Festival takes place	**13** Most distant Moon of 2010 (406, 541 km)	**14**  02h 51m *PM*: Jupiter, Venus, and a 15-hour old Moon *may* be visible very low in the WSW 30 mins after sunset Neptune in conjunction with the Sun (not visible)
15 1564: Italian astronomer Galileo Galilei born	**16** *PM*: Venus and Jupiter lie just ½° apart in the WSW	**17**	**18** Minor planet 4 Vesta (6.1^{m}) is at opposition, just ½° from gamma Leonis (2.01^{m})	**19** 1473: Astronomer Nicholas Copernicus born	**20** 1962: John Glenn is the first American to orbit the Earth	**21** Occultation of some of the outlying members of the Pleiades star cluster by the Moon
22  00h 42m Comet 81P/Wild 2 is at perihelion	**23**	**24** 1968: First pulsar discovered by Jocelyn Bell-Burnell	**25** *PM*: Mars 7½° to the left of the Moon after dark — gap closes during the night	**26** 1966: First unmanned sub-orbital test of NASA's Saturn 1B rocket	**27**	**28**  16h 38m Jupiter in conjunction with the Sun (not visible)

The gap between Earth and **Mars** widens during February as we move on in our orbit and pull away from the planet. Its brightness declines too from –1.3 to –0.6 by the end of the month. The North Polar Region of Mars is on view at present and the glistening ice cap is a dramatic sight in a telescope. **Saturn** (magnitude 0.7) is retrograding in Virgo close to the magnitude 3.86 star eta Virginis this month. **Jupiter** will probably be lost to view by the beginning of the third week but you may still spot it around then by using Venus as a guide — both planets close to just ½° apart on the 16th very low in the south-western sky. Binoculars will help you spot the pairing but wait until after sunset to look lest you accidentally sweep up the Sun while scanning the skyline. **Venus** climbs rapidly out of the dusk during the latter half of the month and sets an hour after the Sun by the end of February. The piercing light of the magnitude –3.9 planet is unmistakeable. A small telescope will show the disk almost full at this time. **Mercury** will have been reined back into the solar glare by the end of the first week of February but you may still catch it the first few days of the month when it is a magnitude –0.1 object low above the south-eastern horizon before sunrise.

March 2010

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1 1744: multi-tailed de Cheseaux's comet, the brightest of modern times (-7^{m}) reached perihelion	**2**	**3** 1972: Launch of the *Pioneer 10* mission to the outer solar system	**4** PM: Use binoculars to spy Uranus 1° from Venus low in the western sky 30 minutes after sunset	**5**	**6** 1787: Birth of Joseph Fraunhofer, German spectroscopist who mapped absorption lines in the solar spectrum	**7**  15h 42m
8	**9** *AM*: lambda Sagittari (2.8^{m}) is the brightest star to be occulted from Ireland by the Moon in 2010	**10**	**11** Mars stationary, prograde (or direct) motion resumes	**12**	**13** Minor planet 532 Herculina (8.8^{m}) is at opposition	**14** Mercury is at superior conjunction (not visible)
15  21h 01m	**16** PM: 21½-hour old Moon visible in the western sky after sunset. Venus blazes 8° to the Moon's upper left	**17** St. Patrick's Day Uranus is in conjunction with the Sun (not visible) Saturn passes 8' from the star 10 Virginis (5.9^{m})	**18** Planned launch of STS-131 *Atlantis* with components for the *International Space Station*	**19** 721 BC: First recorded total lunar eclipse	**20** Spring equinox, 17h 32m	**21** 1927: Controversial US cosmologist Halton Arp born
22 Saturn (0.5^{m}) at opposition near the star 10 Virginis Neptune passes from Capricornus into Aquarius today	**23**  11h 00m	**24** 1893: US astronomer Walter Baade born	**25** Comet C/2009 O2 (Catalina) is at perihelion	**26** *PM*: Mercury < 1° from epsilon Piscium (4.28^{m})	**27** 1968: Yuri Gagarin killed in a plane crash	**28** Summertime begins, clocks forward by one hour
29 1974: First flyby of Mercury by *Mariner 10*	**30** 02h 25m Mars at aphelion, 1.66594 AU distant	**31** Jupiter triple satellite transit (not visible from Ireland unfortunately.) The planet is 8' from the star phi Aquarii (4.28^{m}) tonight	**Venus** dominates the evening sky and blazes at magnitude –3.9 above the western horizon. **Mercury** leaps out of the solar glare at the end of March when the sun-scorched planet burns brighter than magnitude –1.0. Venus points the way to Mercury by the 31st as the fleet-footed little world climbs higher to meet it — both are closest the beginning of April though. **Mars** remains in Cancer and sees a dramatic decline in brightness from magnitude –0.6 to 0.2 along with the disk diameter dropping below 10" by the end of the period. **Saturn** is magnitude 0.5 when at opposition on the 22nd. The relative dimness of this opposition is due to the fact the icy rings are still at a shallow tilt. Their reflectivity does play a part in contributing to Saturn's overall brightness. **Jupiter** is too close to the Sun to be seen in March.			

April 2010

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Venus casts a serene eye over the evening landscape and does not set until 22:30UT the end of April. Like a mother leading a curious child away from the dangerous solar flames, Venus and **Mercury** travel in parallel for a few days. Mercury shakes free of its "parent" on the 10th though and turns back Sunward while Venus continues to soar higher. The innermost planet remains on view until around the 25th in the ENE when it is a magnitude 0.5 spark. The crescent Moon enhances the scene on the 15th and 16th. **Mars** passes the Beehive cluster once again in mid-April and is on view 'til the early hours			**1**	**2** Good Friday 1845: First photo of the Sun taken	**3** 1966: *Luna 10* (USSR) becomes the first spacecraft to orbit the Moon	**4** Easter Sunday *PM*: Mercury (-1.5^{m}) and Venus (-3.9^{m}) are 3° apart above the western skyline
5 Bank Holiday 1972: Launch of *Pioneer 11* (US)	**6**  09h 37m	**7** Pluto stationary	**8** Mercury at greatest elongation East (19° 21')	**9** 1959: NASA names the seven Project Mercury astronauts	**10** Cosmos 2010 astronomy weekend in Tullamore, Co. Offaly	**11** 1970: Launch of *Apollo 13* on it's ill-fated Moon mission
12 1961: Yuri Gagarin makes the first manned space-flight	**13**	**14** 12h 29m *PM*: Mars approaches and passes the Beehive star cluster (M44) over the next few nights	**15** *PM*: Mercury lies 1° to the left of the 1-day old crescent Moon low above the WNW horizon	**16** *PM*: The day-older Moon now lies mid-way between Venus and the beautiful Pleiades star cluster	**17**	**18**
19 1971: The first space station, *Salyut 1*, is launched	**20** 1972: *Apollo 16* lands on the Moon	**21**  18h 20m *PM*: Mars is 6½° to the upper left of the First Quarter Moon	**22** Lyrid meteor shower peaks	**23** *PM*: Venus passes 3½° from the Pleiades star cluster in Taurus over the next few evenings	**24** Astronomy Day	**25** 1990: Deployment of the *Hubble Space Telescope*
26 1848: 9 Metis discovered (first asteroid to be found from Ireland)	**27** June Bootids meteor shower peaks (variable ZHR from 3 to 100+)	**28** 12h 18m Mercury is at inferior conjunction (not visible)	**29**	**30** Comet C/2009 K5 (McNaught) is at perihelion	Although it declines in brightness from magnitude 0.2 to 0.8 the Red Planet still outshines the stars of Cancer where it currently lies. **Saturn** dims a couple of notches to magnitude 0.8 by the end of April but is visible in Virgo until 4am. Fat **Jupiter** heaves itself above the skyline just ahead of the Sun the last week but will be in the morning twilight so you may not spot it 'til early next month.	

May 2010

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Venus is on view in the western evening sky and does not set until 23:30UT at the end of May. The planet passes close to the binocular star cluster M35 on the 21st when astrophotographers might like to capture the scene. **Mars** crosses into Leo from Cancer the second week as it heads eastward and remains on view until the wee hours. It ends the month at magnitude 1.1 and within a few degrees of the first magnitude star Regulus. **Saturn** shuffles slowly through Virgo and manages to discard a tenth of a magnitude during May. The rings are at their minimum tilt for the year at the end of the period but that brightness drop is also due to the widening distance between us and Saturn. **Jupiter** is now an easy morning object and rises two hours before the Sun at the end of May. Early risers may scoop the discovery of a lifetime such as what happened in July 2009 when Australian amateur astronomer Anthony Wesley spotted the scar of an asteroid impact in the Jovian atmosphere. **Mercury** is not visible this month.					**1** *PM*: Venus threads its way between the stars upsilon and kappa Tauri	**2** Jupiter crosses from Aquarius into Pisces today
3 May Day Bank Holiday	**4** Minor planet 2 Pallas at opposition (8.7^{m})	**5** 1961: Alan Shepard becomes the first American in space	**6** 04h 15m eta Aquarid meteor shower peaks	**7**	**8** *PM*: Venus lies on the edge of the binocular star cluster NGC 1746 in Taurus	**9** *AM*: Jupiter lies 6½° to the lower left of the Moon
10	**11** 1918: Richard Feynmann born	**12** Mars crosses from Cancer into Leo today	**13** Summer begins in the northern hemisphere of Mars	**14** 01h 04m *PM*: Venus lies equidistant between the stars beta and zeta Tauri, marking the "horns of the Bull"	**15** *PM*: A slender 20¼ hour old Moon will be visible above the WNW horizon	**16** *PM*: Venus 5° to the lower left of the Moon
17 1968: First European satellite, *Esro 2B*, is launched	**18** 1969: Launch of *Apollo 10* on the final dress-rehearsal for the Moon landing	**19**	**20** 23h 43m Planned launch of Japan's *Planet-C* Venus orbiter	**21** *PM*: Venus lies very close to the open star cluster M35 in Gemini	**22** 1724: Last total solar eclipse visible from Ireland (next is not 'til 2090)	**23**
24 Saturn stationary, prograde motion resumes **31**	**25** 1961: President John F Kennedy announces the US intention to land a man on the Moon by 1970	**26** Mercury at greatest elongation West (25° 08')	**27** 23h 07m *PM*: Venus passes ¼°from the star epsilon Geminorum (3.01^{m}) over the next two nights	**28** Saturn's rings at their minimum tilt for the year (1.676°)	**29** *AM*: Jupiter (-2.3^{m}) and Uranus (5.9^{m}) are ending the month 1° apart (use binoculars to spy Uranus)	**30** 1975: European Space Agency (ESA) founded

June 2010

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Space-birds and herring-bone clouds are aplenty in June's perpetual twi-light as orbiting satellites and high-altitude silvery noctilucent clouds catch the midnight Sun's light.	**1** Neptune stationary, pro-grade motion resumes	**2**	**3** 1948: Official dedication of the 200-inch telescope on Mt Palomar, California	**4**  22h 13m	**5**	**6** Jupiter and Uranus are 28' apart — this is the first of a triple series of conjunc-tions between both
7 Bank Holiday *PM*: Mars passes within 1° of the first magnitude star Regulus in Leo	**8**	**9** 1979: *Voyager 2* makes its closest approach to Jupiter	**10** Planned sample return from Japan's *Hayabusa* (Falcon) mission to the asteroid Itokawa	**11** 1985: *Vega 1* probe (USSR) lands on Venus	**12**  11h 15m	**13** 1983: *Pioneer 10* leaves the solar system
14 *PM*: Venus 6¼° to the up-per left of the Moon	**15**	**16** 1963: Valentina Tereskova is the first woman in space	**17** Earliest sunrise of the year at Dublin (03h 56m)	**18** Minor planet 1 Ceres at opposition (7.0^{m})	**19**  04h 29m *PM*: Venus passes through the Beehive star cluster over the next two evenings	**20** Saturn at eastern quadra-ture
21 Summer solstice (11h 00m)	**22** 1978: Pluto's moon Charon discovered	**23** Jupiter at western quadra-ture	**24** Latest sunset of the year at Dublin (20h 58m)	**25** Pluto at opposition	**26** 11h 30m Partial eclipse of the Moon — not visible from Ireland Mars close to the star beta Virginis (3.6^{m})	**27** Minor planet 15 Eunomia at opposition (9.0^{m})
28 Mercury at superior con-junction (not visible)	**29**	**30** 1908: A small comet ex-ploded over Tunguska, devastating large tracts of forest in the region	**Venus** continues to extend its stay in our evening skies and remains on view until 23UT at the end of June. Another photo opportunity arises on the 19th/20th when the veiled world glides by the lovely Beehive star cluster. **Mars** fades to magnitude 1.4 during the month and when close to Regulus on the nights of June 6th and 7th it is interesting to contrast the orange-tinted planet with the blue-white of the celestial lion's *lucida* while both are similarly bright. Shift one constellation left and you'll find magnitude 1.1 **Saturn** in Virgo. The narrow ring angle will surprise first-time Saturn watchers who may expect them to be more obvious. Magnitude –2.5 **Jupiter** is in Aquarius and rises around 02UT at the beginning of the month but two hours earlier by the end of June. **Mercury** is not visible this month.		

July 2010

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Three planets in the evening sky sees **Venus** brighten to mag. –4.3 the end of July. Its viewing window is starting to close as Venus sets 2 hours after the Sun on the 1st but only 70 minutes later by the 31st. The planet is pursuing **Mars** which itself is chasing slower moving Saturn. Mars continues to fade (it ends July at magnitude 1.5) while the disk size is now a paltry 5 arc-seconds. Yellowish **Saturn** is a steady magnitude 1.1 "star" plodding across Virgo. Magnitude –2.7 **Jupiter** sports its banded atmosphere from midnight on the 1st and two hours earlier by the end of July. **Mercury** is not visible this month.			**1** 1985: Europe's *Giotto* spacecraft is launched to encounter Halley's comet	**2** Comet C/2009 R1 (McNaught) at perihelion	**3**	**4**  14h 35m 1054: First sighting of the Crab Nebula supernova
5	**6** Earth at aphelion Uranus stationary, begins to retrograde	**7**	**8** Jupiter crosses the celestial equator going from south to north	**9** *AM*: Jupiter, Uranus and minor planet 6 Hebe all lie in the same binocular field	**10** *Rosetta* flyby of the minor planet 21 Lutetia *PM*: Venus lies less than 1° from Regulus in Leo	**11**  19h 40m Total solar eclipse visible — crosses the southern Pacific Ocean
12 1977: *High-Energy Astronomical Observatory* (HEAO-1) launched	**13** *PM*: With a clear horizon you may spot Mercury and the Beehive cluster very low in the NW 45 mins after sunset (use binoculars)	**14** 1965: *Mariner 4* (US) makes the first flyby of Mars	**15**	**16** 1994: First fragment of comet Shoemaker-Levy 9 hits Jupiter	**17** 1850: First photo taken of a star (Vega)	**18**  10h 11m Favourable lunar libration to see Mare Crisium well in from the Moon's limb
19 Mars crosses from Leo into Virgo today	**20** 1976: Landing of *Viking 1* on Mars	**21**	**22** 1784: Friedrich Bessel born	**23**	**24** Jupiter stationary, begins to retrograde	**25** PM: Mars lies ¼° from the star beta Virginis (3.6^m)
26 01h 37m 1971: Launch of *Apollo 15*	**27**	**28** Southern delta Aquarid meteor shower peaks	**29** 1958: NASA founded	**30** *PM*: Saturn (1.1^m) and Mars (1.5^m) are less than 2° apart low in the twilight	**31** Jupiter crosses the celestial equator going from north to south	

August 2010

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
A fascinating celestial waltz takes place above the western skyline this month as **Venus** (magnitude –4.3), **Saturn** (1.1), and **Mars** (1.5) trade places on the evening sky stage. The trio form a sharp isosceles triangle on the 1st but the symmetry is ruined by the end of the first week as Venus passes Saturn and closes on Mars. As the month progresses the grouping is getting lower and lower in the evening twilight so an unobstructed horizon will be a prerequisite to spotting them. A small telescope will show Venus at half-phase in mid-August while the rings of Saturn will be seen to have opened up just a fraction more. The slender lunar crescent joins the scene on August 13th. As the curtain falls on the western sky drama you'll find **Jupiter** appearing above the eastern skyline. The magnitude –2.8 planet dominates the constellation of Pisces, one of the watery groups in an area of sky known as the Celestial Sea. Jupiter rises at 22:00UT at the beginning of August and by 20:00UT at the end of the month. Bottle-green **Uranus** is in the area too — the magnitude 5.8 planet lies in the same low-power binocular field as Jupiter all month (Uranus is a naked eye object from a dark site.) **Mercury** is too close to the Sun to be seen this month.						**1** *PM*: Saturn and Mars remain less than 2° apart. Venus blazes 7½° to their lower right
2 Bank Holiday *PM*: The star within the isosceles triangle of Venus, Saturn and Mars is beta Virginis (3.60^{m})	**3**  04h 59m	**4** *early AM*: Comet 10P/Tempel 2 lies very close to the star eta Ceti (3.46^{m})	**5** 1930: Neil Armstrong born	**6** Comet 2P/Encke at perihelion	**7** Mercury at greatest elongation East (27° 22')	**8** *PM*: Close planetary grouping of Venus, Mars and Saturn in the western sky
9 1877: Deimos, one of two moons of Mars, found. Phobos was discovered seven nights later.	**10** 03h 08m	**11** First day of Ramadan	**12** Perseid meteor shower peaks tonight	**13** *PM*: The crescent Moon is near the trio of Venus, Saturn and Mars Neptune passes from Aquarius into Capricornus	**14** *PM*: Bright Venus (-4.3^{m}) glides by dimmer Mars (1.5^{m}) over the next few evenings	**15**
16  18h 14m Venus is 50% sunlit in a small telescope	**17**	**18** *PM*: Venus and Mars are 1½° apart very low above the western horizon	**19** 1646: John Flamsteed, first Astronomer Royal, born	**20** Neptune at opposition Venus at greatest elongation East (45° 58')	**21**	**22** 1963: Highest altitude reached by the *X-15* rocket plane (106.8 km)
23 **30**	**24**  17h 05m Most distant Full Moon of 2010 **31**	**25** 1989: *Voyager 2* (US) flyby of Neptune	**26** *PM*: Jupiter is 6½° to the lower right of the Moon as it rises	**27** 1962: *Mariner 2* (US) makes the first Venus flyby	**28**	**29**

September 2010

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Venus (magnitude –4.6), **Saturn** (1.0), and **Mars** (1.5) succumb to the solar glow this month and all three will be lost to view in our evening sky after the third week. The Moon paired with Venus on the 13th will guide you to Saturn and Mars but you may need binoculars to spot the dimmer planets. **Mercury** puts on its best morning sky show of the year from the second week of September [*contd*.]		**1**  17h 22m *PM*: Venus opens the month very low in the SW and 1° from the star Spica	**2**	**3** Mercury is at inferior conjunction (not visible)	**4**	**5** 1977: Launch of *Voyager 1* (US) on a mission to encounter Jupiter and Saturn
6	**7**	**8**  10h 30m Saturn crosses the celestial equator, going from N to S	**9**	**10**	**11** SAC's Burren Star Party Minor planet 8 Flora is at opposition (8.2^{m}) *PM*: Venus 3¼° from the Moon very low in the SW	**12**
13 1959: Luna 2 (USSR) is the first spacecraft to impact the Moon	**14** Pluto stationary	**15**  05h 50m	**16** Planned launch of STS-134 shuttle mission to the ISS	**17** *AM*: Mercury is 10' from the star rho Leonis (3.85^{m})	**18**	**19** Mercury at greatest elongation west (17° 52' W)
20	**21** Jupiter at opposition (-2.9^{m}) Uranus at opposition (5.7^{m}) 6 Hebe at opposition (7.7^{m})	**22** Jupiter and Uranus are 53' apart in the second of their triple conjunction in 2010/11	**23**  09h 17m Autumnal equinox Venus is at greatest illuminated extent (-4.6^{m})	**24**	**25** 1644: Danish astronomer Ole Römer born	**26** Mars crosses from Virgo into Libra today
27 *AM*: Mercury is 10' from the star sigma Leonis (4.0^{m}) PM: Moon is within 5° of the Pleiades as they rise	**28**	**29** 1962: Launch of *Alouette 1* (first Canadian satellite)	**30**	[*from top left*] The innermost planet stands almost 10° above the eastern horizon at the beginning of civil twilight the third week of September when it reaches magnitude –0.4. Mercury continues to brighten after western elongation and will shine at magnitude –1.1 at the end of the month. This fine apparition continues into the first week of October. **Jupiter** (-2.9) is at opposition on the 21st along with **Uranus**. The pair are closest the next evening when binoculars will let you spot more distant Uranus. This is also the date both lie on the same line of right ascension on the celestial sphere.	

