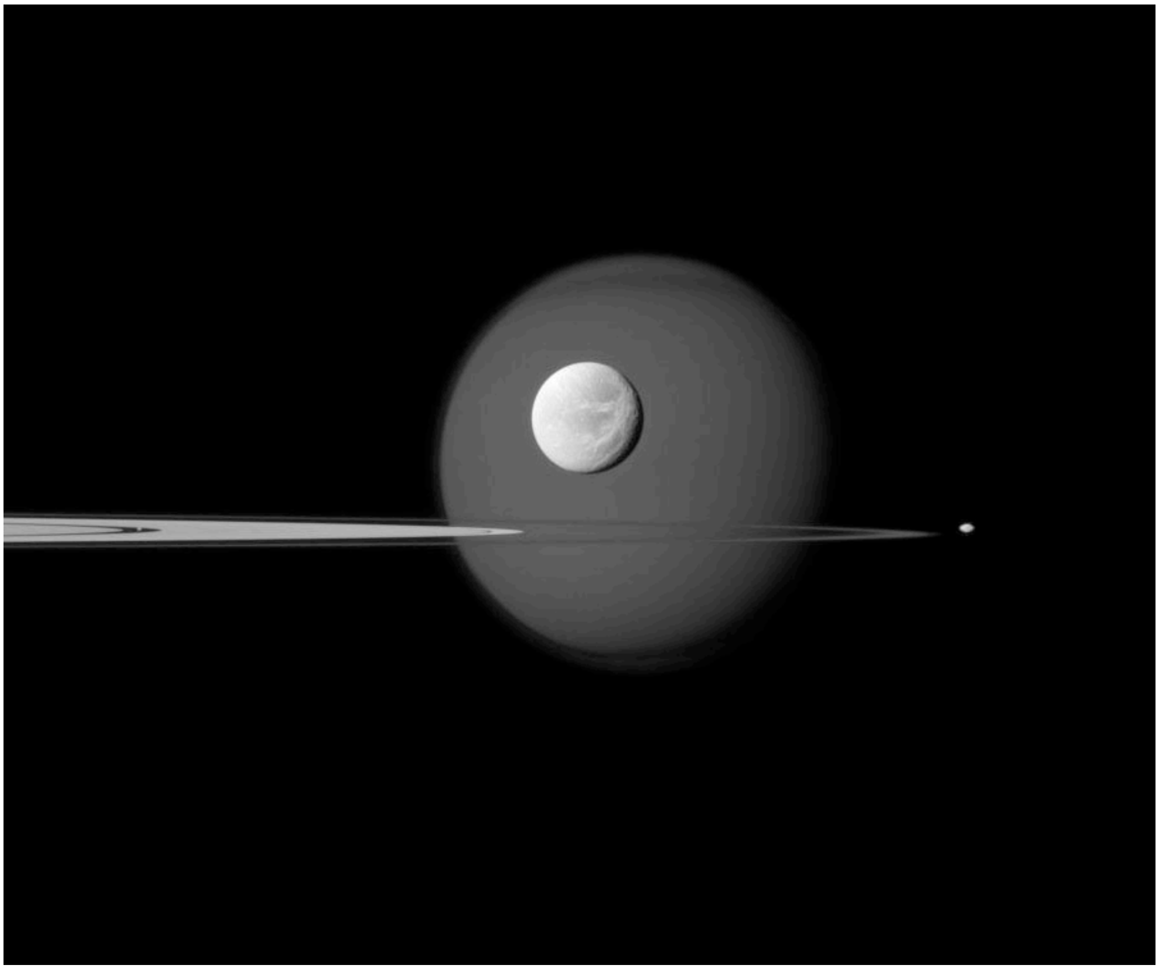
SkyWAAtch



Four Out of Sixty

At latest count, Saturn has 60 moons, 53 of which have been named. This NASA photo depicts four: first -- and farthest in the background -- is Titan, the largest moon of Saturn and one of the larger moons in the Solar System. The dark feature across the top of this perpetually cloudy world is the north polar hood. The next most obvious moon is bright Dione, visible in the foreground, complete with craters and long ice cliffs. Jutting in from the left are several of Saturn's expansive rings, including Saturn's A ring featuring the dark Encke Gap. On the far right, just outside the rings, is Pandora, a moon only 80-kilometers across that helps shepherd Saturn's F ring. The fourth moon? If you look closely in the Encke Gap you'll find a speck that is actually Pan. Although one of Saturn's smallest moons at 35-kilometers across, Pan is massive enough to help keep the Encke gap relatively free of ring particles.

