The ASTERISM

as' ter ism ~ a recognizable pattern of stars
con stel la' tion ~ an internationally designated area of the sky

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What's Inside…

Note: Use bookmark panel in Adobe Reader.

Rainbow Physics

By Dr. Lew Thomas

A rainbow results from the refraction of sunlight by droplets of water in the air. While we generally observe a colored arc in the sky, the compete rainbow is a circle with its center directly opposite the Sun. Of course, the Earth gets in the way and prevents a land observer from seeing this entire circle.

Photo by Karl Kaiser 10-28-02 Austria

The arc has its greatest extent just after sunrise and just before sunset. The nearer the time is to local noon, the shorter the visible arc. We can never see a rainbow at local noon since it is below the horizon. Only pilots and their passengers flying in aircraft can view a complete rainbow. It appears below the plane with the plane's shadow at its center. (Ed note: Some people call that kind of a rainbow the 'captain's halo'. Most of the people who use this nomenclature are themselves airline captains.)

So how does a rainbow form? Of course it requires rain in a direction away from the Sun and, of course, a clear Sun itself. Most droplets of rain are roughly spherical in shape. When a ray of sunlight strikes a droplet it is refracted inward, then is reflected on the far side of the drop, and finally refracted outward. But sunlight is a continuum of all colors ranging from red, to orange, to yellow, green, blue, indigo, and finally violet. Each of these colors is refracted at a different angle; red being the least refracted and violet, the most. This is illustrated in Figure 1. Note that the red ray exits from the droplet at an angle of 42 degrees with respect to the incident ray, whereas the blue ray exits at a 40 degree angle. Note, too, that in this case there is only one internal reflection.

Now there are many raindrops in a storm and we have selected just one. The illustration in Figure 2 selects two out of the many to illustrate why red appears at the top of a rainbow. Of course, since sunlight is a continuum of colors from top to bottom, the rainbow shows red, orange, yellow, green, blue, indigo, and violet.

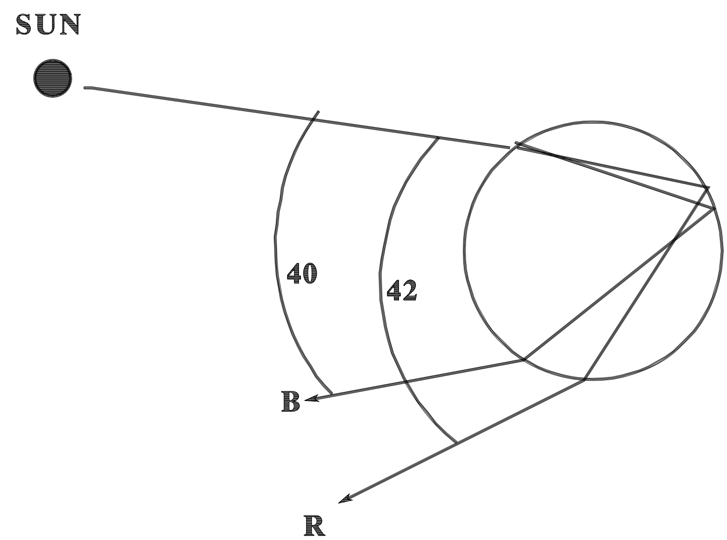

Fig. 1 Differential refraction of colors within spherical raindrops.

The Secondary rainbow

Occasionally, a second rainbow will appear above the brighter lower one. The colors are reversed in the secondary bow; red being at the bottom. This occurs when there is a second reflection within the raindrops. In that case, not all of the light exits the drop. A portion is reflected back inside. This makes its way around the interior of the drop before the red ray exits at an angle of 50 degrees. Blue light emerges at an angle of 53 degrees. This places the shorter wavelengths above the longer red ones. However, the secondary bow is dimmer than the primary one since more light is lost in the extra internal reflection. See Figure 3 on the next page for an example.

Somewhere Under the Rainbow

A brighter illumination is seen under the rainbow, and this is produced in the following manner. So far in our diagrams we have illustrated dichromatic light. But we know that all the colors of the rainbow are involved. All these colors exit below the red ray and many of these including the red rays are scattered by the atmosphere. This scattering produces white light under the rainbow. Since there are no rays exiting above the red ones, no scattering can occur above the rainbow and therefore this region is darker.