October 2010

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Jupiter lords over the evening sky in Pisces and remains on view almost the whole night. A small telescope will let you see the dusky cloud belts of its turbulent atmosphere and the disk is a noticeably oblate shape because of the planet's rapid rotation (Jupiter turns once in less than 10 hours.) **Saturn** was first to slip into the solar glare last month and is now first to reappear in our morning skies whereas **Venus** and **Mars** are still too close to the Sun. You should spot magnitude 0.9 Saturn paired with **Mercury** (-1.3) on the morning of the 8th but you will need binoculars to tease them out of the dawn glow. Saturn is better placed by the end October though when it is rising at 04:45UT. Mercury is visible the first week of the month but is rapidly losing altitude and will be lost to our view after the 8th.				**1**  03h 52m Saturn in conjunction with the Sun (not visible)	**2**	**3**
4 1957: Launch of *Sputnik 1* (USSR)	**5** 1882: Robert Goddard, US rocket pioneer, born	**6** 1990: Launch of *Ulysses* (ESA), a mission to explore the Sun's poles	**7**  18h 44m Mars is less than 1° from alpha^2 Librae (2.75^m)	**8** *AM*: Mercury and Saturn ½° apart very low on the E horizon 30 mins before sunrise (use binoculars) Draconid meteor shower peaks	**9** 1873: Astronomer Karl Schwarzschild born	**10** 1846: William Lassell discovers Neptune's largest moon Triton
11 Scheduled flyby of comet 103P/Hartley 2 by NASA's *EXPOI* mission (using the *Deep Impact* spacecraft)	**12**	**13**	**14**  21h 27m Jupiter crosses from Pisces back into Aquarius today 1947: Sound barrier is broken for the first time during a flight by Chuck Yaeger	**15** 1997: Launch of the *Cassini/Huygens* mission to Saturn	**16**	**17** Mercury is at superior conjunction (not visible) The *New Horizons* spacecraft is now half-way to Pluto
18 Predicted maximum of the long period variable star Mira Ceti	**19** *PM*: Jupiter lies a fist-width from the Moon tonight and tomorrow night	**20**	**21** Orionid meteor shower peaks tonight Saturn passes ½°from the star gamma Virginis (2.74^m)	**22** *AM*: Saturn passes ½° from the star gamma Virginis	**23**  01h 37m	**24** Double shadow transit of Jupiter's moons Europa and Ganymede (01h 40m)
25 Bank Holiday 1671: Saturn's enigmatic moon Iapetus is discovered by Cassini	**26** Mars crosses from Libra into Scorpius today 1959: First pictures of the far side of the Moon received	**27**	**28** Comet 103P/Hartley 2 is at perihelion	**29** Venus is at inferior conjunction (not visible)	**30**  12h 46m 1998: John Glenn becomes the oldest person in space at 77 years of age	**31** Summertime ends — clocks go back one hour

November 2010

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1 1962: *Mars 1* (USSR) is the first attempt to send a probe to Mars (failed)	**2**	**3** 1973: *Mariner 10* (US) is the first mission to the planet Mercury	**4** *AM*: Saturn lies a fist-width from the Moon	**5** *AM*: Venus and the Moon are less than 1° apart Southern Taurid meteor shower peaks	**6** ● 04h 52m	**7** Neptune stationary, pro-grade motion resumes Mars crosses from Scorpius into Ophiuchus today
8 1656: Edmond Halley born	**9**	**10** 1970: Launch of Luna 17 (USSR) — carried *Lunokhod 1*, the first remotely con-trolled Moon rover	**11**	**12** Northern Taurid meteor shower peaks	**13** ◗ 16h 39m Autumnal equinox begins in the N hemisphere of Mars	**14** 1969: Launch of *Apollo 12* on the second manned Moon landing mission
15 1988: First and only flight of the USSR's *Buran* space shuttle	**16** *PM*: Jupiter lies a fist-width from the Moon	**17** Leonid meteor shower peaks tonight	**18** Planned launch of Europe's second ATV (named *Johan-nes Kepler*) to the *ISS*	**19** Jupiter stationary, pro-grade motion resumes	**20** 1889: Edwin Hubble born	**21** ○ 17h 27m PM: Mercury and Mars are 1½° apart but very low above the SW skyline
22	**23** 1885: First photograph of a meteor is taken	**24**	**25**	**26** 1965: First launch of a French satellite, *Asterix 1*	**27**	**28** ◐ 20h 36m 1999: Meteorite fall in Leighlinbridge, Co. Carlow
29 1803: Christian Doppler born	**30** Planned launch of the Expedition 26 crew to the *ISS*	**Mercury** returns to our evening skies this month but only just — it may be spotted very low above the south-western horizon the very last day of November at magnitude -0.4. **Jupiter** (magnitude -2.8 at the beginning of the month slipping to –2.6 on the 30th) continues to rule over the night and is not setting until the hours after midnight. **Saturn** is a magnitude 0.9 object in Virgo and rises in the early morning hours. The Ringed Planet appears above the skyline at 04:30UT at the beginning of November but by 03:00UT on the 30th. A telescope will show the rings have now opened out quite a bit and they are tipped 9° towards us by the month's end. **Venus** is an easily seen morning sky object by the end of the first week of November and blazes more brilliantly each day as the brightness climbs from –4.2 to magnitude –4.9 during the month. Venus rises more than 3 hours ahead of the Sun by the 30th and even steadily held binoculars are sufficient to show its slender crescent phase. **Mars** is not on view this month.				

December 2010

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
A chance to spy **Mercury** in the evening and morning sky falls in December. The planet never gets higher than 2° though at the end of evening civil twilight the first week of the month when a mag. –0.2 pinpoint above a flat south-western horizon. It is easier to spot in the morning sky after the 24th and ends 2010 a magnitude 0.3 object 6½° up at the beginning of civil twilight. **Mars** is not on view.		**1** *AM*: Saturn is 8½° to the left of the Moon Mercury is at greatest elongation east (21° 27' E)	**2** *AM*: Venus is 8½° to the left of the Moon Mars passes from Ophiuchus into Sagittarius today	**3** 1973: *Pioneer 10* flyby of Jupiter	**4** Venus is at greatest illuminated extent (-4.6)	**5** ● 17h 36m
6	**7** *PM*: Mercury, Mars and the Moon are visible low above the SW skyline	**8**	**9**	**10** Saturn lies with 3' of the star 44 Virginis (5.8^{m})	**11** 1972: *Apollo 17* landing on the Moon	**12** 1546: Danish astronomer Tycho Brahe born
13 ◗ 13h 59m *PM*: Jupiter is 5° to the lower right of the Moon Earliest sunset of the year at Dublin (16h 06m)	**14** *PM*: Mercury and Mars are 1½° apart low in the SW Geminid meteor shower peaks in the early hours	**15** 1970: *Venera 7* (USSR) is the first spacecraft to soft-land on Venus	**16** 1917: Arthur C Clarke born	**17** Jupiter is at eastern quadrature. The planet crosses into Pisces from Aquarius	**18**	**19**
20 Mercury is at inferior conjunction (not visible)	**21** ○ 08h 13m Total lunar eclipse visible from Ireland. The Moon will set while still eclipsed.	**22** Winter solstice, 23h Ursid meteor shower peaks	**23**	**24** 1968: *Apollo 8* crew make their famous broadcast from lunar orbit	**25** Christmas Day	**26** St. Stephen's Day
27 Pluto is in conjunction with the Sun (not visible)	**28** ◖ 04h 18m	**29** Latest sunrise of the year at Dublin (08h 41m) Jupiter lies 3' from the star 20 Piscium (5.0^{m})	**30** 1930: Robert Goddard launches his first rocket	**31** New Year's Eve	**Jupiter** (magnitude –2.4) remains in Pisces and is visible most of the evening time hours. By the end of the year it sets just before midnight. **Saturn** is rising at 03:00UT on the 1st and by 01:00UT on the 31st. The rings are now well displayed as the planet brightens to magnitude 0.8 in Virgo. **Venus** rises four hours before the Sun as 2011 dawns and will light the way home for bleary-eyed revellers.	

The Sun

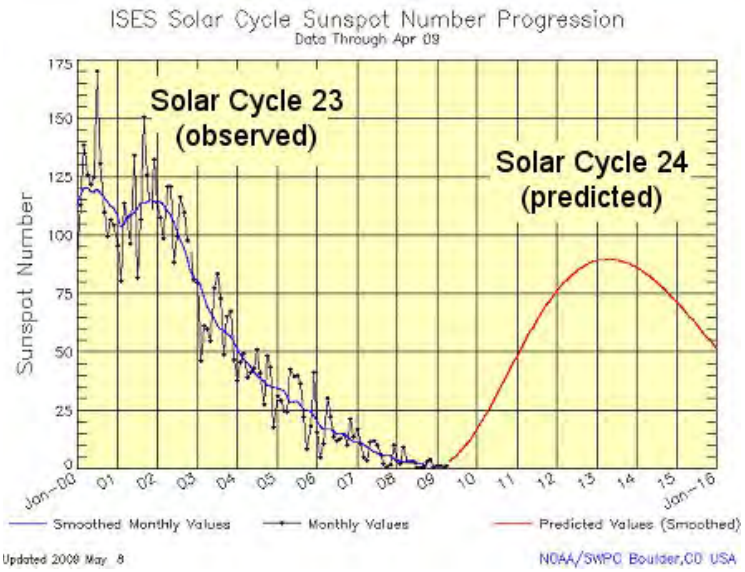
The consensus is that we reached the minimum of the current solar cycle in December 2008. However, astronomers have been struggling to predict just how the next one (number 24) will behave.

The problem is the Sun has been bereft of sunspots for weeks or months at a time over the last two years. There is general agreement that this is the deepest solar minimum in a century. It has played havoc though with attempts to forecast the next bout of solar weather.

The Solar Cycle 24 Prediction Panel is a group of astronomers who meet on an irregular basis to review solar cycle predictions in the peer-reviewed literature or submitted directly by other scientists. The experts almost unanimously agree that Cycle 24 will be below average in intensity and reach maximum in March or April 2013 with a maximum relative sunspot number of 89 ± 25 — that's a lot less than the cycle just past which was one of the stormiest on record.

When graphed over time the peaks and troughs of sunspot activity don't always keep to the generally touted 11 year cycle. Sometimes a cycle may last just 9 years while on other occasions it can stretch to 14. The Maunder Minimum in the 17th century when the Sun was spotless for 70 years still baffles scientists. The sunspot number is variable too at the peak of a solar cycle.

Sunspots are regions of intense magnetic activity on the surface of the Sun and form when the magnetic fields block the flow of heat from the Sun's interior. They appear dark because they are cooler than their surrounds but still sizzle



at 4000°C compared to 6000°C for the rest of the solar surface. Radiation from high-energy flares spawned by complex spot groups can cause severe disruption in the Sun-Earth environment with the sensitive electronics of satellites in orbit especially prone to damage. Downtime in ground-based electrical and communications services may occur too. Even during a relatively quiet cycle, as the next one may be, there is the possibility of a strong solar flare which could have a major impact on our wired world.

Whatever happens, Cycle 24 is sure to spring some surprises which will only help in understanding the weather whims and complexity of our nearby star on which we are so dependant.

Carrington Rotation Numbers

The Carrington Rotation Number is a system designed to identify individual rotations of the Sun. It commenced with rotation number 1 on 1853 November 9. Under the system, the Sun is assigned a mean rotation period of 25.38 days. Rotation number 2091 commenced on 2009 December 07 while rotation number 2106 extends to 2011 January 20.

No.	Date	No.	Date	No.	Date
2091	07 Dec	2096	22 Apr	2101	05 Sept
2092	03 Jan	2097	20 May	2102	03 Oct
2093	30 Jan	2098	16 Jun	2103	30 Oct
2094	27 Feb	2099	13 Jul	2104	26 Nov
2095	26 Mar	2100	09 Aug	2105	24 Dec

Safe solar viewing

Great care should be taken in observing the Sun because of the risk of instant blindness should you accidently look through a telescope without a proper filter in place. Many cheap telescopes come with a so-called Sun filter. Often they are nothing more than pieces of smoked glass and are generally designed to fit over the eyepiece of the telescope. This does nothing to dim the full power of the sun and the filter can shatter without warning because of the intense heat concentrated at the eyepiece, driving shards of glass into your eyes. Neither do they filter out the more harmful invisible solar rays. Such filters therefore are **not safe** and should be immediately discarded.

A more practical method is to project the Sun's image on to a piece of white card. Care should be used in case someone tries to take a quick glance through the eyepiece. Some telescopes may not be suited to using the projection method; one potential problem is that the lens cement of your eyepiece could melt. Check with a local astronomical society if you have any doubts.

A number of commercial companies offer specialised solar telescopes that allow you view the Sun in the light of the hydrogen-alpha line (you can also buy H-α filters sets that can be fitted to conventional refractor telescopes.) The view through these telescopes is extraordinary and fiery prominences can be seen around the limb of the Sun while granulation and other features are seen on the solar disk itself. H-α telescopes are not cheap but the budding daytime observer can get started with the versatile Coronado Personal Solar Telescope (PST) which retails for about $500/€500.

Eclipses

Two solar and two lunar eclipses occur during 2010. The total lunar eclipse of December 21st that is visible from here will be highly anticipated when you consider the last few have been rather clouded out for observers in Ireland!

2010 January 15 — Annular Solar Eclipse

The track of this eclipse starts in the Central African Republic and moves eastward through central Africa before crossing over the Indian Ocean with the Maldives in the path. The southern tip of India and northern Sri Lanka then experience just over 10 minutes of annularity as the eclipse continues on towards Burma and finally ends southeast of Beijing after crossing central China.

The duration of annularity will be 11 minutes 8 seconds at maximum — the longest until that of December 3043. An annular (from "*annulus*", or "ring") eclipse occurs when the Moon's disc is too small to cover the Sun. No stage of this eclipse is visible from Ireland.

2010 June 26 — Partial Lunar Eclipse

This eclipse is not visible from Ireland, but from Australasia, the western coast of the Americas, and parts of eastern Asia. The umbral magnitude will reach 0.537* when at maximum.

2010 July 11 — Total Solar Eclipse

The track of this eclipse is mostly over the southern Pacific Ocean with only a few islands in the path of totality. One of these is Easter Island and visitor numbers are expected to soar at this time. Annual cloud statistics show that the eastern Pacific is not favourable for viewing totality so many tour groups have selected French Polynesia as their base. The eclipse track actually passes just 20 km south of Tahiti so most observers will therefore view the event from on board cruise ships. The eclipse ends over the fiords of western Chile but the low altitude coupled with poor weather prospects mean few will venture to that region to observe totality there. A detailed eclipse bulletin is available from http://sunearth.gsfc.nasa.gov/eclipse

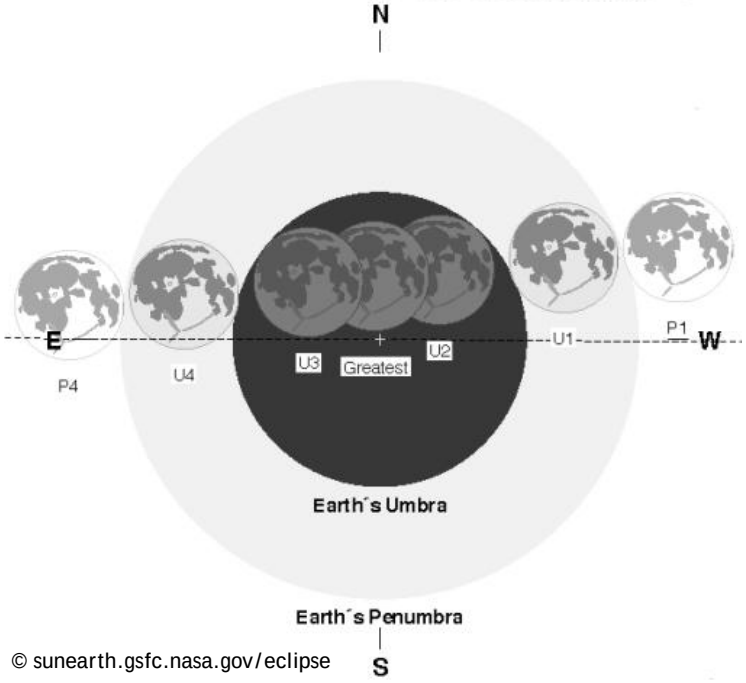
2010 December 21 — Total Lunar Eclipse

This will be a dramatic total lunar eclipse from here as Moonset will occur while the Moon is still immersed in the Earth's shadow. A carefully selected foreground will enhance any photo composition. The Moon will lie in Taurus at the time of eclipse and passes north of the central part of Earth's shadow. This will lead to a brightness contrast between the two lunar hemispheres during mid-totality.

* The *magnitude* of a eclipse is a measure of the extent of an eclipse. For a lunar eclipse it is the fraction of the Moon's disk covered by the Earth's umbra.