Credit: Cassini Imaging Team, ISS, JPL, ESA, NASA

Events for December 2011

WAA Lectures

"A More Perfect Heaven"
Friday December 2nd, 7:30pm
Miller Lecture Hall, Pace University
Pleasantville, NY

Award-winning science journalist and author of several books including *Longitude* and *Galileo's Daughter*, Dava Sobel will discuss her new book *A More Perfect Heaven*, about the life and contributions of Copernicus. If you wish to have a copy of *A More Perfect Heaven* signed by the author, please purchase one at your local bookstore or on-line and bring it to the meeting. Unfortunately, copies will not be available for sale at the meeting. Free and open to the public. Directions and Map.

Upcoming Lectures
Miller Lecture Hall, Pace University
Pleasantville, NY

On January 6th, our presenter will be Andy Poniros, a NASA/JPL Solar System Ambassador. He will speak on "The Icy Moons of Saturn." Free and open to the public.

Starway to Heaven

Meadow Picnic Area, Ward Pound Ridge Reservation, Cross River

There will be no public *Starway to Heaven* in December, January or February. *Starway to Heaven* events will resume in March 2012.

Renewing Members. . .

Bob Kelly - Ardsley
Parrington Family - Babylon
Josh Knight - Mohegan Lake
Matthew Fiorillo - Bedford
Vince Quartararo - Katonah
Daniel Poccia - Cortlandt Manor
Paul Andrews - Patterson
Al Forman - Croton-on-Hudson
Scott Nammacher - White Plains
Tom Boustead - White Plains

Barnard's Loop

John Paladini captured this image of Barnard's Loop, an emission nebula in Orion and part of a large molecular cloud covering much of the Constellation.

Members Classified

As a service to members, the WAA newsletter will publish advertisements for equipment sales and other astronomy-related purposes. Ads will only be accepted from WAA members and must relate to amateur astronomy. Please keep to 100 words, include contact info and provide by the 20th of the month for inclusion in the next issue. The newsletter is subject to space limits; so ads may be held to subsequent issues. The WAA may refuse an ad at its sole discretion. In particular, price information will not be accepted. Members and parties use this classified service at their own risk. The Westchester Amateur Astronomers (WAA) and its officers accept no responsibility for the contents of any ad or for any related transaction.

Send classified ad requests to: Newsletter.

Westchester Amateur Astronomers, Inc., a 501(c)(3) organization, is open to people of all ages with the desire to learn more about astronomy. The Mailing address is: P.O. Box 44, Valhalla, New York 10595. Phone: 1-877-456-5778. Observing at Ward Pound Ridge Reservation, Routes 35 and 121 South, Cross River. Annual membership is $25 per family, and includes discounts on *Sky & Telescope* and *Astronomy* magazine subscriptions. Officers: President: Doug Baum; Senior Vice President: Larry Faltz; Vice President Public Relations: David Parmet; Vice President Educational Programs: Pat Mahon; Treasurer: Rob Baker; Secretary/Vice President Membership: Paul Alimena; Vice President Field Events: Bob Kelly; Newsletter: Tom Boustead.

Articles and Photos

Water, Water, Everywhere...
by Larry Faltz

The physical characteristic that distinguishes Earth from every other planetary body, in our solar system or any other found to date, is the presence of so much liquid water in equilibrium with water vapor in an oxygen-containing atmosphere, a situation optimal for the formation of life as we know it. Some exoplanets appear to be orbiting in the "habitable zone" where surface temperatures permit liquid water to exist (such as CoRoT-9b) and some appear to have densities that imply a large amount of water (such as GJ 1214 b). Water was detected in the atmosphere of HD 209458 b, a planet orbiting just 0.045 AU from a 7th magnitude G-type star in Pegasus 154 light years from us, but the planet is a gas giant with a surface temperature of over 1,000 degrees Celsius. You're not likely to be able to go swimming there.