Where Do the Arcs Come From?

Sometimes, so called supernuminary arcs appear at the top of a rainbow. This is an interference effect. Some (chiefly red) rays emanating near the top of the rainbow are sufficiently scattered and remain close to each other such that, because their path lengths are slightly different, they can interfere with each other. When adjacent paths differ in length by half a wavelength, destructive interference occurs dimming the light. Along the path lengths the difference departs from half a wavelength and constructive interference occurs forming a brighter region. This occurs repeatedly along the path lengths forming bright arcs separated by darker valleys. The arcs are seen near the top of the rainbow where the brightness of the bow cannot obscure them.

All Drops are Not the Same

Naturally rain drops vary in size. Large drops of about 1 mm in diameter produce brilliant bows with well defined colors. Smaller drops around 0.01 mm make rainbows with overlapping colors which are pastel at best and even whites in some regions.

So far in the discussion, we have assumed that the rain drops were all spherical. In nature, this is not true. Tests have been performed in vertical wind tunnels which mimic the effects of the atmosphere upon falling rain drops. Drops less than 0.14 mm remained spherical in the wind tunnel while drops of 1.4 mm flattened on their windward side so as to achieve a height to width ratio of about 0.85. As the drops become even larger, the flattening increases. Clearly a rainstorm contains drops of various sizes and so a "perfect" rainbow is not possible. For a flattened drop, some of the red refraction is lost at the top and bottom of the drop. We see the rays from these drops only when viewed horizontally. Thus a brighter bow occurs near its vertical sides, particularly those bows observed near sunrise or sunset. Only the smaller spherical drops produce the rainbow at its top, and so the top is dimmer.

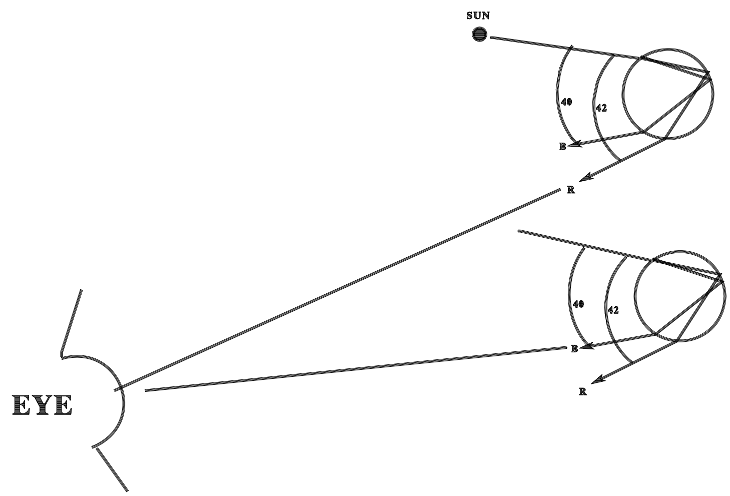

Fig. 2 Refractions from raindrops at various altitudes combine to cause red to appear at the top of the bow.