2010 December 21 — eclipse contact times

P1 = 05:29:17 UT	U3 = 08:53:08 UT
U1 = 06:32:37 UT	U4 = 10:01:20 UT
U2 = 07:40:47 UT	P4 = 11:04:31 UT



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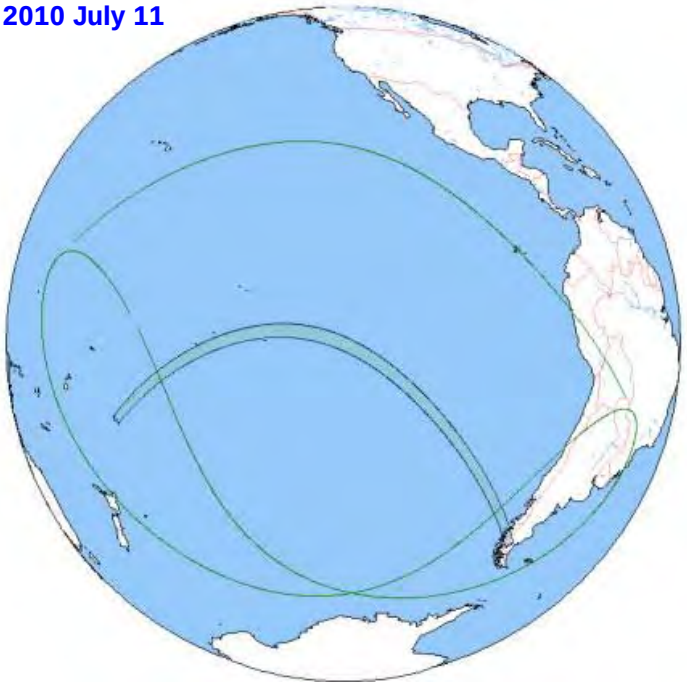
2010 Jan 15

2010 July 11



The Earth

Phenomena

Earth at perihelion	Jan 03d 00h (147,098,089 km)	*Earth at aphelion*	Jul 06d 112h (152,096,453 km)
Spring equinox	Mar 20d 17h	*Autumnal Equinox*	Sept 23d 03h
Summer Time begins	Mar 28th	*Summer Time ends*	Oct 31st
Easter Sunday	Apr 04th	*Earliest sunset*	Dec 13th at 16h 06m
Earliest sunrise	Jun 17th at 03h 56m	*Winter solstice*	Dec 21d 23h
Summer solstice	Jun 21d 11h	*Latest sunrise*	Dec 29th at 08h 41m
Latest sunset	Jun 24th at 20h 58m		

Sunrise and Sunset

The rather densely packed table below details sunrise (s/r) and sunset (s/s) times for an observer at Dublin, Ireland. Also shown are the times for the beginning (b/)and ending (e/) of civil (ct — when the Sun is 6° below the horizon), nautical (nt — Sun is 12° below the horizon), and astronomical (at — Sun is 18° below the horizon) twilight. For example, a column headed e/nt shows the time that nautical twilight ends. "/////" indicates that twilight lasts throughout the night.

	b/at		b/nt		b/ct		s/r		s/s		e/ct		e/nt		e/at	
	h	m	h	m	h	m	h	m	h	m	h	m	h	m	h	m
Jan 01	06	31	07	13	07	58	08	41	16	17	16	59	17	44	18	27
Jan 15	06	27	07	09	07	53	08	34	16	36	17	17	18	01	18	43
Jan 30	06	13	06	54	07	36	08	14	17	03	17	42	18	24	19	05
Feb 01	06	10	06	51	07	33	08	11	17	07	17	45	18	27	19	08
Feb 15	05	48	06	28	07	09	07	45	17	35	18	11	18	52	19	32
Feb 29	05	19	05	59	06	40	07	15	18	02	18	37	19	17	19	58
Mar 01	05	17	05	57	06	37	07	12	18	04	18	39	19	19	20	00
Mar 15	04	42	05	24	06	05	06	39	18	30	19	05	19	46	20	28
Mar 30	03	59	04	45	05	28	06	03	18	58	19	33	20	16	21	02
Apr 01	03	53	04	40	05	23	05	58	19	01	19	37	20	20	21	07
Apr 15	03	07	04	01	04	48	05	25	19	27	20	04	20	51	21	46
Apr 30	02	10	03	19	04	12	04	53	19	54	20	34	21	28	22	39
May 01	02	05	03	16	04	10	04	51	19	56	20	36	21	31	22	44
May 15	/////		02	37	03	40	04	25	20	20	21	04	22	08	/////	
May 30	/////		01	59	03	16	04	05	20	41	21	31	22	49	/////	
Jun 01	/////		01	54	03	14	04	03	20	44	21	34	22	54	/////	
Jun 15	/////		01	31	03	04	03	56	20	56	21	48	23	22	/////	
Jun 30	/////		01	38	03	09	04	01	20	57	21	49	23	19	/////	

	b/at		b/nt		b/ct		s/r		s/s		e/ct		e/nt		e/at	
	h	m	h	m	h	m	h	m	h	m	h	m	h	m	h	m
Jul 01	/////		01	40	03	10	04	02	20	56	21	48	23	17	/////	
Jul 15	/////		02	12	03	28	04	16	20	46	21	34	22	48	/////	
Jul 30	00	53	02	53	03	55	04	39	20	24	21	07	22	08	00	11
Aug 01	01	16	02	58	03	58	04	42	20	20	21	03	22	03	23	39
Aug 15	02	29	03	34	04	26	05	06	19	53	20	32	21	23	22	28
Aug 30	03	17	04	09	04	55	05	32	19	19	19	56	20	41	21	33
Sep 01	03	22	04	13	04	59	05	35	19	14	19	51	20	36	21	26
Sep 15	03	57	04	42	05	24	05	59	18	40	19	15	19	57	20	42
Sep 30	04	28	05	10	05	51	06	26	18	04	18	38	19	19	20	01
Oct 01	04	30	05	12	05	53	06	27	18	01	18	36	19	16	19	58
Oct 15	04	57	05	37	06	17	06	53	17	28	18	04	18	44	19	24
Oct 30	05	23	06	03	06	44	07	21	16	56	17	33	18	14	18	54
Nov 01	05	26	06	06	06	48	07	25	16	52	17	29	18	10	18	51
Nov 15	05	48	06	29	07	12	07	51	16	28	17	07	17	50	18	31
Nov 30	06	09	06	51	07	35	08	17	16	11	16	53	17	37	18	19
Dec 01	06	10	06	52	07	37	08	18	16	10	16	52	17	36	18	18
Dec 15	06	24	07	07	07	52	08	35	16	06	16	49	17	35	18	17
Dec 30	06	31	07	13	07	58	08	41	16	15	16	58	17	43	18	26

The Earth

Hours of darkness

The table below shows the number of hours of darkness for each day of 2010 for an observer at Dublin. The conditions are that the Sun is at least 18° below the horizon (end of astronomical twilight) and the Moon is absent from the sky. That is not to say observing is not possible on other nights or for longer periods, just that these times are considered true dark.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1		01h 45m		01h 55m	01h 18m				00h 23m	03h 01m	07h 31m	10h 02m
2	00h 26m	03h 11m	01h 15m	03h 09m	01h 57m				01h 23m	04h 26m	08h 59m	11h 28m
3	01h 59m	04h 35m	02h 41m	04h 09m	02h 23m				02h 37m	05h 57m	10h 28m	11h 55m
4	03h 26m	05h 57m	04h 03m	04h 56m	02h 42m				04h 03m	07h 27m	10h 45m	11h 56m
5	04h 50m	07h 15m	05h 20m	05h 30m	02h 45m			00h 42m	05h 36m	08h 50m	10h 49m	11h 58m
6	06h 12m	08h 26m	06h 27m	05h 54m	02h 34m			01h 54m	06h 26m	08h 54m	10h 51m	11h 59m
7	07h 33m	09h 28m	07h 21m	06h 12m	02h 23m			02h 53m	06h 32m	08h 59m	10h 55m	12h 01m
8	08h 52m	10h 17m	08h 02m	06h 06m	02h 11m			03h 03m	06h 37m	09h 03m	10h 57m	11h 18m
9	10h 07m	10h 33m	08h 32m	06h 00m	01h 58m			03h 12m	06h 42m	09h 08m	10h 41m	10h 05m
10	11h 16m	10h 30m	08h 37m	05h 54m	01h 43m			03h 21m	06h 48m	09h 12m	09h 33m	08h 54m
11	11h 50m	10h 26m	08h 32m	05h 48m	01h 27m			03h 30m	06h 53m	09h 16m	08h 22m	07h 44m
12	11h 48m	10h 23m	08h 28m	05h 42m	01h 07m			03h 38m	06h 59m	08h 41m	07h 12m	06h 37m
13	11h 46m	10h 19m	08h 23m	05h 35m	00h 38m			03h 47m	07h 04m	07h 38m	06h 02m	05h 29m
14	11h 45m	10h 15m	08h 18m	05h 29m				03h 55m	06h 33m	06h 30m	04h 55m	04h 21m
15	11h 42m	10h 12m	08h 14m	05h 22m				04h 02m	05h 37m	05h 21m	03h 48m	03h 11m
16	11h 40m	09h 00m	08h 09m	04h 30m				04h 10m	04h 33m	04h 12m	02h 41m	01h 59m
17	11h 03m	07h 46m	07h 38m	03h 15m				04h 03m	03h 25m	03h 04m	01h 32m	00h 47m
18	09h 51m	06h 30m	06h 20m	02h 11m				03h 15m	02h 16m	01h 57m	00h 22m	
19	08h 40m	05h 12m	05h 00m	01h 20m				02h 16m	01h 08m	00h 50m		
20	07h 29m	03h 53m	03h 42m	00h 41m				01h 13m	00h 00m			
21	06h 15m	02h 37m	02h 31m	00h 12m				00h 05m				
22	04h 58m	01h 28m	01h 31m									
23	03h 39m	00h 32m	00h 45m									00h 43m
24	02h 19m		00h 10m								00h 17m	02h 09m
25	01h 03m										01h 36m	03h 33m
26											02h 59m	04h 57m
27										00h 37m	04h 23m	06h 20m
28										01h 50m	05h 48m	07h 43m
29									00h 36m	03h 12m	07h 12m	09h 05m
30				00h 27m					01h 42m	04h 37m	08h 37m	10h 25m
31	00h 16m		00h 34m							06h 03m		11h 40m

The lingering twilight from our latitude during the Summer months may mean observing activity wanes a little but there are bonuses. You might notice a surfeit of artificial satellites slowly threading their way across the sky each night at this time of year. There's a good reason for this. The Sun never dips far below the horizon during the summer period so the Earth's shadow cast in space is low in the sky. During the winter, when the shadow is higher, most satellites tend to be eclipsed by the Earth's umbra for an observer on the ground, leading to fewer of these space-birds being seen.

The night-long twilight also lends itself to occasional displays of noctilucent cloud (NLC). These are clouds that form in the cold air at altitudes of about 80km and are the highest occurring clouds seen. NLCs are visible long after sunset when their great height allows them to remain lit by the Sun. Troposphere clouds lower down can often be seen in silhouette against them. NLCs are usually bluish or silvery in hue and can appear as a fine tenuous veil or exhibit a herringbone-like structure. Extensive displays of NLCs have been seen from here the last couple of years.

The Moon

THE MOON is a wonderful object to follow during the month and the attentive observer soon becomes tuned to the many facets of her aspect. Here we describe a few to watch for.

When the Moon is a slender crescent you may notice a phenomenon called **Earthshine** that is also popularly known as "the old Moon in the new Moon's arms". This is due to sunlight reflected off the day side of the Earth on to the unlit portion of the Moon. The brightness of Earthshine is often an indicator of the weather situation on our own planet as dense cloud cover on the day side of Earth reflects more sunlight.

When we see the First or Last Quarter Moon we are looking right along the **Earth's path around the Sun**. The Last Quarter Moon marks the Earth's approximate position about 3½ hours hence while the First Quarter Moon marks the Earth's previous location by about the same length of time (and we're roughly either 370, 000 km ahead or behind the Moon in our own orbit at these moments.)

Easter Sunday this year is on April 4th and is generally taken as the first Sunday after the first Full Moon following the Spring Equinox. The computation is a little more complex than this but it's a useful rule of thumb.

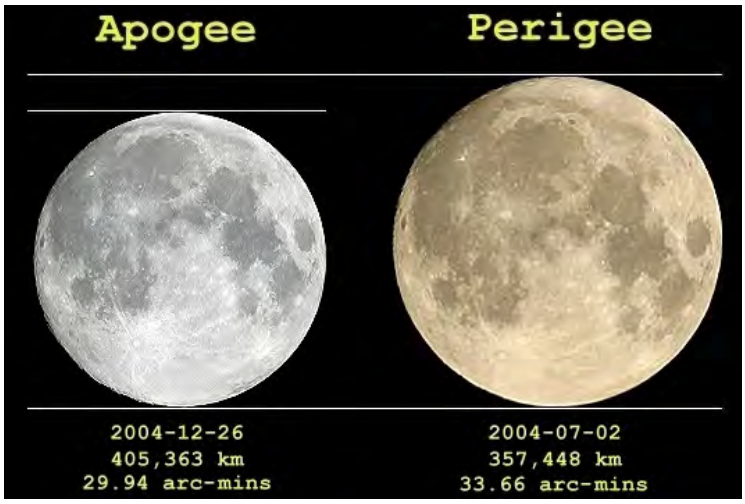
The Full Moon of September 23rd is by definition the **Harvest Moon**; that is, it is the closest Full Moon to the Autumnal Equinox. On average, the Moon rises around one hour later each night. What marks out the Harvest Moon as special is that it appears to rise around sunset for several successive evenings at this time.

The Moon revolves around the Earth in 29·53059 days (known as the *synodic* month) and so we may see the same lunar phase repeat in a month. This occurs about every 2·5 years on average. This year we have two Last Quarter moons in October. The second Full Moon in a month is popularly called the **Blue Moon**.

Apollo astronauts described the lunar surface as being grey in colour. It follows that the Moon's disk will adopt the colour of the sunlight it reflects; a yellow-white hue. But our perception of the brilliant white of the Full Moon at night is largely due to it being vastly brighter than its background. When low on a hazy night it can become a deep gold or honey colour. Follow the Full Moon some evening after it rises and note the changing colour of the disk.

The Moon's orbit is not perfectly circular, resulting in the distance from us varying over the course of a month. This also leads to a change in the Moon's angular diameter or apparent size in the sky. The composite here dramatically shows this apparent size change and was assembled by Greek amateur astronomer Anthony Ayiomamatis (see more of Anthony's fine images of the sky at www.perseus.gr).

The closest (**perigee**) Full Moon of 2010 (356,739 km) falls on January 30th when the disk measures 33' 41". It is the also the closest Moon of the year. The most distant (**apogee**) Full Moon is that of August 24th and the disk will measure 29' 32" or about 13% smaller than January's. The furthest Moon of 2010 (406,537 km) falls on February 13th.



New Moon				First Quarter				Full Moon				Last Quarter			
	d	h	m		d	h	m		d	h	m		d	h	m
												Jan	07	10	39
Jan	15	07	11	Jan	23	10	53	Jan	30	06	18	Feb	05	23	48
Feb	14	02	51	Feb	22	00	42	Feb	28	16	38	Mar	07	15	42
Mar	15	21	01	Mar	23	11	00	Mar	30	02	25	Apr	06	09	37
Apr	14	12	29	Apr	21	18	20	Apr	28	12	18	May	06	04	15
May	14	01	04	May	20	23	43	May	27	23	07	June	04	22	13
June	12	11	15	June	19	04	29	June	26	11	30	July	04	14	35
July	11	19	40	July	18	10	11	July	26	01	37	Aug	03	04	59
Aug	10	03	08	Aug	16	18	14	Aug	24	17	05	Sept	01	17	22
Sept	08	10	30	Sept	15	05	50	Sept	23	09	17	Oct	01	03	52
Oct	07	18	44	Oct	14	21	27	Oct	23	01	37	Oct	30	12	46
Nov	06	04	52	Nov	13	16	39	Nov	21	17	27	Nov	28	20	36
Dec	05	17	56	Dec	13	13	59	Dec	21	08	13	Dec	28	04	18

The Moon

The annual attempt of trying to spot **the youngest Moon** is a real thrill. Certain conditions need to be satisfied to come close to present records for the youngest Moon seen (how soon after moment of New the crescent is first spotted). Currently, the records stand at 11.7 hours using giant binoculars and a little over 15 hours with the naked eye.

Certain factors are critical to spot a young Moon. Time of year is important. During the Spring, the ecliptic, or apparent path of the Sun on the celestial sphere, makes its steepest angle to the horizon. This causes the Sun to sink rapidly, darkening the sky while placing the lunar crescent at a respectable altitude above the horizon.

Equally important is time of New Moon. Theory shows that the lunar crescent should become invisible when within 7° of the Sun because the limb will be obscured by shadows cast by mountains on the terminator. Therefore, New Moon should fall some time between midnight and sunrise of the day you are attempting any record sighting.

Two additional factors aid your sighting attempt. The further north the Moon is from the ecliptic, the longer it remains above the horizon after sunset. Secondly, the Moon should be at perigee, or closest to the Earth in its orbit. Then the Moon's orbital motion is fastest, rapidly increasing the angular distance between it and the Sun.

A difficult 14½-hour old Moon may be seen on **February 14th** when the very thin crescent is a little over 1° above the WSW skyline at the end of civil twilight. Both Jupiter and Venus are to the Moon's left that evening.

Two better chances to spy the slender phase occur on **March 16th** (21½ hour old Moon) and **May 14th** (20¼ hour old Moon). The lunar curl will not set for over an hour after sundown on both these dates. These opportunities may not be record breakers but the sight of any lunar crescent less than a day old is breathtaking.

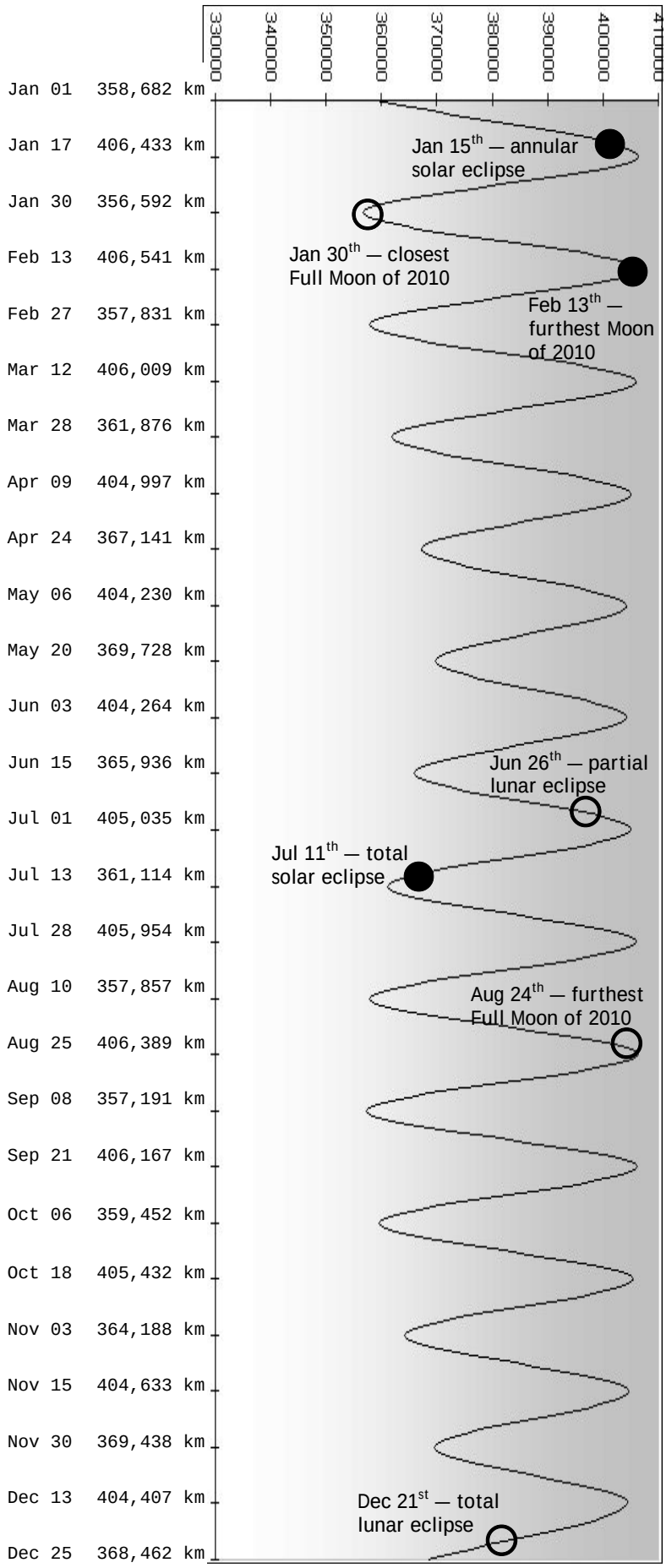
Vera Historia (*True History*) written in the second century AD by Lucian of Samosata is generally considered the first science fiction story. It tells how a whirlwind plucks a galleon from the sea and holds it aloft for seven days and seven nights before depositing it on a strange island that turns out to be the Moon. There, the crew stumble upon an interplanetary war being waged by the rulers of the Sun and the Moon over who had colonisation rights to Jupiter.