There's plenty of extraterrestrial water in the solar system, much of it in the form of ice on asteroids, comets, Kuiper belt objects and even satellites of the outer planets. Water droplets are present in Jovian and Uranian gas clouds. Observations of Europa strongly suggest a liquid ocean under the moon's icy surface, and sub-ice oceans may be present on other large outer solar system bodies and under Neptune's hydrogen/helium atmosphere. Mars has water in its polar caps and there's evidence for Martian subterranean aquifers as well. Most, but not all, of Venus' water has boiled off, leaving an atmospheric concentration of only 0.002% (compared with Earth's 0.4%). There are tiny amounts of water in deep polar craters on the Moon and even on Mercury. A graphic on the web site io9.com nicely shows the location of the solar system's of water.

According to the US Geological Survey, if all of the free water (oceans, atmosphere, rivers, lakes, aquifers, ice caps, and water in organisms) on Earth was collected, it would form a sphere 860 miles in diameter, a volume of about 333 million cubic miles (3.33×10^8), just over a thousandth of the earth's total volume (2.6×10^{11} cubic miles), and weighing 1.38×10^{24} grams. Where did it come from?

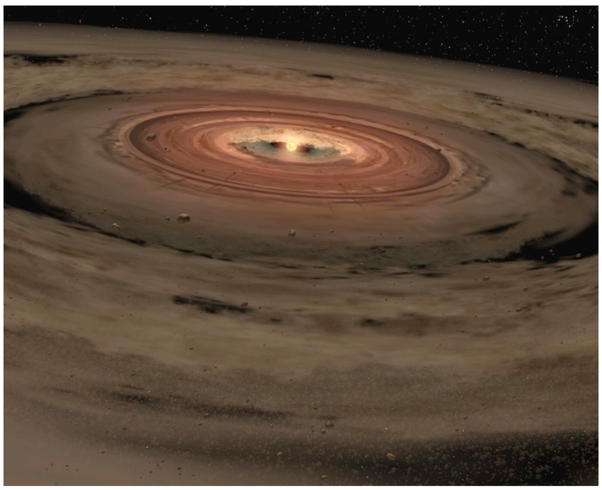
There are five likely sources of terrestrial water.

- Outgassing of water into the atmosphere as the nascent earth cooled
- Deposition of water from comets or asteroids impacting the earth during the bombardment phases
- Biochemical processes
- Leakage of water from hydrous minerals in the earth's crust
- Photolysis due to radiation

Water was undoubtedly present in the material that condensed to form our planet, probably in both vapor and solid phases (ice). The newly-formed Earth itself was initially too hot to have liquid water. One reasonable scenario is that after the moon-forming impact of a Mars-sized body very early in the Earth's history (an event now viewed by the astronomical community as a near certainty), the dense post-impact atmosphere, composed of rock vapor and CO_2, had high enough pressure to retain liquid water on the surface. As the Earth cooled and the atmosphere matured, liquid water would be retained. However, the mechanism currently in greatest favor for liquid terrestrial oceans is thought to be deposition from asteroid and comet impacts at a somewhat later time. The ratio of hydrogen to deuterium in the Earth's oceans is closer to that of chondrites, rocky bodies that formed by accretion of dust grains in the asteroid belt, than of comets, which formed much further out. The other mechanisms seem unlikely to be able to provide enough water to fill the oceans and saturate the atmosphere.

We have to examine circumstellar dust clouds surrounding newly-formed stars to get a better understanding of the distribution of chemical species in proto-solar systems. Detecting water outside of earth's atmosphere is difficult using ground-based instruments because atmospheric water vapor contaminates spectra from extraterrestrial sources. Fortunately, instruments on space-based observatories have been designed to scan the required wavelengths in the far infrared part of the spectrum where water signatures are found. With their incredible resolution, they allow us to map the distribution of molecules of interest in nascent solar systems.

Carr and Najitam, using the infrared spectrograph on board the Spitzer Space Telescope, observed emission spectra of water (among other molecules) in the disk around the star AA Tauri (*Science* 2008; 319: 1504-1506), finding that water molecules were the most abundant volatiles in the disk after hydrogen. This is probably typical of circumstellar disks that are forming solar systems.