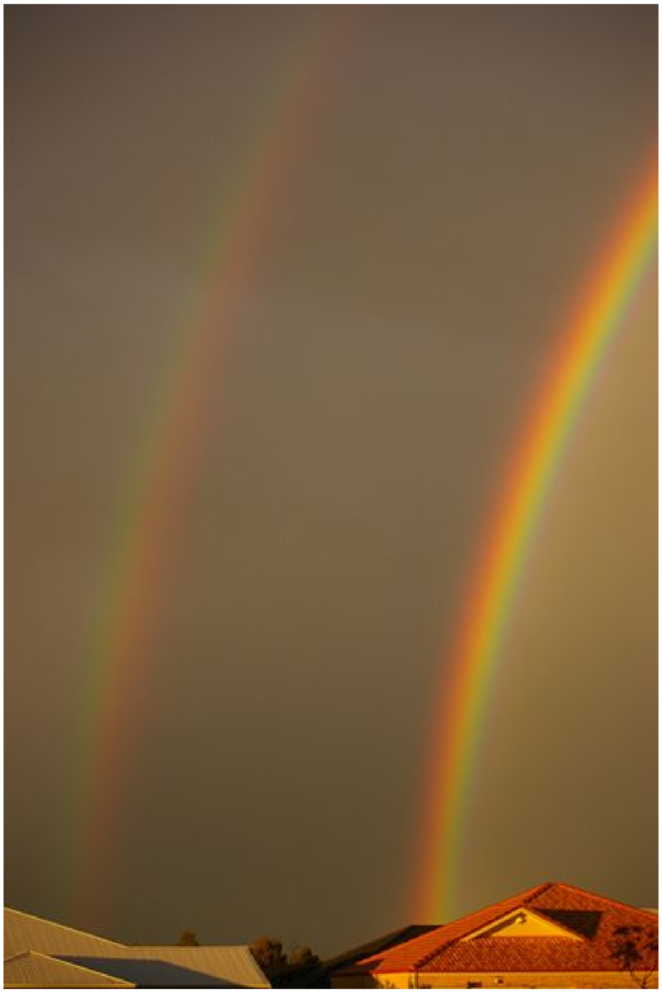

Fig. 3 A double rainbow features reversed colors in the outer (secondary) bow, with the dark Alexander's band between the bows.
source:Photo by Gnangarra comons.wikimedia.org

Rainbows are Polarized

An interesting experiment is to rotate a transparent piece of polarized material in front of your eyes while viewing a rainbow. As the piece is rotated, you will see parts of the rainbow disappear.

Distance to a Rainbow

Since the rainbow is the result of the action of rain drops, the rainbow is as far away as the rain storm.

Some are even formed by X-Rays

See an example of an X-Ray rainbow on page 8.

Any Questions?

There are probably many other questions about rainbows to be answered and perhaps our readers would like to submit these. Here's one for the reader. Why are there many more rainbows in summer than in winter? Send your questions for Dr. Lew to: editor@asterism.org

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Stewart's Skybox

by Stewart Meyers

Prompted by the International Astronomical Union's resolutions concerning the status of Pluto, a number of prominent Pluto advocates have decided to run an event in Laurel, Maryland this month billed as "The Great Planet Debate". So now might be a good time to discuss the history of the International Astronomical Union (IAU), the organization that is the arbiter of all things astronomical and which has aroused such a strong reaction in so many people.

A Perfect (Almost) Anarchy

Back in the days when astronomy was becoming a true science (the early to mid 1600's), it operated in a state of anarchy. No, this is not to imply that astronomy was violent and lawless. What it means is that astronomy was in a state where regulations and oversight were not needed. This was because there were very few active astronomers at the time, and they pretty much knew each other's work. However, there were some ground rules that were agreed on. These were basics that came from antiquity. For example, the magnitude system was pretty much standardized and many, but not all, the constellations dated from classical Greco-Roman times, as did the names of the planets. But this state would gradually start to change.

Very High Societies

As the 17th century wore on and more advances were made in the sciences in general, governments of some of the major European powers took notice. Since science had many practical benefits, these governments sought to enhance it. This was accomplished by chartering scientific societies (such as the Royal Society, officially founded in 1660 and the French Academy of Sciences founded in 1699). This gave the early scientists, including astronomers, places to meet and discuss their work in an organized manner. Also, these scientists benefited from government support. Edmund Halley could never have made his maps of magnetic variation, nor conducted his work observing stars in the southern hemisphere without the Royal Navy providing the special ship (in the case of the magnetic research) and also transportation to St. Helena for his star mapping.

This organized interaction improved the quality of science education as many members of these societies either were university professors or became them, and led to more people getting into the field. However, astronomy was still an activity of gentlemen and those who wanted to be gentlemen. The few disagreements at the time were minor and most were handled amicably, with the possible exceptions being Sir Isaac Newton's long feud with Robert Hooke, which only ended with Hooke's death and the arguments between the Royal Society and Astronomer Royal John Flamsteed over Flamsteed's star atlas.

While scientific societies operated on the national level, astronomers still were in contact with each other across national boundaries, even when international tensions in Europe were high. This networking would really start to become important in the late 18th century.