Since then other tales have conjured up voyages to our companion in space where adventurers found a fantastic world lush with exotic flora and fauna. Early writers surmised too whether lunar inhabitants led a blissful existence – easy to imagine when wishing to escape the daily grind on Earth and fly to a lunar Utopia (the then generally accepted view of the Moon.)

Voyages to the Moon by Marjorie Hope Nicholson (MacMillan, 1948, but reprinted since) is an extraordinary account of pre-1850 science fiction with a specific emphasis on such imaginary flights to the Moon.

Lunar Perigee and Apogee 2010

(distance in km)



Occultations and librations

On it's journey round the sky the Moon can pass in front of a star or another celestial body. Such an event is called an **occultation**. The Moon's west to east motion means an object disappears at the left edge and reappears at the right side. The lack of a lunar atmosphere means the sudden disappearance of a star at the limb can be striking.

The table on the next page lists lunar occultations of stars or planets for Dublin-based observers. That doesn't mean a particular occultation will be unobservable from other parts of Ireland; rather, it is the time Dublin-based observers will note the object's disappearance (D) or reappearance (R).

Graze events, where the limb of the Moon just touches a star, are noted by a "G" in the phase column (Ph.). Numerous disappearances and reappearances of a star may occur during a graze event as it is alternately hidden by mountains at the Moon's limb.

The magnitude (Mag.) and position angle (P.A.°) are also shown. Position angle is defined as the angle between the lunar north pole, the centre of the Moon and the position of the star at the moment of occultation. The angle increases eastward and is expressed in degrees.

A star magnitude limit of 6·5 has been adopted for the table. There are times when you will see a fainter star than our magnitude limit occulted around the same time as a brighter one listed here.

No particular lunar occultation highlights for 2010 stand out although a few outlying members of the Pleiades (M45) will be occulted on the evening of February 21st. There's a near-miss the morning of July 8th when the waning lunar crescent lies below the cluster before dawn. The Pleiades are immortalised in Tennyson's *Locksley Hall* and star lore world-wide. This stellar association "*tangled in a silvery braid*" is a wonderful sight in binoculars. Long exposure photographs reveal blue strands of gas and dust permeating the group. This was once thought to be material left over from when the Pleiades formed but current thinking though is that the cluster is just passing through the nebula.

Stellar occultations by planets & asteroids

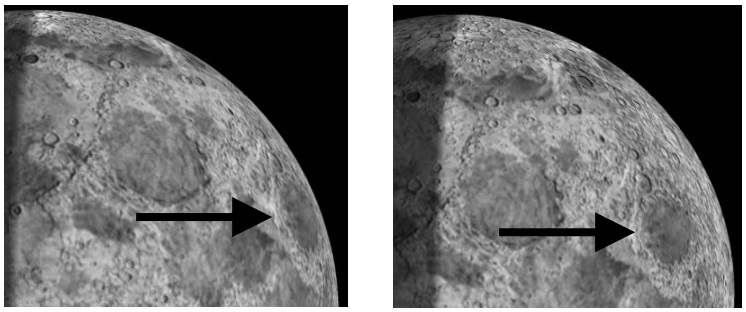
A rare occultation by Pluto of a magnitude 10.4 star in Sagittarius is predicted to occur for European observers on the morning of February 14th at 04h 48.2m. The star's light will drop by over three magnitudes with the duration of the event lasting about 95 seconds. The European Occultation Network (EON) will publish a more definitive track closer to the date.

Asteroid occultations of stars are very important because careful timings enable astronomers construct a shape-profile of the object. Such events can also reveal if there is a satellite companion and a number have been found in this way. The best event of 2010 from here is that listed below but accurate predictions should be sourced closer to the time from www.asteroidoccultation.com

2010 Jan 31: 106 Dione occults a magnitude 9.06 star in Pisces at 17h 59.7m as seen from the S coast of Ireland.

Librations

The rotation period of the Moon is the same as the length of time it takes to revolve (orbit) around the Earth. This has the effect of tidally locking the Moon so that approximately the same aspect is always pointed towards us. An apparent "nodding" of the lunar disk known as **libration** allows us to peer a little beyond its edge however. Close to the eastern limb is the circular Mare Crisium. The Mare can vary in appearance from a thin dark line to an easily seen dark oval patch when libration conditions are favourable. The table below lists the libration maxima for 2010.



Simulation of the appearance of Mare Crisium (arrowed) at the Moon's limb on January 23rd (left) & July 18th (right.)

Date	Tilt °	Viewable region (phase or if at dark limb)
08 Jan	9.9	region is at the dark limb
23 Jan	10.1	region is at the dark limb
04 Feb	10.2	region is at the dark limb
20 Feb	9.5	region is at the dark limb
04 Mar	9.6	region is at the dark limb
19 Mar	8.5	region is at the dark limb
01 Apr	8.5	region is at the dark limb
14 Apr	8.0	region is at the dark limb
28 Apr	7.6	Mare Humboldtianum
11 May	8.1	craters Inghirami and Baade
25 May	7.6	craters Hayn and Belkovich
08 Jun	8.6	craters Inghirami and Baade
21 Jun	8.2	Mare Humboldtianum
06 Jul	9.0	craters Graff and Baade
18 Jul	9.0	craters Fabry and Vashakidze
03 Aug	9.0	craters Graff and Baade
15 Aug	9.4	craters Fabry and Harkhebi
30 Aug	8.4	southern aspect of Cordillera Mts
12 Sept	9.1	craters Gauss and Vestine
26 Sept	7.4	crater Graff and Vallis Bouvard
10 Oct	8.1	craters Gauss and Vestine
22 Oct	6.9	craters Andersson and Chadwick
06 Nov	6.8	region is at the dark limb
18 Nov	7.0	region is at the dark limb
01 Dec	6.8	region is at the dark limb
16 Dec	7.3	region is at the dark limb
28 Dec	7.2	region is at the dark limb

		Time (UT)	Star	Mag.	Ph.	P.A.°
Jan	01	04:01:17	44 Gem	6.0	R	322
Jan	01	21:29:56	85 Gem	5.4	R	326
Jan	02	02:15:05	PPM 124820 (Cnc)	6.2	R	262
Jan	04	00:24:14	PPM 156374 (Leo)	6.1	R	275
Jan	04	01:34:19	pi Leo	4.7	R	278
Jan	05	07:29:55	62 Leo	5.9	R	220
Jan	06	05:12:16	PPM 194890 (Vir)	5.6	R	278
Jan	25	17:00:49	36 Tau	5.5	D	85
Jan	26	02:46:38	62 Tau	6.3	D	154
Jan	27	03:27:00	118 Tau	5.8	D	56
Jan	27	17:09:57	5 Gem	5.8	D	107
Jan	28	18:45:09	delta Gem	3.5	D	77
Jan	28	21:48:45	PPM 97507 (Gem)	6.5	D	102
Jan	28	22:16:41	63 Gem	5.3	D	108
Jan	31	00:14:55	xi Leo	5.0	R	316
Jan	31	05:21:46	omicron Leo	3.5	R	302
Jan	31	21:26:53	PPM 156779	6.5	R	315
Feb	02	05:00:26	87 Leo	4.8	R	269
Feb	10	07:16:52	PPM 268836 (Sgr)	5.8	R	233
Feb	20	22:56:42	companion of ε Ari	5.6	D	39
Feb	20	22:56:44	epsilon Ari	4.7	D	39
Feb	21	19:15:26	M45 star	5.4	D	122
Feb	21	19:56:39	26 Tau	6.5	D	18
Feb	21	19:58:46	M45 star	6.2	D	67
Feb	23	00:13:37	98 Tau	5.8	D	69
Feb	25	19:33:09	85 Gem	5.4	D	53
Feb	26	00:11:28	PPM 124820 (Cnc)	6.2	D	101
Feb	26	04:35:22	PPM 125020 (Cnc)	6.5	D	140
Feb	27	21:05:43	PPM 156338 (Leo)	5.8	G	28
Feb	27	21:50:14	PPM 156374 (Leo)	6.1	D	130
Feb	27	22:59:03	pi Leo	4.7	D	124
Mar	08	04:50:18	PPM 266967 (Oph)	6.0	R	293
Mar	09	06:09:45	lambda Sgr	2.8	R	240
Mar	19	20:38:36	mu Ari	5.7	D	64
Mar	26	20:48:55	xi Leo	5.0	D	52
Mar	27	01:52:33	omicron Leo	3.5	D	82
Mar	29	02:13:16	87 Leo	4.8	D	152
Apr	03	05:17:46	PPM 265306 (Sco)	6.1	R	278
Apr	19	22:40:58	PPM 95944 (Gem)	6.1	D	96
Apr	29	01:24:21	PPM 263395 (Lib)	6.1	D	36
Apr	29	01:47:47	PPM 263395 (Lib)	6.1	R	360
Apr	29	22:49:29	42 Lib	5.0	G	17
May	15	22:04:03	103 Tau	5.5	D	77
May	17	22:22:54	PPM 97133 (Gem)	6.4	D	103
May	22	00:02:37	PPM 157292 (Leo)	6.4	D	172
Jun	09	03:06:10	PPM 117986 (Ari)	6.4	R	254
Jun	23	22:31:26	V913 Sco	5.4	D	92
Jun	28	23:38:06	rho Cap	4.9	R	248
Jun	30	00:41:41	PPM 238627 (Aqr)	6.4	R	287
Jul	02	23:49:26	9 Psc	6.3	R	283
Jul	29	04:33:25	kappa Aqr	5.0	G	327
Jul	31	23:15:07	PPM 143767 (Psc)	6.5	R	287
Aug	02	04:20:13	101 Psc	6.2	R	234
Aug	03	23:31:21	PPM 92243 (Ari)	6.4	R	198
Aug	06	01:17:56	103 Tau	5.5	R	288
Aug	30	03:17:22	PPM 117986 (Ari)	6.4	R	228
Aug	31	01:41:03	47 Ari	5.8	R	324
Sept	01	04:36:20	33 Tau	6.1	R	271
Sept	01	23:01:45	95 Tau	6.2	G	352
Sept	13	19:51:29	PPM 265065 (Sco)	6.2	D	111
Sept	16	22:08:09	PPM 269095 (Sgr)	5.9	D	65
Sept	21	00:36:41	PPM 206033 (Aqr)	6.5	D	26
Sept	22	23:59:54	16 Psc	5.7	D	58
Sept	30	03:56:50	121 Tau	5.4	R	292
Sept	30	22:43:20	mu Gem	2.9	R	204
Oct	01	23:16:38	56 Gem	5.1	R	306
Oct	02	01:15:41	61 Gem	5.9	R	300
Oct	13	19:24:40	24 Sgr	5.5	D	119
Oct	14	19:06:47	50 Sgr	5.6	D	140
Oct	14	21:46:58	PPM 269885 (Sgr)	6.1	D	118
Oct	18	22:56:58	kappa Aqr	5.0	D	19
Oct	20	02:28:59	kappa Psc	4.9	D	73
Oct	20	02:42:58	9 Psc	6.3	D	116
Oct	24	20:27:50	zeta Ari	4.9	R	314
Oct	24	23:49:04	tau Ari	5.3	R	219
Oct	27	22:57:20	3 Gem	5.8	R	301
Oct	28	00:11:53	6 Gem	6.5	R	256
Oct	28	05:03:12	mu Gem	2.9	D	156
Oct	28	05:47:22	mu Gem	2.9	R	228
Oct	29	06:11:52	56 Gem	5.1	R	338
Nov	03	04:36:50	PPM 194890 (Vir)	5.6	R	251
Nov	13	23:04:16	PPM 239151 (Cap)	6.1	D	133
Nov	16	19:41:59	19 Psc	4.9	D	47
Nov	18	02:30:59	PPM 143767 (Psc)	6.5	D	95
Nov	19	21:37:40	PPM 117986 (Ari)	6.4	D	38
Nov	21	02:00:17	PPM 92243 (Ari)	6.4	D	93
Nov	21	04:54:50	zeta Ari	4.9	D	72
Nov	21	19:02:37	PPM 92958 (Tau)	6.1	R	268
Nov	21	22:25:52	32 Tau	5.6	R	230
Nov	24	03:55:30	1 Gem	4.3	R	320
Nov	24	07:43:03	6 Gem	6.5	R	341
Nov	24	21:37:07	36 Gem	5.3	G	5
Nov	25	20:59:42	81 Gem	4.9	R	274
Nov	27	05:48:49	PPM 125986 (Cnc)	6.5	R	342
Nov	30	02:04:18	87 Leo	4.8	R	286
Dec	13	16:55:50	kappa Psc	4.9	D	75
Dec	13	17:16:52	9 Psc	6.3	D	124
Dec	19	05:01:25	PPM 92958 (Tau)	6.1	D	98
Dec	19	19:11:08	72 Tau	5.5	G	170
Dec	19	23:48:15	V1116 Tau	6.0	D	139
Dec	20	04:18:36	PPM 93742 (Tau)	6.3	D	58
Dec	21	03:25:18	V731 Tau	6.2	D	136
Dec	21	18:14:00	mu Gem	2.9	R	301
Dec	22	02:00:41	PPM 96308 (Gem)	6.1	R	285
Dec	23	05:47:41	81 Gem	4.9	R	314
Dec	25	02:01:46	6 Leo	5.1	R	275

The Planets

Mercury and Venus, the inner planets, are very much tied to the realm of twilight though Venus can be well placed in a dark sky after sunset or before sunrise when at a favourable elongation. Mars, Jupiter and Saturn may be seen right throughout the night when at opposition.

Mercury and Venus are closer to the Sun than the Earth while Mars, Jupiter, Saturn, Uranus, Neptune and the Dwarf Planets are further out. The planets are always to be found in the **zodiac** — a band which cuts the sky in half that lies either side of the ecliptic. The **ecliptic** is the plane of the Earth's orbit projected on to the celestial sphere. Mercury and Venus seem to swing from one side of the Sun to the other but as viewed from Earth they never get further away than the positions known as **greatest elongation**. The other planets can be anywhere in the zodiacal band.

The moment when Mercury or Venus are directly between the Earth and the Sun is known as **inferior conjunction**. They are at **superior conjunction** when they pass behind the Sun. Obviously, the other planets outside our orbit can only pass through superior conjunction.

When outer planets are in **opposition** they are opposite the Sun to us and are on the celestial meridian at midnight. The **celestial meridian** is an imaginary line that starts at the north point of the horizon, rises directly through the North Celestial Pole (NCP) to the zenith and then continues on down to the southern point of the horizon. The NCP is less than one degree from Polaris, the Pole Star.

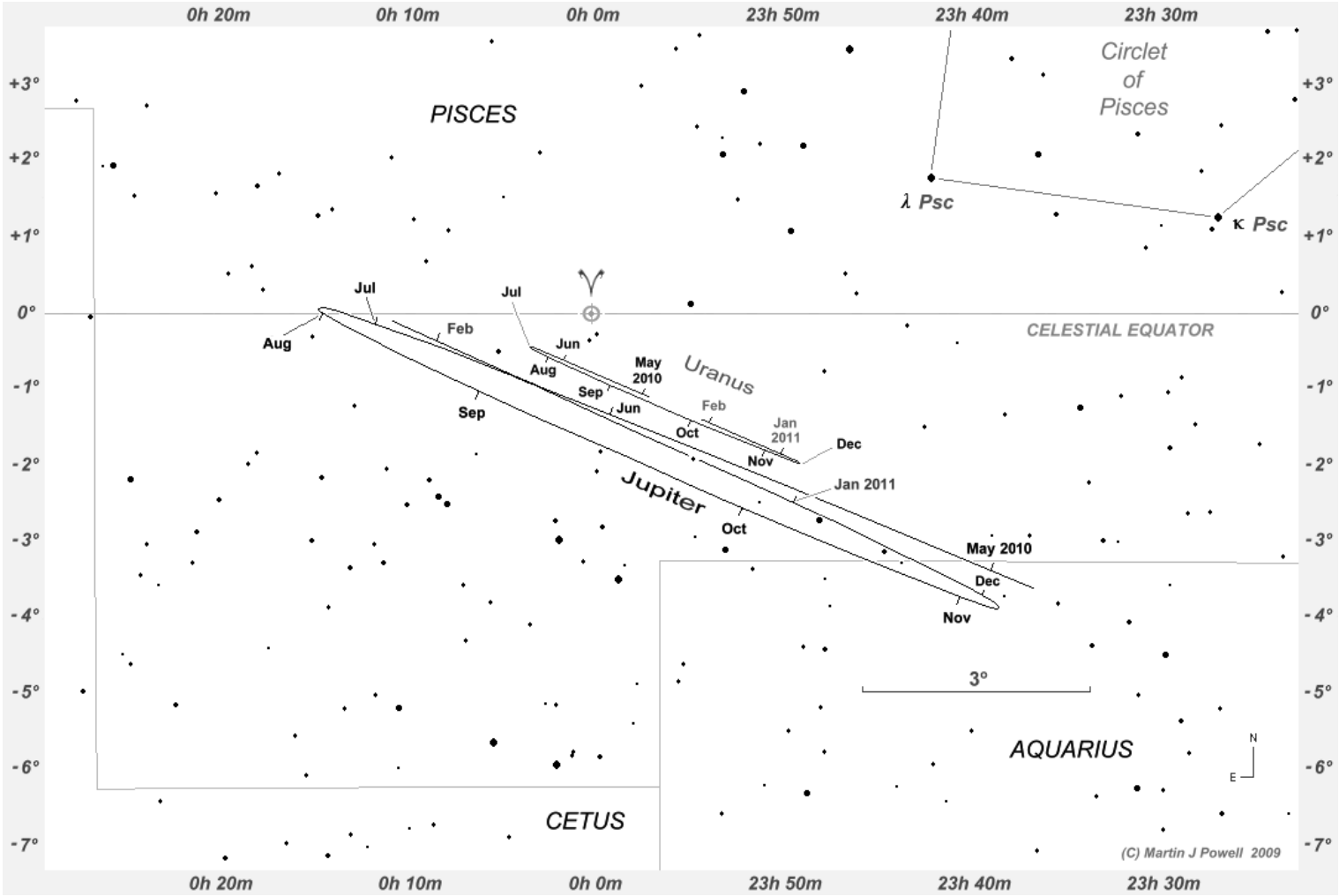
Venus and Mercury show phases like the Moon. Mars can look gibbous, i.e. not quite full. Jupiter can show very slightly less than full at **quadrature** in amateur telescopes.

The outer planets can exhibit a phenomenon known as **retrograding**. A consequence of them lying further from the Sun than us is that they orbit more slowly than the Earth. Therefore, at opposition, the Earth can overtake an outer planet causing its apparent movement against the stars to grind to a halt, move back to the right, halt, and then resume direct motion once again.

A good book that clearly explains many terms found in *Sky-Guide* is Ian Ridpath's *Oxford Dictionary of Astronomy*.

The Jupiter-Uranus triple conjunction

The diagram below (© Martin J Powell) illustrates a remarkable opportunity during 2010/11 to observe Jupiter and Uranus in close proximity. The pair meet on three occasions during the period in what astronomers call a conjunction in right ascension. This is where the two planets simultaneously lie on the same line of right ascension on the celestial sphere. The conjunctions occur on 2010 June 6 (when both are 28 arc-minutes apart), 2010 September 22 (53 arc-minutes separation) and 2011 January 2 (a 34 arc-minute gap.) Uranus will be easily seen in binoculars or with the naked-eye from a dark site.