Artist's conception of the disk around AA Tauri (NASA)

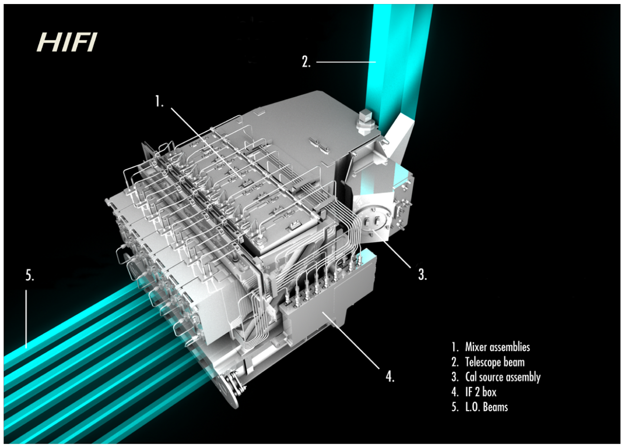
AA Tauri (spectral type K7, magnitude 12.8, distance 465 light years) is thought to be only 2.4 million years old. The observations concentrated on zones within the disk where temperatures are high enough for ice to sublimate (out to 5 AU). The diversity of molecular species indicates an active chemical network with reactions in the gas phase. The authors of this study note that "the indication of molecular synthesis in AA Tauri suggests that more complex organic molecules, including those of pre-biotic interest, might be produced within disks." It may be that the chemistry of life indeed started in outer space.

One might logically expect water in the circumstellar disk to be distributed as hot vapor near the star and ices further out, and that generally appears to be the case. Ices are harder to detect, however. Recent data from the Herschel Space Observatory (Hogerheijde, et. al., *Science* 2011 [21 October]; 334:338-340) using Herschel's HIFI spectrometer (Heterodyne Instrument for the Far-Infrared) provides new information on the distribution and circulation of water within the cloud surrounding TW Hydrae, an 11th magnitude, type K8 orange dwarf, 176 light years from Earth, thought to be about 10 million years old and have a mass of 0.6 suns.

Herschel under construction (European Space Agency)

The Herschel Space Observatory was launched on May 14, 2009. It was designed for far infrared and sub-millimeter parts of the spectrum. The dish is 3.5 meters in diameter. The science payload complement comprises two cameras/medium resolution spectrometers (PACS and SPIRE) and a very high resolution heterodyne spectrometer (HIFI), housed in a superfluid helium cryostat.

The helium is expected to last through February 2013.



The HIFI instrument on Herschel (European Space Agency)

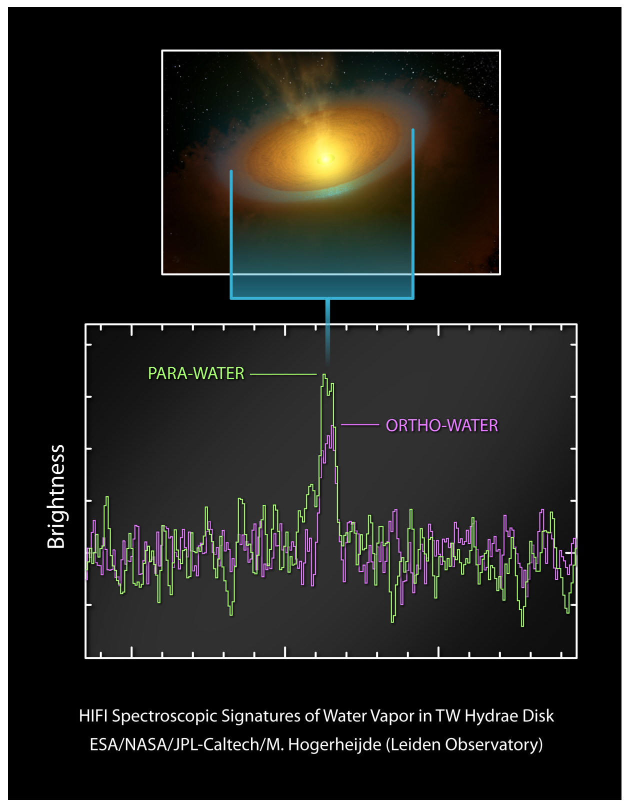
The disk of TW Hydrae, made up of hydrogen, dust grains and other chemical species, was first detected by measuring radio emission with the Very Large Array (Wilner, et. al., *Astrophys J* 2005; 626: L109). It is thought to have a radius of about 196 AU. Dominik, et. al, (*Astrophys J* 2005; 635: L85) showed that interstellar ultraviolet radiation penetrating the upper layers of the cloud causes some water ice on the grains to go back into the gas phase. This suggested that cold (<100 K) water vapor is present throughout the disk. Hogerheijde and his colleagues sought to detect this vapor.