Star Cops

Despite the fact that astronomers were in France, Britain, and the countries that would later become Germany and Italy, they could quite easily relay news of their work. For instance, Sir William Herschel was well aware of Charles Messier's accomplishments and held them in such high regard that he left Messier's objects out of his own catalog of nebulae and clusters. But the story that really shows how international cooperation worked in astronomy concerns a little piece of cosmic numerology called the Bode-Titius Law.

Since this was already discussed in an earlier column, I will not dwell on it too long here. Essentially, the "law" was a numerical trick for remembering the distances of the planets from the Sun. However, this seemed to indicate that there should be a planet between Mars and Jupiter. Rather than question the validity of the "law", a group of Europe's top astronomers assembled and decided to search for this putative planet.

It was pretty much a who's who of late 18th century astronomy that composed this group that billed itself as "the Celestial Police". Sir William Herschel was invited to join, but did not, though he did help in organizing it. Other notables involved were Heinrich Olbers, Johann Schroter, and a relatively obscure Sicilian astronomer/exiled priest by the name of Giuseppe Piazzi was on the list to be invited. The plan was for each member of the group to select a 15-degree stretch of sky along the ecliptic, create a chart, and look for anything that moved. However, in January of 1801, Piazzi got results before the planned search even started - in fact, his invitation to join the Celestial Police was still in the mail - by discovering Ceres. However, the effort did not go to waste since some searching did take place and resulted in the discovery of several other asteroids until the group disbanded in 1815.

In 1821, H.C. Schumacher, a German astronomer working at Altona Observatory in Denmark (at the time - the town of Altona would later become part of Germany), decided to improve the international flow of astronomical information by founding Astronomische Nachtrichten (Astronomy Notes), the world's first international scientific journal for astronomy. Interestingly enough, Astronomische Nachtrichten is still being published and is now owned by Wiley Publishing. The first edition appeared in 1823 and it only ran papers from German astronomers. But, by 1827, it was publishing papers from astronomers all over Europe.

Doing The Confusion

One problem when there is no central oversight is that things can get confusing when several people have their own ideas about how things should be done. This was not a new problem as there was quite a bit of confusion over how to name lunar features in the late 1600's. Fortunately for science, there were not too many lunar astronomers and the problem was quickly resolved when Riccioli's system of naming features on the lunar surface became popular. Instead of naming craters after royalty or other things, Riccioli named them after famous astronomers and scientists, with more ancient ones generally in the northern hemisphere and the more recent ones in the southern hemisphere. However, there were other, more serious issues.

As asteroids were being discovered, there was considerable disagreement over how they should be classified. It seemed that every major reference source in the mid-1800's had its own opinion on the matter. Some encyclopedias and astronomy books considered all asteroids to be planets. Others considered only some to be planets, and yet others stayed out of the argument altogether. But eventually, this matter was settled by gradual consensus as the number of asteroids kept growing.

But there was yet another confusing issue. When Hipparchus composed his star catalogue in ancient Greece, there were 48 constellations. These stood the test of time and were accepted almost without question ever since. As Europeans started exploring the southern hemisphere in the 16th century, they found stars that were never seen by the Greeks or other classical cultures. It was pretty much a free-for-all, with various astronomers coming up with their own constellations. Many of these did not catch on, but some did and eventually the southern skies were charted.

But constellation confusion was not limited to the southern skies. There were many stars in the sky that, while visible to the unaided eye, were dim. Some of these were organized into constellations in classical times, but others were what could be called unincorporated, as the ancients did not feel they were worth bothering with. Atlas makers and astronomers started creating their own constellations using these stars. Some, like Bufo the Toad and Apus the Bee, were dismal flops. Scutum the Shield, however, caught on and still exists today. And there was one atlas maker, Julius Schiller, who decided that the whole sky needed a makeover and, in 1627, replaced all the constellations with new Christian ones of his own devising as well as coming up with new names for the planets. Fortunately, this never caught on and was largely forgotten. However, a small number of extreme Christian fundamentalists latched onto and still support Schiller's constellations.