The Planets

Visibility of the planets in 2010

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Mercury	pre-dawn from 9th	pre-dawn to the 6th	evening from 23rd	evening to the 25th	not on view	not on view	not on view	not on view	pre-dawn from 8th	pre-dawn to 8th	dusk Nov 30 - Dec 10	pre-dawn from 23rd
Venus	not on view	early-eve from 20th	sets late evening	sets late evening	sets near midnight	sets near midnight	sets late evening	sets early evening	in dusk to 3rd week	not on view	pre-dawn from 5th	visible pre-dawn
Mars	visible all night	visible all night	almost all night	almost all night	sets early a.m.	sets near midnight	sets late evening	sets early evening	in dusk to 3rd week	not on view	not on view	not on view
Jupiter	sets early evening	sets early evening	not on view	pre-dawn last week	rises be-fore dawn	rises early a.m.	rises near midnight	rises late evening	visible all night	almost all night	sets early a.m.	sets about midnight
Saturn	rises late evening	rises early evening	visible all night	visible all night	sets early a.m.	sets early a.m.	sets near midnight	sets early evening	in dusk to 2nd week	pre-dawn last week	rises be-fore dawn	rises early a.m

Uranus crosses from Aquarius to Pisces in mid-January and remains in that constellation for the rest of 2010. The planet is at first an evening sky object but becomes too close to the Sun from late-February until mid-April to be seen. It then re-appears in the morning sky and reaches opposition on September 21st when it can be found as a magnitude 5.7 "star" a lit-tle under 1° N of more brilliant Jupiter. Its opposition brightness places Uranus above the theoretical naked-eye limit but binoculars will aid any sighting. A **triple conjunction between Jupiter and Uranus** during 2010/11 is described on page 26.

Slower moving **Neptune** is in the evening sky in Capricornus at the beginning of 2010 before conjunction with the Sun on February 14th. It returns to the morning sky in early March and passes into Aquarius mid-month where it remains until mid-August. It then returns to Capricornus where it stays the rest of the year. Neptune comes to opposition on August 20th when it will reach magnitude 7.8. The planet can then be found ½°NE of the magnitude 5.0 star mu Capricorni.

Pluto, now classed as a Dwarf Planet, is beyond the scope of this guide. A detailed finder chart is necessary to identify it, with an 20-cm telescope probably the minimum aperture. Pluto is magnitude 13.9 when it reaches opposition in Sagittarius on 2010 June 25. The planet is 4,614 million kilometres from the Sun at this time and getting more distant with each year.

Mercury

inferior conjunction	Jan 04		*greatest elongation*	Aug 07	27° 22' E
greatest elongation	Jan 27	24° 45' W	*inferior conjunction*	Sept 03	
superior conjunction	Mar 14		*greatest elongation*	Sept 19	17° 52' W
greatest elongation	Apr 08	19° 21' E	*superior conjunction*	Oct 17	
inferior conjunction	Apr 28		*greatest elongation*	Dec 01	21° 27' E
greatest elongation	May 26	25° 08' W	*inferior conjunction*	Dec 20	
superior conjunction	Jun 28				

Venus

superior conjunction	Jan 11	
greatest elongation	Aug 20	45° 58' E
greatest illuminated extent	Sept 23	
inferior conjunction	Oct 29	
greatest illuminated extent	Dec 04	

Zeta Ursae Majoris, or Mizar, is the middle star in the handle of the Plough and forms a wide naked-eye double with fainter Alcor. Within the same binocular field is an unrelated eighth magnitude mote that goes by the grand title of Sidus Ludoviciana. This star had a brief period of fame when it was misidentified as a new planet in the early 1700s.

Johann Georg Liebknecht chanced upon the star in the same field as Mizar on December 2nd, 1722. Inaccurate positional measurements led him to believe he detected it slowly moving against the stellar background. Convinced he had found a new planet Liebknecht named it Sidus Ludoviciana in honour of his monarch Ludwig of Hessen-Darmstadt. Far superior tele-scopes showed that Liebknecht's "planet" was nothing more than a fixed star however. Rather unsavoury and libellous ex-changes then ensued between Liebkneckt and his detractors before the star became but a footnote in astronomical history.

The Planets

The Superior Planets

	Mars	Jupiter	Saturn	Uranus	Neptune	Pluto
conjunction	—	Feb 28	Oct 01	Mar 17	Feb 14	Dec 27
western quadrature	—	Jun 23	—	Jun 22	May 20	—
stationary (begins retrograde)	—	Jul 24	Jan 14	Jul 06	Jun 01	Apr 07
opposition	Jan 29	Sept 21	Mar 22	Sept 21	Aug 20	Jun 25
stationary (prograde motion resumes)	Mar 11	Nov 19	May 31	Dec 06	Nov 07	Sept 14
eastern quadrature	May 04	Dec 17	Jun 20	Dec 19	Nov 18	—

This year **Neptune completes its first orbit** since the planet was found on 1846 September 23 by Galle and d'Arrest. Neptune will return to the discovery point in its orbit in late-June 2010. The predicted existence of Neptune was a triumph for positional astronomy. Following the discovery of Uranus in 1781 astronomers noted that the planet deviated slightly from its expected orbit. What could be the cause? Evidence mounted that the gravitational force of an unknown body beyond Uranus was tugging on the planet. Independently, Urbain Le Verrier and John Couch Adams set about determining the position of the speculated world (all the mind-numbing calculations were laboriously worked out by hand.) After some cajoling of observational astronomers into actually looking for Neptune the eighth planet was found close to the predicted position.

Jupiter's Galilean moons

Binoculars are sufficient to show the changing positions from night to night of Jupiter's four Galilean satellites **Io**(I), **Europa**(II), **Ganymede**(III), and **Callisto**(IV). They appear as tiny points of light close in to the planet and all four would be visible to the naked-eye but for glare from the primary. There is anecdotal evidence that some eagle-eye people *have* seen one of the moons without optical aid. This is certainly plausible when Callisto is at greatest elongation.

We can occasionally witness **shadow transits** of two of the Galilean moons. The only favourable date for Ireland in 2010 is on **October 24th** when the shadows of Europa and Ganymede can both be seen crossing the Jovian disk starting at 01h 40m. The time given is for when the *second* satellite's shadow falls on Jupiter's cloud-tops.

A **triple satellite transit** (shadows of Io and Europa and a transit of Callisto) between March 31st at 22h 07m and April 1st at 00h 19m is of academic interest. Unfortunately, from here Jupiter does not rise until later in the pre-dawn.

An 80mm telescope at high power is about the minimum size needed to see the various transit phenomena while a 150mm or larger instrument is sufficient to show Jupiter's four largest moons as tiny disks with some subtle colour differences between them also evident.

Twice in every revolution of Jupiter around the Sun, or roughly every six years, the orbits of the Galilean moons are presented nearly edge-on to us and we can observe the moons going behind, or passing in front of each other. This gives rise to various mutual occultation and eclipse phenomena.

The mutual events commenced in January 2009 and continue until April 2010. The scope of *Sky-Guide 2010* is too broad to describe the satellite phenomena and how they occur. However, a good primer along with details of phenomena during the year ahead can be found at the web site of the group coordinating the worldwide observing campaign — http://www.imcce.fr/phemu09

Saturn's moons

Steadily mounted binoculars will let you spot Saturn's largest satellite **Titan**. The moon orbits Saturn in about 16 days and appears like a magnitude 8 "star" lying about five ring-widths from the planet when Titan is at eastern (E) or western (W) elongation. Some dates in 2010 that are fairly favourable for viewing are listed in the table on the right.

A scope is required for the brightest of Saturn's other moons. These are Rhea (maximum magnitude 9.7), the enigmatic Iapetus (varies from 10^m to 12^m), Thetys (10.3^m) and Dione (10.4^m).

A consequence of Saturn's rings close to edge-on at the moment is a chance see transits and eclipses of the moons which lie in the planet's equatorial plane. These continue into early 2010. The monthly astronomy magazines should carry details.

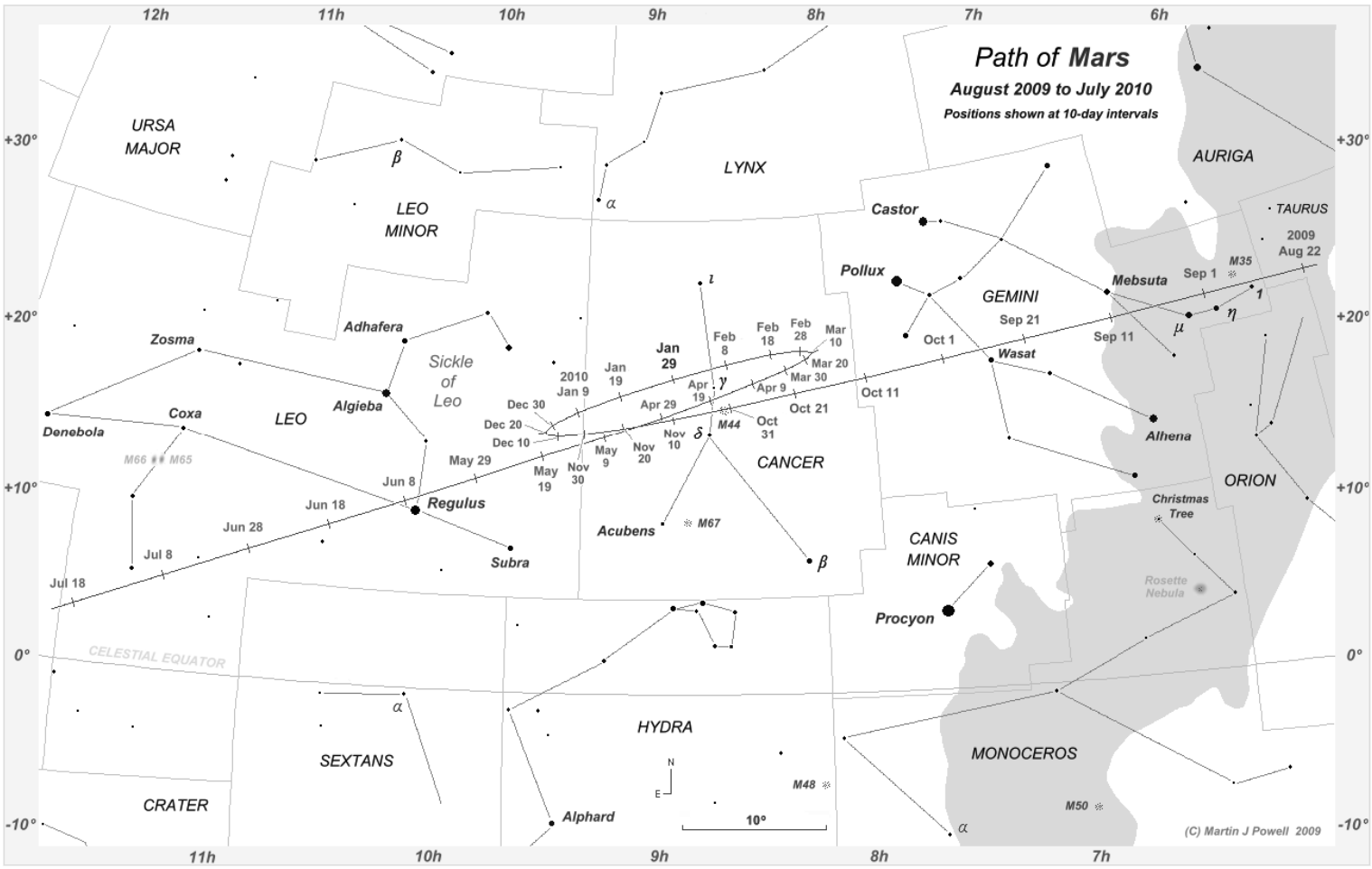
Titan elongations

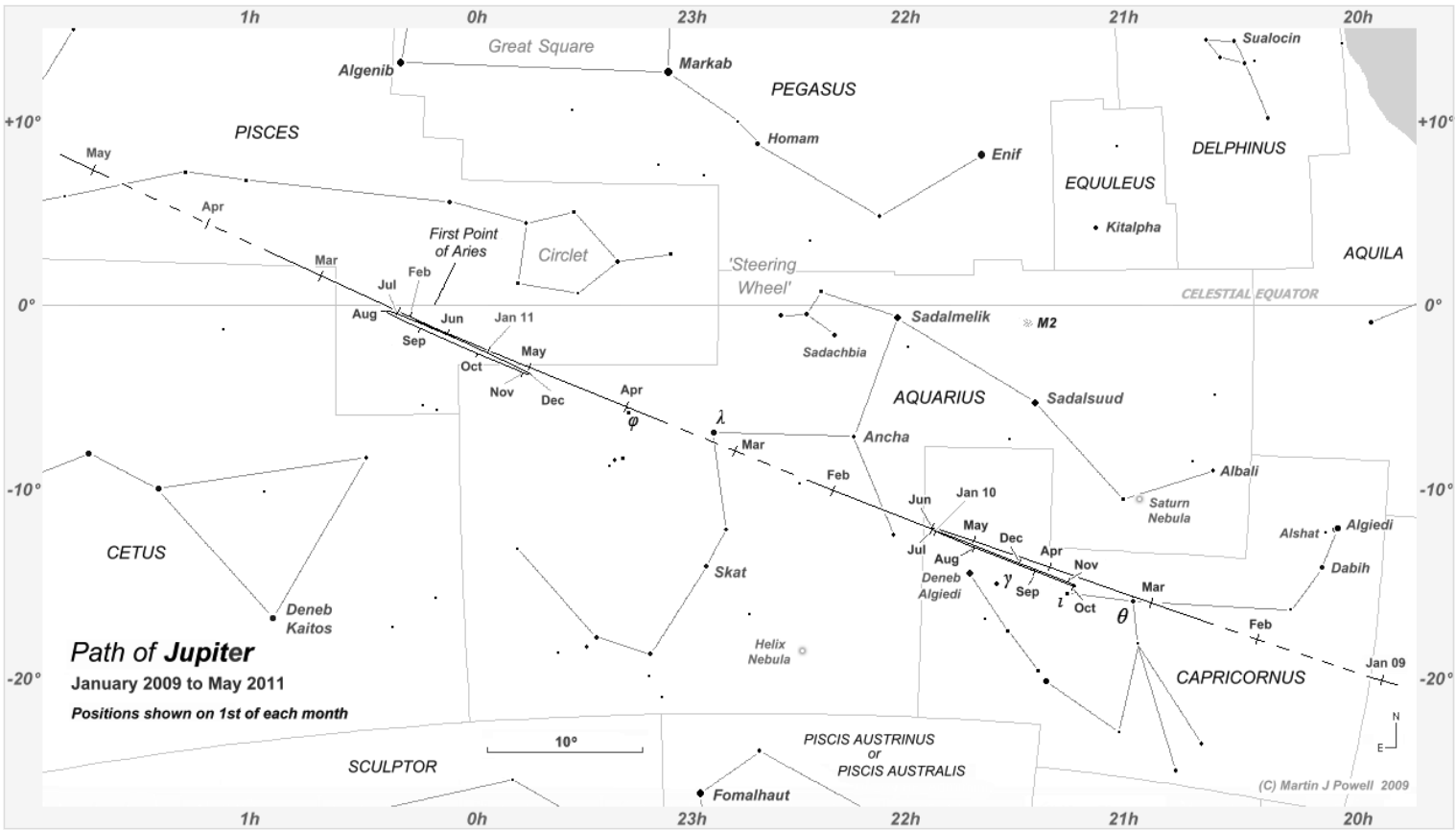
Jan 06d 04h 42m E	Feb 22d 23h 24m E
Jan 14d 00h 48m W	Mar 10d 21h 00m E
Jan 22d 03h 18m E	Mar 26d 18h 24m E
Jan 29d 23h 18m W	Oct 12d 06h 48m W
Feb 07d 01h 36m E	Dec 31d 07h 54m W

The table above only shows events where Saturn itself is above the horizon at the time and during the hours of darkness or in the pre-dawn/dusk light.

The Planets

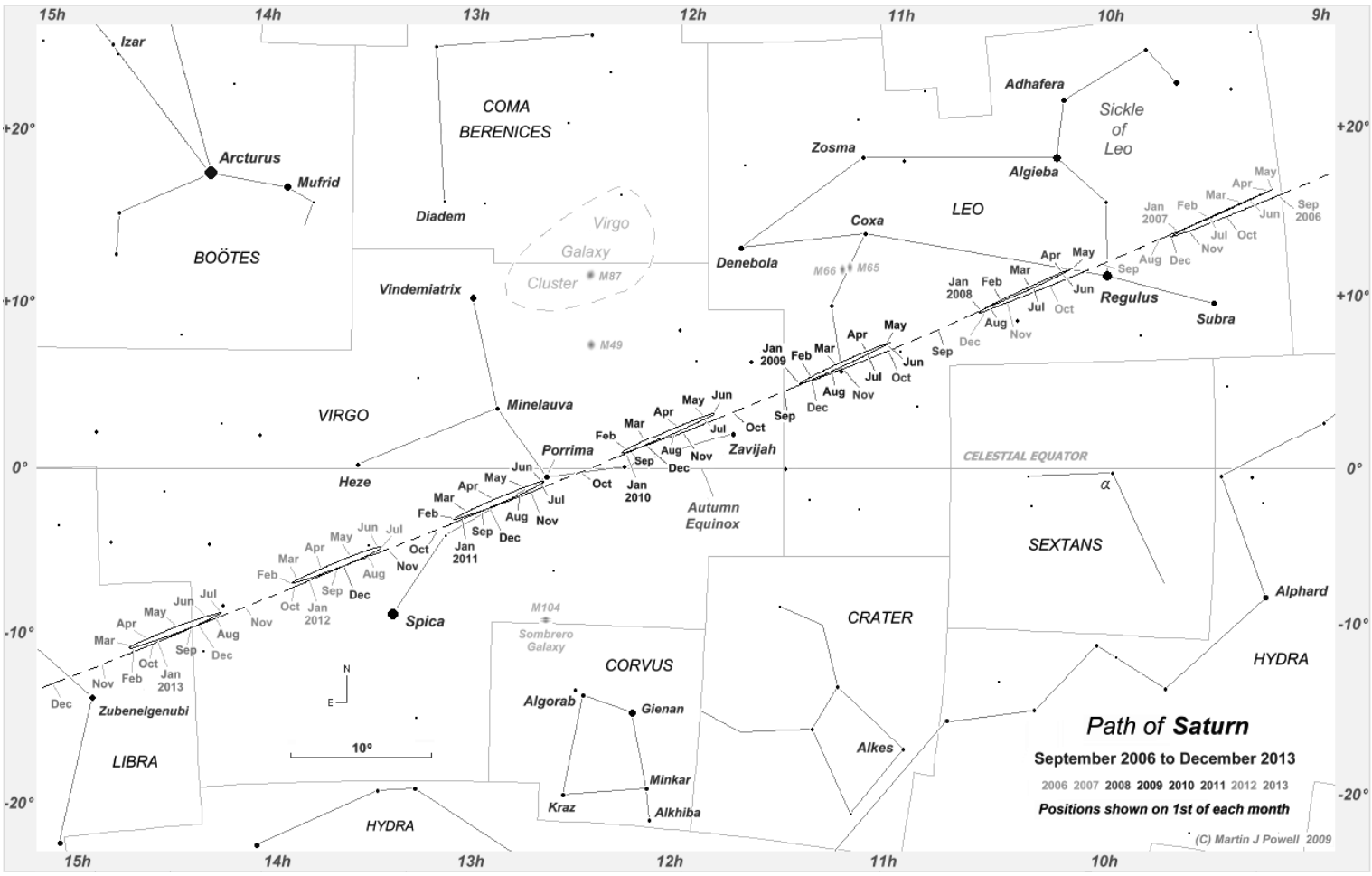
The diagrams on pages 26, 29, and 30 are copyright Martin J Powell who has a wonderfully informative web site that explains the naked-eye aspects of the planets, their motions in the sky, and much more. Martin's pages on the Solar System can be found at homepage.ntlworld.com/mjpowell/Astro/Naked-Eye-Planets/Naked-Eye-Planets.htm