The critical technique is to use spectroscopy to differentiate the two spin isomers of water. Each hydrogen atom has a single proton in its nucleus. Protons have a quantum property called spin (really spin angular momentum) which we can consider to be either "up" or "down". Water contains two hydrogen atoms, so a water molecule can either be *ortho* (both protons with the same spin direction) or *para* (spinning in opposite directions). The ratio of *ortho* to *para* water is temperature-dependent, cooler temperatures favoring the *para* form.

The authors, using HIFI, were able to detect emission lines for each form of water, calculate their intensities and also measure the line widths, which indicate radial velocity. To quantify the amount and physical state of water at various points in the disk, they fitted their results to a model based on previously published observations about the dust structure of the cloud.

The authors found that there was a differential distribution of water and ice not only in a radial direction (from the star) but within the thickness of the disk, with water vapor abundance of around $1x10^{-7}$ (relative to H_2) at an intermediate height within the disk. Above that (nearer the surface of the cloud), water was photodissociated from grains into the vapor phase by interstellar UV light, while more centrally it was frozen out on dust grains with an ice abundance of 10^{-4} relative to H_2. Ice-mantled larger dust grains settle to the center of the disk; the smaller, ice-bare dust grains at the edges shield them from more UV radiation, stabilizing their ice content.

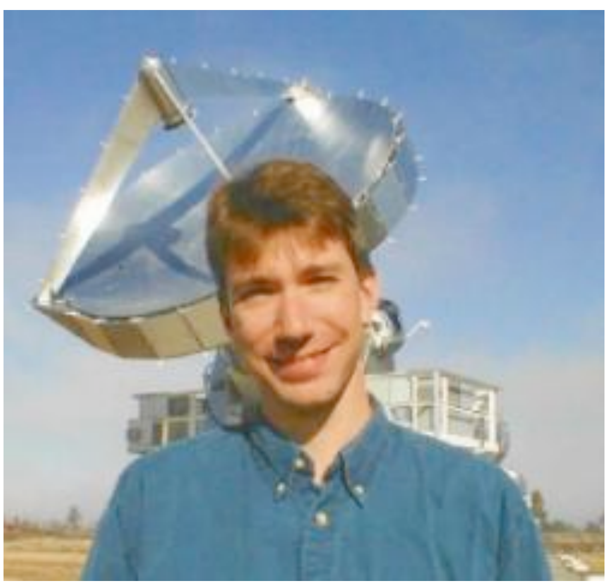
The observations show that there is a thin zone of cold water vapor at an intermediate depth in the disk outside of the "snow line" (~5 AU, where ice can condense), in equilibrium with ice on dust grains, and that water in vapor form is about $8x10^{-4}$ as abundant as in ice. They further suggest that the total ice reservoir in TW Hydrae contains $9x10^{27}$ grams of water, equivalent to about 6,500 Earth oceans.



European Space Agency (artist's conception of the disk)

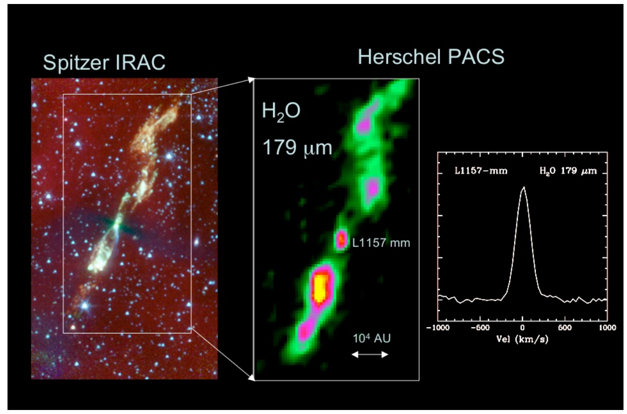
In addition to finding these reservoirs of water vapor and ice, the authors calculated a statistical temperature called T_{spin} based on the measured *ortho*-to-*para* water ratio of 0.77 ± 0.07. T_{spin} in the disk was found to be 13.5 ± 0.5 K, which contrasts with a known value of >20 K in solar system comets. Reasoning from this and other data, the authors conclude that there are dynamic transport processes throughout the entire solar nebula that mix water formed at high (>50 K) temperatures with that formed at lower (<20 K) temperatures, prior to the water being incorporated into larger bodies like comets or planets.