Then there was the boundary issue. The ancient Greeks never really formalized the boundaries between constellations. But since there was a good amount of space between the brighter stars that defined the constellations, boundaries were never considered an issue. Atlas makers were pretty much free to put the boundaries wherever they saw fit, usually making sure to leave enough room for the elaborate mythological artwork they drew around the stars of the constellations. However as astronomers started studying fainter and fainter stars, it became confusing to determine in some cases what constellation a dim star was in.

The Yankees Get into the Game

You might have noticed that American astronomy has so far not been mentioned in this article. Is this a simple oversight? Deliberate snub? No. The reason is that astronomy took longer to achieve major status in the United States. For instance, John Quincy Adams spent his presidency trying to establish a national observatory. After he left office, the US Naval Observatory was established, but its primary function was to calibrate ship chronometers and improve charts used in celestial navigation. Astronomy was a secondary concern.

Of course, American astronomers made discoveries in the 19th century. The satellites of Mars and some milestones in astrophotograpy are prime examples. But, American astronomy and science were still held in low regard throughout the world.

As the 19th century drew to a close, American astronomy was slowly gaining stature. To aid this goal, the American Astronomical Society (AAS) was founded in 1899. It had a number of prominent members such as Edward Pickering and George Ellery Hale. In 1916, the AAS weighed on the question of adopting daylight savings time since Woodrow Wilson's administration proposed it in the belief that it would save coal that would be needed when the United States got into World War I. The first vote went 8 in favor, 7 against, and 14 abstentions. The second vote went against the idea 22 votes to 18 with 6 not voting and the AAS made some arguments against the idea of daylight savings time. But as is typical in the United States and much of the world, nobody listened to the astronomers and the rest is history.

One accomplishment of the AAS that is relevant to this story is that it inspired Hale to set up a group initially called the International Union for Cooperation in Solar Research in 1904. The group soon became known as the International Solar Union and was a coalition of prominent astronomers (mainly solar, but a few from outside the field as well). They had set up a policy where the ISU would meet every three years in different venues. At their meeting in 1910, they adopted a system of classifying stars by spectral type that was devised by Annie Jump Cannon. This system was soon adopted by all astronomers and it forms the basis of our modern spectral class system. The ISU also had a role to play in the rise of organization in the world of astronomy.

Astronomical Convergence

Even the incredible growth of astronomy in the 19th century and the growing need for oversight were not enough to change the old ways of doing things. What did bring about the change were three major scientific projects and two disasters. In 1887, the director of the Paris Observatory, Admiral Ernest Mouchez, along with Scottish astronomer Sir David Gill had an idea that seemed extraordinarily brilliant at the time. Astrophotography got to the point where it could record stars fairly well. So, it was natural to propose that astrophotography be used to create the next great star catalogue. This was the start of the soon-to-be infamous Carte du Ciel (Star Chart) project. Unlike the excellent freeware of a similar name (Cartes du Ciel), this project was seriously flawed and ran into problems almost immediately. The photographic telescopes were of a special design and rather inconvenient to use. Then, all the plates had to be inspected and measured by computers. Back in those days, the term computer did not refer to a machine such as a large number-crunching supercomputer or the machine that you are reading this article on. It meant a human being, usually a woman, who was a low-paid mathematical worker. Naturally, this took time. Lots of time. The first observatory in the project that finished its part of the job (an observatory in Algeria) did so in 1919. The rest took much longer. In 1958, the project was officially abandoned, though almost all who were involved in the project had given up well before then, and some of the resulting observations formed the Astrographic Catalogue, which has had some practical use for astrometry. For European astronomy, the Carte du Ciel project was a major disaster. By diverting their resources and efforts into this failure, many European astronomers missed out on the astronomy's switch in emphasis to astrophysics. On the other hand, American astronomers who never were involved in Carte du Ciel, hopped on the astrophysics bandwagon and put American astronomy on the map.

The International Solar Union, mentioned in the last section, proved that it was possible to set up an organized international group of astronomers and actually accomplish some things.

The last project of the three was called the International Time Bureau. Created by Benjamin Baillaud, a prominent French astronomer, in 1912, the International Time Bureau had the goal of setting time standards for science. Unfortunately, before the Bureau could do much of anything, 1914 came along and with it, World War I. As anyone who knows even a little history knows, the effect on Europe was disastrous. Even the scientific community was not spared as Germany drafted some scientists into the frontline infantry (noted astronomer and physicist Karl Schwarzchild died on the Russian front in 1916). But, the end of the war set the stage for the next part of the story.