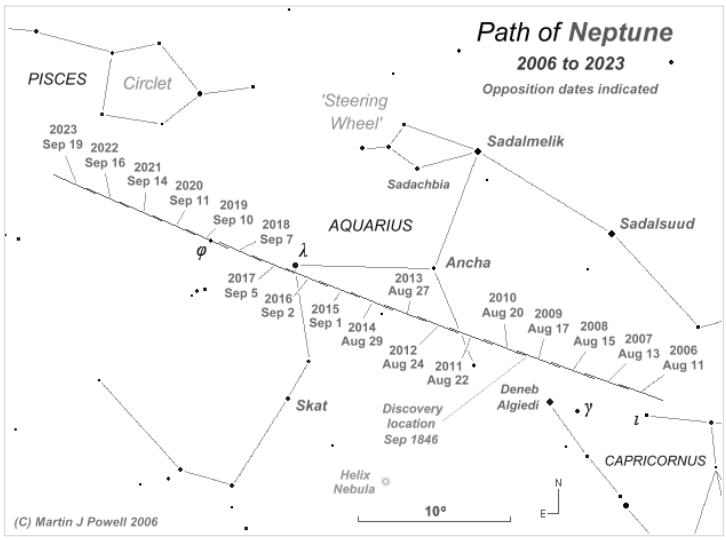


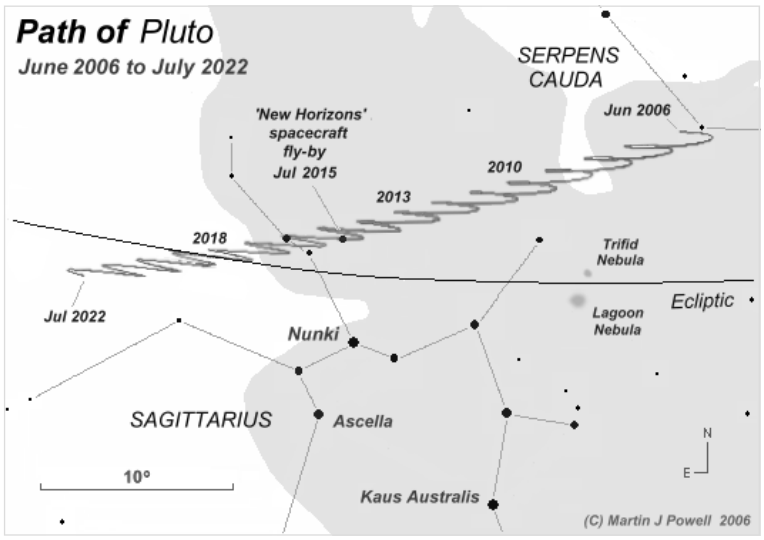


The Planets

To the unaided eye Mercury is a golden or pinkish hue, a result of its light passing through a thicker layer of our atmosphere when Mercury is low above the horizon. The harsh white light of Venus contrasts with the smouldering orange coal of dust-covered Mars. Jupiter has a soft creamy texture while Saturn tends to show a yellowish tint. What colours do you see?







New Horizons mission to Pluto

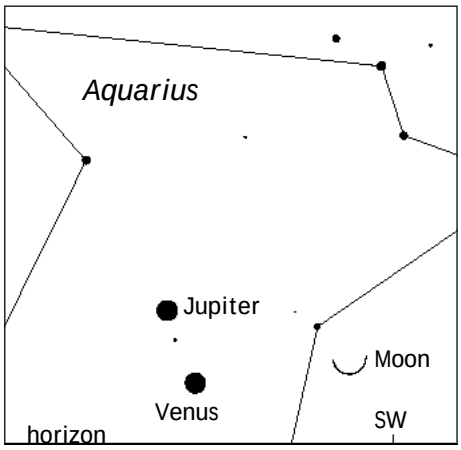
New Horizons is NASA's ambitious mission to investigate Pluto and its three moons. The probe was launched in January 2006 and passed Jupiter in February 2007 to boost its speed with an assist from the planet's gravity. Closest approach to Pluto occurs on 2015 July 14 and scientists then hope to re-target the spacecraft to some Edgeworth-Kuiper Belt objects. Mission objectives include mapping Pluto and its largest moon Charon, studying their surface composition and analysing Pluto's tenuous atmosphere. Planetary scientists had to lobby hard to get the mission off the ground in the first place as it originally succumbed to a number of budget cuts. *New Horizons* reaches the mid-point of its journey to the distant world in October 2010. Interestingly, the probe carries some ashes of Pluto discoverer Clyde Tombaugh along with other artefacts.

The Planets

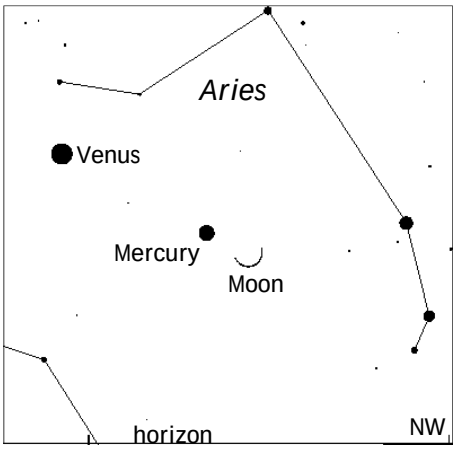
The dance of the planets in 2010

The complex dance of the planets on the nightly stage leads to occasions where two or more vie for attention as they pass close to each other. A beautiful sight awaits even the most casual sky-watcher when the Moon glides on to the scene too.

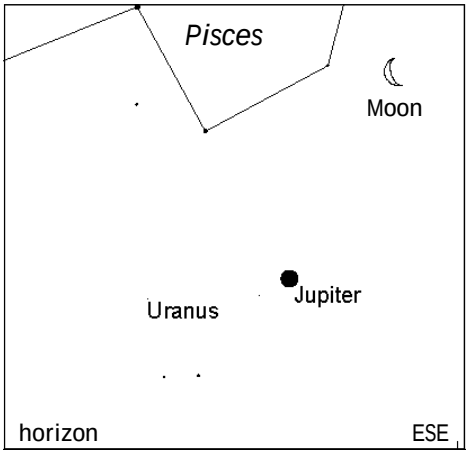
The diagrams here highlight some of the more interesting dates during 2010 when there is a gathering of planets. Planetarium software will let you simulate other events that are highlighted in the monthly calendar notes of *Sky-Guide 2010*.



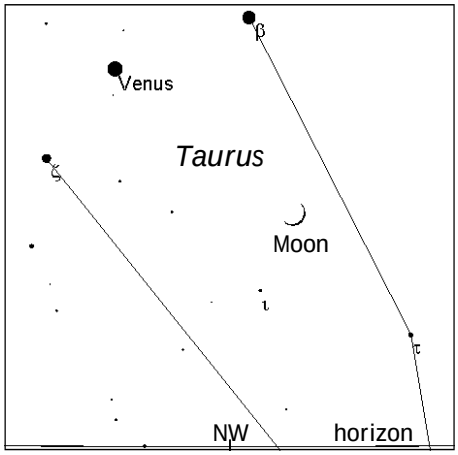
PM: A sight for lovers on Feb 14 at 6pm



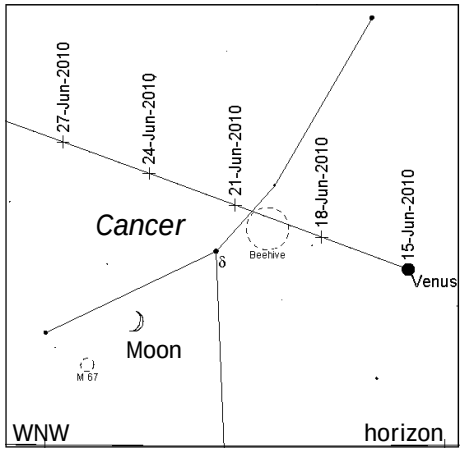
PM: Mercury, Moon and Venus on Apr 15



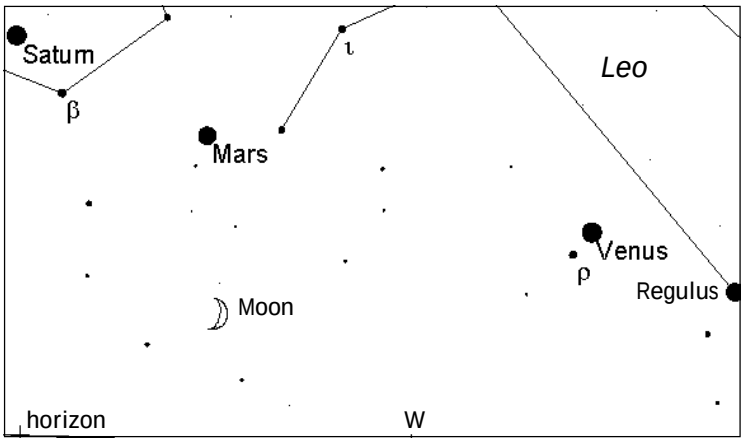
AM: Jupiter in the early hours on May 9



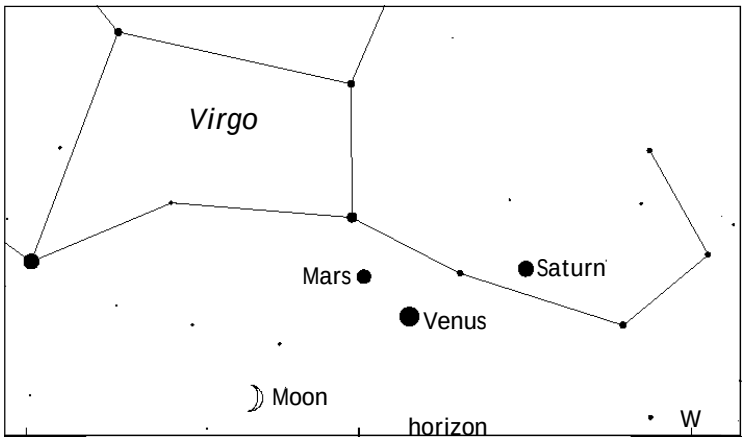
PM: Venus and the Bull's "horns" May 15



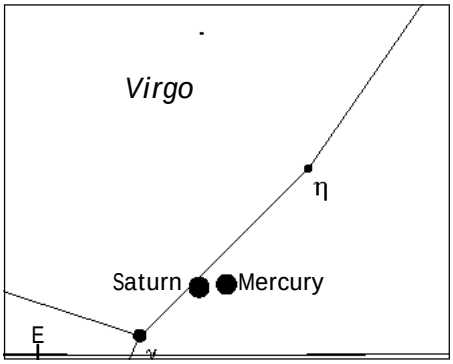
PM: Venus passes through the Beehive



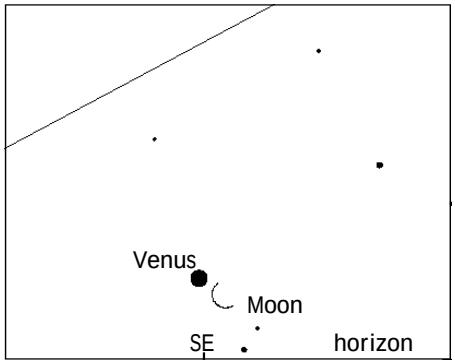
PM: A gathering of planets on the evening of July 15



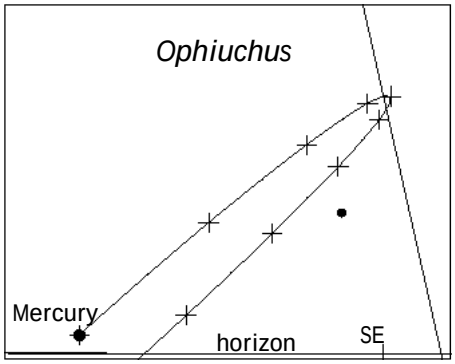
PM: A planetary trio and the Moon low in the evening sky on Aug 13



AM: Saturn & Mercury *very* low Sept 8



PM: Venus and the Moon on Nov 5



AM: Mercury every 2 days from Dec 22

Minor Planets

Orbiting the Sun between Mars and Jupiter are innumerable rocky bodies ranging in size from hundreds of kilometres in diameter to small boulders. These are the minor planets, or asteroids, and since the first, Ceres, was spotted by Piazzi in 1801, we have added considerably to the number known. Tens of thousands now have their orbits accurately determined with more being found each month.

Their orbits are not just confined to the main asteroid belt; many range over highly elliptical paths that bring them closer to the Sun than Mercury while others merit a careful watch as potential Earth-crossers. In the last decade, members of the far-flung Edgeworth-Kuiper Belt of icy-bodies have been detected beyond the orbit of Pluto while exotica such as Scattered Disk Objects and near-Earth asteroids are all the rage in Solar System studies.

Earth-crossers — also known as Potentially Hazardous Asteroids (PHAs) — pose a slim risk of collision with Earth, though they are officially classified as an asteroid that can come within 0.05 astronomical units (AU) of Earth's orbit and is larger than a few hundred metres across.

Minor planets are given an official number once their orbits are confirmed. At the time of writing (October 2009) over 460,000 asteroids have been discovered with 210,000 assigned a number and some 15,000 named. The Minor Planet Center in the US has some interesting discovery statistics on their web site highlighting how various automated search programmes have scooped many of the recent finds. Leading the way is the Lincoln Laboratory in New Mexico which has found 107,582 asteroids since 1980.

The first asteroids to be discovered from Ireland in 160 years were imaged during 2008 when Dave McDonald and Dave Grennan each found a Main Belt object (they have subsequently discovered another three.) The previous find from here was 9 Metis on April 26th, 1848 by Andrew Graham at Markree Castle, Co. Sligo.

A number of asteroids can be seen in binoculars while a small telescope will let you sweep up many more. Some of the brighter ones you might like to hunt during 2010 are listed in the table at the top of this page. Most popular planetarium programs will let you plot an asteroid's position on a chart to take into the field. Compare the view against your printed map and you'll find that the "star" which has moved from night to night will be the asteroid.

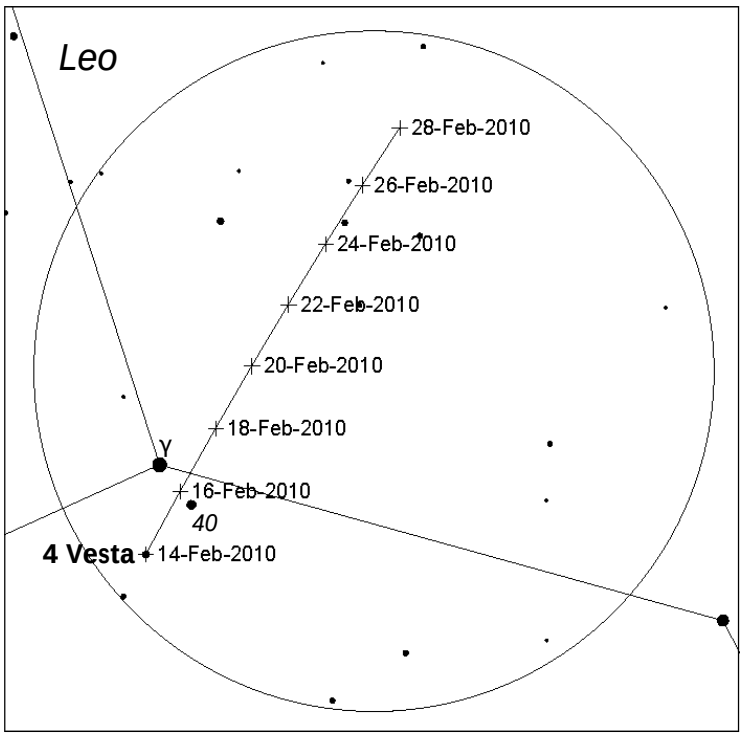
1 Ceres can be found slowly threading its way westwards below the famous Lagoon Nebula (M8) in the early part of June. Ceres lies just under 2½° north of the magnitude 4.56 star 3 Sagittarii on the day of opposition.

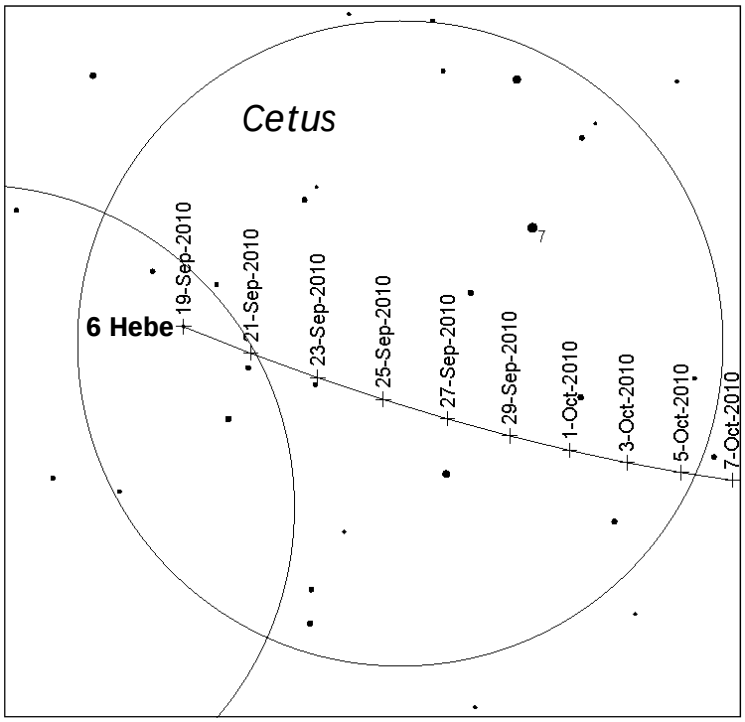
4 Vesta regularly brightens to naked-eye visibility and comes to opposition this year on February 18th. Binoculars will suffice to sweep it up as a magnitude 6.1 speck in the constellation Leo. Keen-eyed observers may spot it with the unaided eye from a very dark site.

Of note is 32 Ponoma (10.6m), 60 Echo(10.2m), and 79 Eurynome (11.1m) who just about fit within a 5° circle on February 23rd when Echo and Eurynome are at opposition.

Selected asteroids at opposition during 2010

Asteroid	Opposition	Mag.	Constellation
4 Vesta	Feb 18th	6.1	Leo
532 Herculina	Mar 13th	8.8	Coma Berenices
2 Pallas	May 4th	8.7	Serpens
1 Ceres	Jun 18th	7.0	Sagittarius
15 Eunomia	Jun 27th	9.0	Sagittarius
8 Flora	Sept 11th	8.2	Aquarius
6 Hebe	Sept 21st	7.7	Cetus





The charts above show stars to magnitude 8·0 and the circle diameter is 5°. 6 Hebe reaches opposition 4½° west of the magnitude 2.04 star beta Ceti (Diphda.)

Comets

A couple of bright comets in the Summer and late-Autumn will be the highlight for observers this year but there are also a number of other celestial snowballs on view during 2010 for the casual sky watcher. Many of these temporary visitors to the inner solar system often appear no more than a fuzzy blur of light in binoculars or a small telescope but careful observation may tease out the hint of a stubby tail. Only the brightest of comets have a more dramatic train blown off by the solar wind.

81P/Wild is a 10th magnitude object in Virgo at the beginning of February 2010 when it rises just before midnight. The brightness should peak in mid-March when 81P/Wild may glow at about magnitude 9.5. The comet remains in Virgo as it slips toward the summer twilight. By then though the comet will be lost to view in all but larger telescopes.