This model is consistent with evidence from a completely different experimental approach, the analysis of minerals in comet samples. The Stardust mission brought back small pieces of the surface of Comet 81P/Wild 2 (Nakamura, et. al, *Science*, 2008: 321: 1664-1667). The samples unexpectedly contained crystalline material. When these were analyzed by physical and chemical methods, they were found to be very similar to chondrules, which are submillimeter-sized particles that dominate inside chondrites and are believed to have formed in the inner solar nebula at distances around 3-5 AU (the location of the asteroid belt). The presence of the chondrule-like objects in the comet suggests that chondrules were transported out to the cold outer solar nebula and spread widely over the early solar system.



Dr. Michiel Hogerheijde, University of Leiden

The main research group studying circumstellar disks with Herschel's HIFI instrument is WISH ("Water in Star forming regions with Herschel"). It operates from the University of Leiden in the Netherlands and has a fine web site with many papers, posters and even outreach videos for non-scientists.



WISH data: Water in L1157, a protostar in Cepheus
WISH, University of Leiden

These studies suggest the early solar nebula not only has centrifugal rotation that leads to planet formation by gravitational attraction, but radial flows that mix material from the inner and outer parts of the nebula. There is stratification and transport between more central zones of the disk and the shell of the nebula, resulting in an enhanced concentration of cold water vapor and ice centrally and ice-poor dust grains in the periphery. These flows occur prior to and during the era when cometary and asteroidal bodies form. These bodies eventually bombard inner planets near the habitable zone, depositing water and other molecular species. Icy bodies closer to the early sun may have been somewhat more likely to deposit water on the young Earth (as evidenced by the hydrogen-deuterium ratio cited earlier) but the mixing demonstrated by Hogerheijde's observations and the results of the Stardust mission suggest that comets from further out in the system also contributed their water to Earth.

The constant circulation and equilibrium of water and ice throughout the maturing nebula in the era prior to planet formation seems to have provided just the right amount of water in just the right places.

Star Party Report: The Shadow Transit of Io from a Suburban Street by Larry Faltz

I took advantage of very clear skies on November 5th for some solar system observing. Jupiter's brightness easily tolerated the 9-day moon and street and house lights on my suburban block. I used my new (NEAF 2011) Stellarvue SVR-105 f/7 triplet refractor on an iOptron MiniTower mount. I started viewing about 7:45 pm, using a 5mm Nagler T6, which gave 147x. Io's shadow appeared as a tiny black dot on the limb of Jupiter, the moon itself already in front of the planet and therefore not visible. For two hours the dot moved slowly across the face of Jupiter, always overlying the South Equatorial Band. At about 9:35 a tiny bud appeared at the edge of the planet. Io separated from the limb over the next two minutes, while the black dot of the shadow remained, getting ever closer to the planet's edge. At 9:52, the dot finally reached the edge and disappeared, and Io continued to move outward.

I had e-blasted club members the night before, inviting them over to share the experience. Several WAA'ers stopped by. Steve O'Rourke from Mamaroneck brought his daughter and two 5th-grade classmates (their knowledge of astronomy was impressive), Erik and Eva Andersen came all the way over from Croton-on-Hudson, and Sharon Gould came from White Plains with her brand-new Orion 90mm Maksutov scope for a shake-out. We did some lunar observing as well and later got a look at Uranus, a tiny but clearly resolved gray-blue ball.

Just *two hours* after the event, Brian Brown of Virginia posted this image on Cloudy Nights. It was taken at 9:41 pm with a Celestron C11 Edge SCT, 2.5x Barlow and Imaging Source camera. Brian graciously gave me permission to publish the image in our newsletter. My view with a 4" scope was good, but certainly not this good!

This is a fine time to view shadow transits of Jupiter, which is nicely placed in the southeast and south each evening for the next month or two. Go to the Sky & Telescope Jupiter JavaScript utility for more information about transits and occultations. Remember to subtract 5 hours since the data is given in GMT. This means you may have to look at data for the next calendar day to find events that will happen in the evening in our time zone.

Almanac

For December 2011 by Bob Kelly

Dec 2 Dec 10 Dec 17 Dec 24

Spring is coming! Of course, here on Earth in the Northern Hemisphere, we have to get through winter first. But on Mars, the Northern Hemisphere has passed the shortest day of its Martian year and approaching spring with the equinox on March 30, 2012. Why do we care? The North Polar Cap on Mars and its associated clouds are brilliant, making Mars look like a black (ok, salmon-colored) and white cookie in our telescopes. In the morning sky, Mars is small at only 8 arc seconds wide and just getting large enough to show some details in moderate to large telescopes. In smaller scopes, Mars may show this large contrast more easily than one might expect. Look high in the pre-dawn sky as Mars crawls eastward under the paws of Leo.