C/2009 O2 (Catalina) was found in July 2009 and is at perihelion on 2010 March 25. It is expected to reach magnitude 9 or maybe a little brighter the second half of March when the comet can be found in Andromeda and is circumpolar (visible all night.) On the nights of March 24th and 25th it lies within 5° of the Andromeda Galaxy before closing to within 2° of the open cluster M34 in Perseus on April 1st. C/2009 O2 will then fade below tenth magnitude the second week of April as it crosses from Perseus into Taurus.

C/2009 K5 (McNaught) was discovered in May 2009 and reaches perihelion on 2010 April 30 when it might reach magnitude 9.5. The comet rises in the wee hours of the morning at the beginning of March when it lies in Aquila. It then sweeps a path along the Milky Way during the month and passes the diminutive constellations of Sagitta and Vulpecula (skirting the loose open cluster Stock 1 on April 1st) before crossing into Cygnus. The comet should break the tenth magnitude barrier by the beginning of April when it is rising an hour or so before midnight. The brightness of C/2009 K5 should then peak in mid-April when large binoculars or a small telescope will reveal its ghostly glow.

C/2009 R1 (McNaught) is another find for Rob McNaught who now has the record for most comet discoveries with 53 to date. This particular comet is expected to reach naked-eye visibility from a dark site and will easily be within reach of binoculars should it fail to do so. It is a ninth magnitude object in Andromeda rising after midnight the third week of May. The comet then brightens as it crosses the chained maiden and rises late-evening by the beginning of June before becoming circumpolar. It then breaks sixth magnitude in mid-June as it passes across the midriff of Perseus and is brighter than fifth by the end of the month when it lies in Auriga. By now the twilight glow will start to swamp the comet and it is soon lost to view from here.

2P/Encke has the shortest period of any known comet and may be picked up an hour before sunrise during July. The comet reaches magnitude 10 mid-month before brightening rapidly as it dives towards solar conjunction at the beginning of August. Encke will probably be around magnitude 7 by the time you loose it in the dawn glow pre-conjunction. That's the last we'll see of Encke unfortunately because by the time it emerges from the solar glare the comet will be a southern hemisphere only object.

10P/Tempel is another summer sky visitor but is not likely to be seen until mid-July onwards due to the perpetual twilight prevalent during June. It should be magnitude 9 or perhaps a half-magnitude brighter when picked up the second half of July. The comet can then be found in Cetus when it rises just after midnight. The brightness slowly fades during August as the comet moves south on the sky and it dips below magnitude 10 at the end of September.

103P/Hartley 2 is the target of NASA's EPOXI mission to study its nucleus up close. EPOXI will use the *Deep Impact* spacecraft retargeted after its encounter with comet 9P/Tempel in July 2005. There are conflicting orbital elements for the comet circulating but the latest MPEC ones indicate Hartley 2 will be magnitude 7 in mid-August and 6 by the end of that month when it crosses into Andromeda. Hartley 2 should then be a fine naked-eye and binocular object in October 2010 as it flits through Perseus and Auriga in our evening skies. Check the astronomy monthlies closer to the time for more details on the visibility of the comet.

The table below will allow you generate ephemerides to plot a comet's path with popular astronomy programs (see also cfa-www.harvard.edu/cfa/ps/Ephemerides/Comets). The headings read: T = the perihelion time, q = perihelion distance (in astronomical units), e = eccentricity, P = the period in years, ω = argument of perihelion, Ω = longitude of the ascending node, and i = inclination.

Comet	T	q	e	P	ω	Ω	i
81P/Wild	2010 02 22.7209	1.598058	0.537391	6.42	41.7939	136.0970	3.2375
C/2009 O2 (Catalina)	2010 03 25.1075	0.706719	1.000000		132.8835	310.2846	108.4767
C/2009 K5 (McNaught)	2010 04 30.0424	1.422647	1.000757		66.1649	257.8515	103.8843
C/2009 R1 (McNaught)	2010 07 02.1654	0.401424	1.000000		130.8635	322.726	76.6891
10P/Tempel	2010 07 04.9073	1.422698	0.536334	5.37	195.6608	117.8251	12.0223
2P/Encke	2010 08 06.5019	0.335869	0.848338	3.30	186.5490	334.5669	11.7831
103P/Hartley 2	2010 10 28.2790	1.058691	0.695127	6.47	181.2928	219.7602	13.6184

Meteor Showers

Meteors, or shooting stars, can be seen any night but during the year the Earth sweeps through dust trails laid down by comets as they circle the Sun. We then get a meteor shower. Some are rather weak with only a few meteors per hour seen while other displays delight amateur astronomers year after year with their greater numbers.

The **Quadrantids** in early January generally exhibit a short, sharp maximum and the peak is predicted for 19h on the 3rd this year. Moonlight will prove a bit of a nuisance unfortunately so only the brighter shower members may be seen. The Quadrantid radiant lies in northern Boötes.

February and March tend to be characterised by low meteor rates with only the minor showers producing some activity. Things then pick up again when the **Lyrid** meteor shower peaks on April 22nd at 17h. The sky is Moon-free for a couple of hours before dawn on April 23rd as the Lyrid radiant gains altitude. Occasional outbursts from the stream have previously been noted with the last in 1982.

The **eta Aquarids** peak on May 6th at 07h but the radiant is low from here and only at a useful altitude in the pre-dawn hours. We are now coming to a time of year when the enduring twilight means the role of monitoring active showers falls to observers using radio techniques.

The southern component of the **delta Aquarid** stream peaks on July 28th but is badly affected by Moonlight this year. The shower radiant clears the horizon after midnight and increases in altitude approaching dawn.

The dependable **Perseids** are predicted to peak at 23h on August 12th and conditions are ideal with the 2 day old Moon setting just before 20h 30m. The double peak noted a few years ago now seems to have merged into the traditional maximum but the International Meteor Organisation suggest the complexity of the Perseids means high rates may persist over a period of almost a full day.

The **Orionids** are October's best known shower and are associated with the well-known comet 1P/Halley. The radiant is near the raised club of Orion and rates tend to be good with many swift meteors. The maximum falls two days before Full Moon so conditions are not ideal this year.

Leonid rates have generally declined back to normal levels following the enhanced activity at the start of the century. The peak falls four days after First Quarter Moon but no outbursts are predicted to occur this year. The radiant in Leo rises at 23h from here.

The **Geminids** (maximum on the 14th at 11h) are affected somewhat by the First Quarter Moon this year in the early part of the night. The Moon sets at 02h though just when the Geminid radiant reaches its highest altitude. The shower remains at maximum for over 24 hours and can be considered even richer than the Perseids. The meteors are bright though few of them produce persistent trains. Computer modelling of the Geminid stream suggests their best is still to come in the latter part of the 21st century.

The other meteor shower for December is the poorly observed **Ursids** which peak this year on the 22nd at 20h. Elevated rates have been noted as recently as 2007 so any results will prove valuable. The Ursid radiant is close to Kocab (beta Ursae Minoris) meaning they are visible all night. Conditions couldn't be worse though with maximum this year washed out by the Moon just 1 day after Full.

Principal Meteor Showers of 2010

Shower	Activity Period	Date of Maximum	Moon's Age	Speed km/s	r	ZHR	Parent Body
Quadrantids	01 Jan - 05 Jan	03 Jan	3 days after Full Moon	41 km/s	2.1	120	2003 EH_1
Lyrids	16 Apr - 25 Apr	22 Apr	1 day after First Quarter	49 km/s	2.9	18	C/Thatcher (1861 G1)
η Aquarids	19 Apr - 28 May	06 May	Last Quarter Moon	66 km/s	2.7	60	1P/Halley
δ Aquarids	12 Jul - 19 Aug	28 Jul	2 days after Full Moon	41 km/s	3.2	20	96P/Machholz (?)
Perseids	17 Jul - 24 Aug	12 Aug	2 days after New Moon	34 km/s	2.9	110	109P/Swift-Tuttle
Orionids	02 Oct - 07 Nov	21 Oct	2 days before Full Moon	66 km/s	2.9	20	1P/Halley
S. Taurids	01 Oct - 25 Nov	05 Nov	1 day before New Moon	29 km/s	2.3	5	2P/Encke
Leonids	14 Nov - 21 Nov	17 Nov	4 days after First Quarter	71 km/s	2.5	var.	55P/Tempel-Tuttle
Geminids	07 Dec - 17 Dec	14 Dec	1 day after First Quarter	35 km/s	2.6	120	3200 Phæthon
Ursids	17 Dec - 26 Dec	22 Dec	1 day after Full Moon	65 km/s	3.0	5	8P/Tuttle

A meteor shower is named for the constellation in which the *radiant*, or point of origin of the meteors, appears to lie. The suffix "id" has a Greek root and means "child of". The exception are the Quadrantids, named for a now defunct star pattern that originally comprised some of the stars of Boötes. "r", the "population index", is an indication of the proportions of bright and faint meteors in a shower. It is computed from the shower's magnitude distribution. A value in the range 2.0 to 2.5 indicates meteors brighter than average while a result closer to 3.0 means fainter.

The date given for a shower is the expected date of the maximum. A shower's period of visibility may extend a few days either side of maximum — though much lower rates may be recorded. The ZHR, or Zenithal Hourly Rate, is a measure of a shower's activity. It is only a theoretical value however; it assumes perfectly dark clear skies, the radiant source overhead, and no meteors missed.

Variable Stars

Not all stars shine with a constant light. Many fall into a category known as variable stars where the light output of the star varies over a period of time. Some may be part of a close binary system with a faint companion eclipsing the brighter such as Algol, while others are single suns that dim and brighten because of genuine changes in light output.

The latter group contains the long period variables (LPVs). Most stars of this type are red giants and they can change in apparent brightness by a large factor. Their periods can range from 100 to 1000 days. The period of any long period variable is not very constant and variations of up to 20 per cent are not unusual.

Favourable times of minimum light for Algol throughout 2010 are listed while the table on the right gives predicted maxima of some of the better placed long period variables that are visible with binoculars. The brightness variations of Algol can be followed with the naked eye and the star is a lovely introduction to an aspect of the ever-changing sky.

Many amateur astronomers submit regular observations and estimates of the brightnesses of selected variable stars while others engage in nova or supernova patrols in an effort to catch these enigmatic objects flaring to brilliance.

Long Period Variable Star	Predicted maximum	Average max mag.	Minimum	Period in days
R AQR	Jan 01	6.5	10.3	387
R SCT	Jan 03	4.5	8.2	146
R VIR	Jan 05	6.9	11.5	146
U ORI	Jan 17	6.3	12.0	368
T CEP	Feb 05	6.0	10.3	388
S VIR	Feb 19	7.0	12.7	375
R TRI	Jun 04	6.2	11.7	267
V BOO	Jun 05	7.0	11.3	258
R LEO	Jul 10	5.8	10.0	310
R AND	Sept 24	6.9	14.3	409
R SER	Oct 04	6.9	13.4	356
OMI CET	Oct 18	3.4	9.3	332

The characteristic red colour of Long Period Variable stars is especially pronounced when they are at minimum.

Algol — the Demon Star

The table below highlights favourable minima of the celebrated eclipsing binary star β (Beta) Persei, or Algol. The star varies in brightness between magnitude 2·1 and 3·4 in a period of 68 hours and 49 minutes.

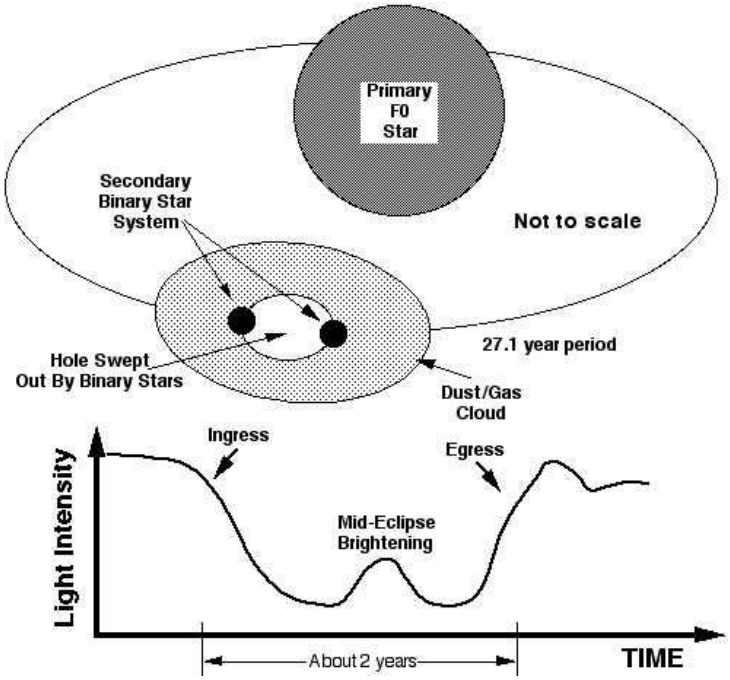
Algol appears as a single star in Earth based telescopes but is known to consist of two stars of unequal brightness quite close to and revolving around each other. The faint one eclipses the bright one once in every orbit and so we see the light drop. During most of the time Algol remains bright but then over a period of about ten hours it loses then regains three quarters of its light. The nature of the Algol system was first explained by the deaf-mute amateur astronomer John Goodricke (1764-1786) in 1782. Goodricke died tragically at the age of 21 before he had fulfilled what would have been a brilliant astronomical career.

Jan	01d 18h 48m; 16d 02h 54m; 18d 23h 42m; 21d 20h 30m
Feb	08d 01h 24m; 10d 22h 18m; 13d 19h 06m
Mar	03d 00h 00m; 05d 20h 48m; 25d 22h 36m
Apr	17d 21h 06m
May	none favourable
Jun	none favourable
Jul	10d 00h 36m
Aug	01d 23h 06m; 22d 00h 48m; 24d 21h 36m
Sept	11d 02h 30m; 13d 23h 18m; 16d 20h 06m
Oct	01d 04h 12m; 04d 01h 00m; 06d 21h 48m; 24d 02h 42m; 26d 23h 30m
Nov	13d 04h 24m; 16d 01h 18m; 18d 22h 00m; 21d 18h 54m
Dec	03d 06h 06m; 06d 03h 00m; 08d 23h 48m; 26d 04h 42m; 29d 01h 30m

epsilon Aurigae

At time of writing (October 2009) astronomers have announced that the enigmatic variable star epsilon Aurigae has entered eclipse. This F0-type supergiant has an unseen companion which passes in front of the primary and causes the star to dim from magnitude 3 to 3.8 for about 610 days. The eclipses occur every 27 years or so and mid-eclipse is predicted for August 2010.

The nature of the eclipsing body is unknown and there are suggestions it might be a disk of material. The graphic below (http://www.aavso.org/vstar/vsots/eps_aur.shtml) is one attempt to explain the system. A detailed timetable and info on the epsilon Aurigae observing campaign can be found at http://mysite.du.edu/~rstencel/epsaur.htm



Spaceflight 2010

This year sees a focus on near-Earth activities with Japan's *Planet-C* Venus orbiter the only deep-space probe listed in the mission schedule for 2010. *Planet-C*, also known as *Venus Climate Orbiter* (VCO) is slated for launch in May and will arrive at cloud-shrouded Venus in December. From an equatorial orbit the spacecraft will image the surface with an infrared camera and look for evidence of current volcanism on the planet — there are strong hints that Venus has some active volcanoes but recent missions or Earth observations have been unable to verify this.

The sample return probe of Japan's *Hayabusa* mission to asteroid Itokawa should land back on Earth in mid-June. Technical difficulties with the spacecraft mean mission scientists are unsure if the sample collection was successful.

NASA woes?

The planned retirement of the US space shuttle fleet following the five missions pencilled in for 2010 will dominate the headlines. NASA is now in a quandary with no immediate successor to the shuttle on the horizon until the replacement vehicle *Orion* is ready in 2015. *Orion* is part of the *Constellation* programme that also includes the *Ares* launch vehicle and may be at risk of being delayed indefinitely. At time of writing (mid-October 2009) the current US administration is looking long and hard at NASA's budget for Constellation, considering it too expensive a project. A full-up boiler-plate test of *Ares X-1* is scheduled for late-October 2009 but this may be the vehicle's only flight. If *Constellation* is shelved and the shuttle fleet pressed into service beyond 2010 funds will need to be found to restart sub-contractor companies who have already lain off highly technical staff in anticipation of the shuttle's retirement. The US space agency has also just released a report recommending more cooperation with private space ventures.

Cramming *ISS* modules and experiments currently awaiting launch into the last five missions has been a consequence of the planned cessation of shuttle flights. Two trips by *Discovery*, two by *Endeavour*, and one by *Atlantis* will ferry replacement Expedition crews to the *International Space Station* as well as the additional components for finalising construction of the permanent space outpost.

A number of Russian *Soyuz* missions will enable the Expedition crews to be rotated and unmanned Progress craft visit the *ISS* to top up supplies. A second flight of Europe's *Automated Transfer Vehicle* (ATV *Johannes Kepler*) will take place in November. This complex spacecraft can dock automatically with the *ISS* where it remains for up to six months before detaching and burning up in the Earth's atmosphere. ESA are currently studying whether the *ATV* could be converted to a manned vehicle to service the *ISS*.

Private spaceflight

So far, we've ignored the private space ventures. They have been quietly working away, somewhat out of the limelight, but are now ready to demonstrate their various transfer-to-orbit solutions. Chief amongst these is SpaceX which has developed a capsule called *Dragon* to re-supply the *ISS* and ultimately will ferry crew to and from the station. Three test flights are scheduled during 2010 before an actual resupply mission to the *ISS* which is now slated for 2011. SpaceX is involved because of a US-Government initiative that opened the way for private space ventures to partner with NASA on developing low-Earth orbit vehicles.

Two to watch

Two other programmes to watch during the year will be *X-37B*, a reusable space plane that is a joint venture between the US Air Force and Boeing. A demonstration flight is planned for February 2010. Information is currently a bit thin on the ground though about China's *Tiangong-1* ("Heavenly Palace"), their planned 8.5 ton space station due to launch at the end of the year. Future generations of the station will have a number of modules and host 3 crew.

Launch Date	Mission Name	Country /Agency	Mission Objectives
**/01/2010	Dragon-C1	SpaceX	Test flight
23/01/2010	Glory	NASA	Climatology
03/02/2010	STS-130	NASA	ISS assembly
**/02/2010	X-37B	USAF	Test flight
18/03/2010	STS-131	NASA	ISS assembly
02/04/2010	Expedition 23	Various	ISS crew rotation
14/05/2010	STS-132	NASA	ISS assembly
20/05/2010	Planet-C	JAXA	Venus orbiter
20/05/2010	IKAROS	JAXA	Solar sail test
30/05/2010	Expedition 24	Various	ISS crew rotation
**/06/2010	Dragon-C2	SpaceX	Test flight
29/07/2010	STS-134	NASA	ISS assembly
**/08/2010	Dragon-C3	SpaceX	Test flight
16/09/2010	STS-133	NASA	ISS assembly
29/09/2010	Expedition 24	Various	ISS crew addition
18/11/2010	ATV-2	ESA	ISS resupply
30/11/2010	Expedition 26	Various	ISS crew rotation
**/12/2010	Tiangong-1	CNSA	Chinese space station

Rendezvous missions

Date	Mission	Objectives
10/07/2010	Rosetta	minor planet 21 Lutetia flyby
**/12/2010	Planet-C	enters Venus orbit

Listed data is accurate at time of writing but launch dates may be subject to change for various reasons. Go to en.wikipedia.org/wiki/Category:Future_spaceflights where you will find latest details of planned and completed space missions. A tentative launch/encounter period is indicated with a double-asterisk (**) in each table's date column.

Rediscovering rainbows

My heart leaps up when I behold
A Rainbow in the sky:

-- *The Rainbow* by William Wordsworth

Painters, poets, and photographers have long tried to convey to us through pictures and prose the beauty of that delicate brushstroke of colour we term a rainbow. But rainbows are just one of the many classes of phenomena that fall into a grey area between meteorology and astronomy – the world of atmospheric optics.

Rainbows, along with the halo we sometimes see around the Moon, are our most familiar and frequent types of optical phenomena in the atmosphere. Many of these complex and beautiful patterns result in most cases from the interplay of light with two simple substances – air and water.

How rainbows form

The philosopher Rene Descartes performed an experiment in 1637 to show how a rainbow was produced. However, he did not understand the nature of light and it was left to Isaac Newton to explain its composition thirty years later. Contrary to popular opinion, Newton did not see seven colours but five. He assumed there were seven colours because it fitted the scheme of the then known solar system of Sun, Moon, and five naked-eye planets.

Basically, a rainbow is a reflection and refraction phenomenon. Sunlight shines on a raindrop and the light is reflected within the drop back towards the observer. It is also refracted because the light passes from one medium to another – in this case from water to air. Various wavelengths of the constituent colours of white light are refracted differently thus giving a spectrum we call a rainbow.

A primary rainbow is always centred round an imaginary point directly opposite to the Sun in the sky – the so-called anti-solar point. When the Sun is on the horizon, this point is on the opposite horizon, but as the Sun gains in altitude, this point is displaced below the horizon. A ray of sunlight is reflected and refracted within a raindrop, leaving at an angle of 42 degrees – this is the angle it subtends from the anti-solar point. From this, we can infer that for a primary rainbow to be visible the Sun must be less than 42 degrees above the horizon. A handy rule of thumb is the higher the Sun, the lower in the sky the rainbow appears. A rainbow at sunset arches high across the sky but by taking on the colours of the setting Sun it may actually display a range of reddish-pink hues.

If the beam of light undergoes two internal reflections in a droplet it exits at an angle of 51 degrees to give a secondary rainbow. If you see this bow you will see the colour sequence reversed to that of the primary. In a primary bow, red is on the outside edge of the arch while in a secondary the same colour is on the inside edge.

Each time the beam of light is reflected the intensity of the resultant bow is one-tenth that of the lesser-order one. Thus, a second-order bow is only one-tenth as bright as a primary rainbow. It's an important point to remember and one reinforced when you see both rainbows.

The many aspects of rainbows

The strength of colours in a rainbow are directly related to the size of the water droplets reflecting and refracting light. If are the droplets are fine enough – such as in mist or fog – you may witness a ghostly arch around the anti-solar point. This is the fog bow, often seen looming ahead of you in mist as a car races by with headlights blazing. A strong streetlight can also serve as the light source for fog bows.

Droplets between 1mm and 2mm in diameter give rise to the most vivid colours in a bow. If the drops are smaller than this, then some of the colours are less pure. Droplets less than 1mm in size may also give rise to supernumerary arcs. These arcs are interference patterns created within raindrops and cause colour overlap. Depending on how the rays mesh together the interference can be constructive, in which case the rays produce a brightening, or destructive, in which case there is a reduction in brightness. The arcs appear at the outer and inner edges of the primary bow.

When you see a primary rainbow you may notice the sky inside the bow is brighter than the outside. This is because light reflected from a raindrop is scattered more towards the inside of the bow. In the secondary light is scattered more to the outside because of two internal reflections. When the two bows appear together this preferential scattering gives rise to a dark strip of sky between them that is termed Alexander's Dark Band. The phenomenon is so-called after Alexander of Aphrodisias who first described it nearly two millennia ago. The stronger the sunlight and rain, the more intense the rainbow and the more likely you will see a prominent display of the dark band.

Other bows

As you can see, rainbows come in many different forms but there are some even more fantastic aspects.

What about reflected bows? Remember what was said about the rainbow centred on the anti-solar point? Well, if the light source is reflected in water, it has the effect of creating a second anti-solar point higher in the sky. If conditions are right a bow may form around this point – a reflection of a true rainbow. What a sight that must be.

Formed in the same way as the daytime bow, the light from the Moon cannot match the brilliance of the solar disk so a moon rainbow is but a pale relative of its daytime counterpart. While sometimes we can see some colour, the moon rainbow normally appears whitish; the colours are just too faint to distinguish properly except with a time-exposure photograph. It is because of this faintness that we normally only see a moon rainbow near time of Full Moon.

Finally, when hill-walking you may have seen your shadow projected against low cloud or a bank of fog. Look more closely and you may see a ring of light encircling the shadow. Sometimes this circle may be coloured. This is a glory, or *Brockenspectre*, caused by the diffraction of light in water droplets. It can also be seen from an aircraft as it breaks through a layer of cloud after taking off.

We've covered a lot of ground in our discussion of bows but have still just touched on their different forms. We did not cover coronas (not to be confused with the Sun's corona visible during a total solar eclipse), aureoles, 360 degree bows, or iridescent cloud, to name some other phenomena. Let us not forget though what the true crock of gold is at the rainbow's end; it's what we experience as we watch all these magical bows that nature plaits, a source of riches that material wealth cannot match.

Read: "Out of the Blue: A 24-hour Sky-watcher's Guide" by John Naylor. Cambridge University Press (2002). ISBN 0521809258

Lunar eclipse tales

A quick glance skyward the morning of Tuesday, 21 December 2010 may reveal all is not well with lovely Luna. Darkness creeps across her face as she immerses herself in the cone of the Earth's shadow splayed into space and undergoes the first total lunar eclipse visible from Ireland since that of 21 February 2008.

Tales of fear and dread

Lunar eclipses have been regarded with awe and fear in equal measure down through history. Superstitious peoples thought they foretold an impending calamity or were the displeasure shown by the lunar gods at events on Earth. Many cultures believed the Moon was being attacked by a large creature just like what apparently happened during total solar eclipses.

The Egyptians invoked the idea of a sow savaging pieces out of the Full Moon to account for its waning phases. After enduring a fortnight of agony, the Moon died and was slowly reborn again. Lunar eclipses were simply caused by the sow swallowing the Moon in one go. Some peoples of the Middle East believed that the Moon showed its displeasure with events on Earth by temporarily turning its face away from us. The Eskimo tribes of the Arctic thought that an eclipse was caused by the Moon leaving the sky and entering their houses to look for food and clothing. To this end they often hid such objects.

Creatures called varcolaci in Romanian myth were said to attack the Moon. When women spun thread at midnight it was believed that vampires and varcolaci could climb up to the sky by the thread and eat the Moon. Only by breaking the thread could the creatures lose their power.

Native American Indians saw an eclipse as the Moon being torn apart by a pack of hunting dogs and her blood flowing profusely. A similar myth comes from Scandinavia and tells of the Moon being eaten by the monster Managarmer and its disk becoming stained with blood. Vikings myth features two wolves — Skoll and Hati — who constantly pursue the Sun and Moon across the sky. An eclipse occurs when the wolves catch up with and devour either of the two luminaries.

The blood red colour of the lunar disk during an eclipse is what probably gave rise to the notions that it was being attacked. To this end, it was thought that creating a chorus of noise would frighten the creature away. Rev. Justus Doolittle, in his Social Life of the Chinese (1867) comments; "A uniform result always follows the official efforts to save the Sun and Moon. They are invariably successful."

Captain Daniel Beeckman, during his exploration of Borneo, recounts that on the night of November 10th, 1714, "we sat very merry until about eight at night, when, we heard all of a sudden a most terrible outcry, mixed with squealing, halloing, whooping, firing of guns, ringing and clattering of gongs or brass pans, that we were greatly startled, imaging nothing less but that the city was surprised by rebels. I ran immediately to the door, where I found my old fat landlord roaring and whooping like a man raving mad. The noise was so great that I could neither be heard, nor get an answer to know what the matter was. At last, I cried as loud as I could to the old man to know the reason for this sad confusion, who in a great fright pointed up to the heavens, and said, 'look, see; the devil is eating the Moon.'"

The Chinese interpretation that a dragon was responsible was a common theme (the Chinese word for an eclipse — *shih* — means "to eat"). Again, people took to banging pots and pans in an effort to frighten away the creature. In India, two dragons were required to cause eclipses, with one at each node in the Moon's orbit. The two nodes were referred to the dragon's head and the dragon's tail and the symbols we now label the nodes with on charts reflect this.

Other causes and interpretations were common also. In Tonga, clouds alone were believed to cause an eclipse while Kalahari bushmen thought that the Moon had suffered an illness. The Tlingits of Canada would stand together and blow towards the Moon to try and dispel the ailment.

Some tribes would fire flaming arrows at the Moon to try and rekindle its light. Others thought that poisonous substances fell from the Moon at the time of an eclipse and so they upturned cooking pots and covered wells. Dogs were whipped into a barking frenzy — unfortunate for them especially in the western US as the tribes there believed that a huge dog was eating the Moon. The Moon painting her face to hide from some celestial danger or the Sun and Moon engaging in a lovers tryst were other explanations. Some west African tribes came close to the mark by saying that the shadow of the Sun pursued the Moon.

Fanciful as all these notions were, it just wasn't hard science. A popular belief with the ancient Greeks was that there was a dark body, a sort of 'counter-Earth', called Antichthon which was responsible for eclipses. This body was invoked to make up to 10 the number of "spheres" which occupied the heavens. Another theory advanced was that the Sun and Moon were compressed clouds which were periodically extinguished. The first to give the true explanation of a lunar eclipse, that it was due to the shadow of the Earth, was Anaxagoras around 460 BC.

What is a total lunar eclipse?

A total lunar eclipse occurs when the Moon passes through the shadow of the Earth cast into space. This means that we can only get a lunar eclipse during time of Full Moon when the Sun, Earth and Moon are in a straight line. We don't get a solar or lunar eclipse every month however because the orbit of the Moon about the Earth is tilted with respect to the Earth's equator.

During a total lunar eclipse our atmosphere acts like a lens bending sunlight around the Earth's limb onto the Moon. Longer wavelengths of light (red and orange) penetrate our atmosphere better than shorter (blue) so during totality the Moon takes on a reddish-orange hue.

The effect is similar to the reddening of the setting Sun. It once led someone to comment that the red colour of the eclipsed Moon is due to all the sunrises and sunsets around the world being painted on the Moon — a rather nice and perceptive observation.

Instances exist throughout history where people have used their knowledge of an impending eclipse to their advantage. Probably the most famous anecdote concerns the use of the total lunar eclipse on February 29th, 1504 by Christopher Columbus to placate the natives of the island of Jamaica.

Less well known is the story of a Belgian officer, Capt. Albert Paulis, who applied a similar tactic when captured by cannibals in the Belgian Congo in 1905. Paulis noticed in his almanac that a lunar eclipse was due on the evening he and his men were to be executed. He duly informed the chief of the tribe that he had the power to kill the Moon unless he and his men were released. When dared to carry out the threat, Paulis pointed to the Moon as the eclipse began. In terror, the cannibals promised anything if the Moon was saved. In return, Paulis demanded the authority of the King of Belgium be recognised over their domain.

The deaths of Kings and Popes have all been traced through consulting the eclipse record. Some scholars have even dated the Crucifixion based on an lunar eclipse that occurred on April 3rd, 33 AD.

Myth, mystery, and magic, total lunar eclipses continue to delight. If the sky is clear the morning of December 21st, look up in wonder at the effect of lunar eclipses on humankind down through the ages and their potential to intrigue.

Eclipse phenomena

Very little dimming is noticed during the initial stages of a lunar eclipse as the Moon slides through the penumbral, or outer portion of the Earth's shadow. Thereafter you will begin to see a slight darkening at the leading limb as the Moon slips deeper into eclipse. If the Moon passes well north or south of the centre of the Earth's shadow then the contrast between either hemisphere can be quite marked with the tones graded from bright to dark across the disk.

The Danjon scale

Atmospheric conditions at the Earth's limb can often have an effect on the visibility of the Moon during an eclipse. The brightness of lunar eclipses can be rated according to a scale devised by the French astronomer Antoine Danjon in the early twentieth century. It is graded as follows:

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·L = 0: Very dark eclipse; Moon hardly visible, especially near mid-totality.
·L = 1: Dark eclipse; grey-to-brown colouring; details on the disk hardly visible
·L = 2: Dark red or rust coloured eclipse with dark areas in the shadow centre, the edge brighter
·L = 3: Brick red eclipse, the shadow often bordered with a yellow edge
·L = 4: Orange or copper-coloured, very bright eclipse with bluish edge
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More on the lore of the Moon

We are all familiar with the nursery rhyme of Jack and Jill but have you ever stopped to think about its origin. Many people are surprised to hear that the story is rooted in Moon lore and the folk tales of the Vikings.

Every culture on Earth has woven their own myths and legends around our companion Moon to explain the markings on the disk or the monthly cycle of its phases.

The Man in the Moon is probably the most familiar pattern that we tease out of the dark blotches that are the lunar maria. Legend has it that he was a thief caught stealing vegetables from a field on the Sabbath and was wished up into the moon by the people of his village.

African folklore has a cautionary tale of a hare sent by the Moon to pass on a message to everybody on Earth that "just as the moon dies and rises again, so shall you."

The poor hare confused the message and in error told everyone that "just as the moon dies and perishes, so shall you." — interestingly, one of the fundamental tenets of Christianity has similar parallels.

On hearing this, the angry Moon beat the hare on the nose with a stick. Henceforth, the hare has sported a split nose. The hare got its revenge though by clawing the Moon and leaving the dark scars on its face that we see today.

The hare also features in another story about a herd of elephants who were trampling the burrows of forest creatures. A wise hare led the elephants to a pool that was mirroring the Moon. When they dipped their trunks in the water rippled the Moon's reflection. The hare explained this was the Moon trembling with rage at their behaviour. The elephants apologised and peace returned to the forest.

And the Jack and Jill story?

Mani was a young Norse god that was appointed by Odin to drive the moon chariot and fill the night sky with light. Two children accompany him on the chariot, Hjuki and Bil. They had been saved by Mani from a cruel father, Vidfinner, who had stolen the magical mead of the gods. Vidfinner often boasted that he had power over even the gods because of the great strength that the mead gave him. He created a secret spring in the mountains so that he would always have a supply of the elixir.

One stormy evening, he ordered his children to go and bring him back some mead. Draping a pole and bucket over their shoulders he sent them on the long journey. Fearing what their father would say if they did not succeed, they climbed the high mountain and filled the bucket with the mead at the spring.

Odin had been watching their journey and in pity ordered Mani to sweep down and take the children into the heavens. Ever since that day, the two children have lived on the face of the Moon and people still whisper to Bil at Full Moon, "drop some of that mead on my lips", for they wish to gain the strength that only the magical drink can give.

While Moon lore is not strictly something observational, it's nice to think though that your interest in astronomy can only be enriched by drawing together the many strands of human culture and myth woven into the sky.

Space and cyberspace

The Internet hosts a treasure trove of information on astronomy and space. Some favourite sites to kick-start your own explorations in space and cyberspace are listed here — www.southdublinastronomy.org has more.

The Sun

www.spaceweather.com — transient events and solar data
www.bbso.njit.edu — solar images daily
www.sundialsoc.org.uk— British Sundial Society

The Moon

www.moonposter.ie — lovely Moon poster printed in Ireland
www.lpod.org — Lunar Photo of the Day
www.inconstantmoon.com/inconstant.htm — lots of info

Eclipses and occultations

sunearth.gsfc.nasa.gov/eclipse — detailed eclipse info
www.ecliptomaniacs.com — Irish eclipse chasers
www.asteroidoccultation.com — details of upcoming events
astrosurf.com/eaon — European asteroid occultation group

Atmospheric optics

www.atoptics.co.uk — a must see site on optical effects
www.kaleidoscopesky.com — an equally awe inspiring site

The planets

seds.lpl.arizona.edu/nineplanets/nineplanets — multimedia tour of the planets
www.solarviews.com/eng/homepage.htm — another site that has a nice overview of the Solar System

Comets and Meteors

www.ast.cam.ac.uk/~jds/ — BAA comet section site
www.imo.net — International Meteor Organisation's page
www.aerith.net/index.html — comet ephemerides
cometography.com — details of historic comets
meteorshowersonline.com — history of meteor showers
www.meteorite-times.com — for meteorite collectors

Stars

www.astro.uiuc.edu/~kaler/sow/sowlist.html — great site by a world expert on stellar evolution
homepage.eircom.net/~irishas/vsog/vsog.htm — home page of the Irish variable star observers group
www.aavso.org — worldwide body for variable star observers
www.ianridpath.com/startales/contents.htm — star lore

Books and small ads

www.bookfinder.com — search multiple booksellers
www.astromart.com — small ads for astronomy gear
www.astrobuysell.com/uk/ — a more local small ads site

Miscellaneous

www.seds.org/billa/astrosoftware.html — astro software
www.explorers.co.uk/astro/default.asp — eclipse tours
planetary.org/radio — Planetary Society podcasts
www.jodcast.net — monthly night sky tour for MP3 players

Irish sites

www.science.ie — news on science in Ireland from Forfas
www.iscan.ie — Irish Science Centre Awareness Network
www.eaas.co.uk/news/metis.html — history of Markree Castle in Sligo (from where the asteroid Metis was discovered)
www.iscan.ie/spotlight/spotlight3.htm - Daramona in Streete, Co.Westmeath was another historic Irish observatory
www.met.ie — will it be cloudy tonight?

Telescope dealers in Ireland

www.andromedaoptics.com — based in Dublin
www.astronomy.ie — Astronomy Ireland's shop & club page
www.mccreaa.freeserve.co.uk — North Down Telescopes

Magazines

skytonight.com (US) — Sky and Telescope magazine
www.astronomynow.com (UK)
www.astronomy.com (US)
www.skyatnightmagazine.com (UK)

Education and observing

www.badastronomy.com — righting astro wrongs
www.astrosociety.org — Astronomical Society of the Pacific
www.astroleague.org — observing handbooks and lists
www.asahi-net.or.jp/~zs3t-tk/atlas/atlas.htm — free star atlases that you can download as pdf documents
www.skymaps.com/downloads.html — very attractively produced star chart that you can download each month
seds.lpl.arizona.edu/messier/Messier.html — Messier DSOs
www.visualdeepsky.co.uk — deep sky observing
www.cloudynights.com — *the* essential hobby advice forum
www.philharrington.net — binocular astronomy
www.scopereviews.com — telescope reviews by Ed Ting
antwrp.gsfc.nasa.gov/apod/astropix.html
www.popastro.com/phpBB2/index.php — the Society for Popular Astronomy in the UK have a quite lively forum
www.covingtoninnovations.com/astro/ — DSLR photography

News

www.astro.uni-bonn.de/~dfischer/index.html
science.nasa.gov — interesting articles by Nasa scientists
www.universetoday.com — great site by Fraser Cain
www.spaceflightnow.com/news/index.html

History

www.daviddarling.info/encyclopedia/ETEmain.html — an online encyclopedia of astronomy and space
www.shastro.org.uk/ — Society for the History of Astronomy
lindahall.org/pubserv/hos/stars/welcome.htm
a wonderfully illustrated history of the star atlas

Satellite and *Iridium* flare predictions

www.heavens-above.com — *ISS* passes for your location
iss-transit.sourceforge.net — *ISS* transits of the Moon
www.calsky.com — predicts all sorts of celestial phenomena

Spaceflight

www.jpl.nasa.gov/calendar — JPL Space Calendar
www.russianspaceweb.com
www.esa.int — European Space Agency
hubblesite.org — *Hubble* space telescope
www.spaceflightnow.com/tracking/index.html
en.wikipedia.org/wiki/List_of_space_agencies

Fun stuff

www.exitmundi.nl/exitmundi.htm - Armageddon outta here!
www.besse.at/sms/smsintro.html — Science made stupid
davidszondy.com/future/futurepast.htm — life in the future envisaged by science fiction magazines of the 1930s