So, what about our own winter solstice? By the 22nd, when the Northern Hemisphere solstice occurs at 12:30am, evening commuters and astronomers may notice that sunset is already starting to move later. The earliest sunset occurs on fourteen days ahead of the solstice at our latitude, on the 8th, thanks to changes in the time when the sun appears to reach the meridian. Morning sky fans: the latest sunrise occurs on January 5th.

We've run out of adjectives for Jupiter, high in the southern sky after dark, at magnitude -2.7 and 45 arcseconds wide. At the November *Starway to Heaven* a family enjoyed picking out more detail in the cloud belts with each glance through an eight-inch telescope. On some evenings, Jupiter's brightest moons cross the disk of the planet, trailing an ink dot of shadow, marking where the moon produces a total eclipse of the Sun on Jupiter's cloudtops. The moons seem easier to see as worlds of their own when closest to the edges of Jupiter.

The next giant planet, Saturn, gets out of the horizon haze this month, well up in the southeastern dawn sky. Saturn is within 4 to 6 degrees (the width of three fingers held together at arm's length) of similarly bright Spica. But in a telescope, Saturn's noticeable size (16 arcseconds wide, not counting the rings), and its rings tilted at an angle of 14 degrees makes it easy to tell from Spica.

Venus makes its move to get our attention in the southwestern sky this month. At magnitude -3.9 but only 12 arcseconds wide, and 85 percent illuminated, it's a small, but dazzling, blaze of light. Compare it with larger, but dimmer, Jupiter over the next few months. Mercury was Venus' companion for half of November, but quickly fell away into the glare of the Sun. In mid-December it jumps up into the morning sky, rising as early as the start of morning twilight around the 23rd. Mercury, at 7 arcseconds wide and magnitude -0.3, only gets about ten degrees above the horizon before the sky brightens up, but for the planet closest to the Sun, that's pretty good. How soon can you see it and how long into the New Year can you follow it?

Find finder charts to locate Uranus and Neptune, at their peak right after sunset. But Pluto is pretty much unfindable this month in the solar glare. Recent data shows that Eris, the object that caused a re-thinking of the question 'What is a planet', is not larger, but just about Pluto's 2,330 km diameter. But since Eris is three times further from the Sun than Pluto, this object named after a personification of strife and discord is really unfindable to almost all observers.

The reliable Geminid meteor shower peaks on the evenings of the 13th and 14th, but the just-past-full-moon wipes out the view. The Ursids, peaking on the 23rd, is a much smaller, more irregular shower, but with the thin moon, more of its fainter meteors may be visible.

Sunspots are popping up on the solar surface as solar activity increases in the new solar cycle number 24. Use safe filters on your telescope!

Usually, a total lunar eclipse would get top billing on this site, but on December 10th, we probably won't see the subtle hint of penumbral shadow that starts the eclipse. Then the moon sets, so we can't see the rest of the eclipse. 'Go west' for a better view - it's best in the far east of Asia, and Australia, but the west coast of the United States has a wonderful view of the first half of the eclipse.

The Moon passes Jupiter on the 6th, Mars on the morning of 17th, Saturn on the morning of the 19th and 20th, to the right of Venus on the 26th and above Venus on the 27th in the evening sky right after dark. You might be able to see the thin Moon in the neighborhood of Mercury on the 22nd.

The International Space Station is down to a crew of three until the next Russian Soyuz launch brings the ship's complement back to six. The ISS is as bright as or brighter than Jupiter on nights when it passes nearly overhead. It looks dimmer, but readily findable on other nights when it passes low in the sky. Passes are visible in morning twilight from now through the 7th. Then from the 14th through January 7th, heavens-above.com predicts passes will be visible in the evening.

Recipients of new telescopes as a holiday gift (or new accessories) will find all the bright planets waiting for them to explore, as well plenty of stellar and nebulous objects left from the fall sky. In addition, about 7pm, Orion rises, looking lethargic as he lies on his side in the eastern sky. Having bright objects will help the new owners to learn to aim their scopes, no matter what their skill level or amount of computerized help their scope has.

Bob Kelly has a blog at:
http://bkellysky.wordpress.com/