Birth of the IAU

After World War I, there was a renewed spirit of cooperation. It was in this climate that Woodrow Wilson proposed the League of Nations and it was implemented. Something similar happened in astronomy. The astronomers who were in charge of two of the international projects mentioned earlier in this article decided to join with the International Solar Union. The new, combined organization drew up a charter in 1919. This was the IAU Charter and Benjamin Baillaud who was involved in the Carte du Ciel project as well as president of the International Time Bureau was appointed the first president of the new organization.

However, the spirit of cooperation that was embodied in the early IAU had limits. Since most of the founding astronomers were French, they harbored considerable resentment towards Germany as a result of World War I. As a result, German astronomers were banned from the IAU until 1928.

The IAU's reputation for slow action was established early. Its first notable achievement was resolving the constellation issue once and for all. In 1928, after long study, the IAU decided that there would be only 88 constellations and it set the boundaries for them. A Belgian astronomer, Eugene Delporte, was assigned to plot the new boundaries on star charts, a task he completed in 1930.

Inner Workings

The IAU (http://www.iau.org) follows many of the conventions set by the International Solar Union, mainly the triennial meeting schedule at different locations. However, the IAU does have a permanent headquarters (office of the IAU Secretariat) located at the Institut d'Astrophysique in Paris. Membership of the IAU is divided into two types. In a holdover from the International Solar Union, there are national members who represent their nations at the IAU and belong to a major organization in their own country. There are 65 national members. Then there are individual members. Individual members must hold at least a PhD, be active professional astronomers, and have the endorsement of the national member from their particular country. There are currently 9,658 individual members. The distinction between these two types of members comes up in voting. National members vote on budgetary issues and changes in IAU rules only. Scientific matters, like the infamous IAU Resolutions 5A and 6A (the ones concerning Pluto's status), are voted on by the individual members only.

To accomplish its goals, the IAU is divided into 12 Divisions (I to XII), each covering a broad category of astronomy, such as variable stars and radio astronomy. In the organizational level below the divisions are 40 Commissions. Some of these are well known to amateurs such as Commission 6 (which reports to Division XII), which is better known as the Central Bureau of Astronomical Telegrams and handles reports of comet discoveries. And at the lowest level are 72 Working and Program Groups. These are responsible for handling specific tasks over a set time period and report to specific Commissions, Divisions, or the IAU Executive Committee.

In addition to the triennial General Assembly meetings where most IAU business is decided, there are three symposiums each year. These are where IAU members who are working on specific aspects of astronomy meet and present papers on a specific topic.

Balkanization

Despite having served astronomy reasonably well for almost 90 years, some Pluto advocates have suggested that, if the IAU doesn't agree with their opinion on a minor issue, another group should be created that will agree. Such a move would only be bad news for astronomy.

As things stand now, the IAU has sole jurisdiction of naming comets and asteroids, as well as publishing their orbits. Suppose there was a rival organization. If someone were to discover a comet, who would be in charge of handling the discovery? Would it still be the IAU, or would the upstart group step in? Would there be questions over which group oversees what? With the way things are stacked against astronomy in today's society, such disunity would do far more harm than good.

However, that is not to say that the IAU does not have problems. It is extremely slow to respond to events. The insistence on transacting the bulk of their business by gathering as many of their members who can travel to some far-off locale for a meeting only once every three years is not a good way to run anything. Also, the IAU, especially the commission that handles nomenclature, seems to believe that everyone in the world who matters is a college or university professor, especially when newly discovered Kuiper Belt Objects are named after obscure tribal deities, such as Make-Make and Sedna, that are known only to ethnology experts. This generates the impression that the IAU is a rather conceited and elitist organization.

But, the way to fix the problem is not with a rival group. A better solution would be to follow historical precedent. After the Revolutionary War, the United States based its government on the Articles of Confederation. While this may have been a smart move early on, the Articles soon proved inadequate for the task of governing the new country. Instead of setting up a rival government, a convention was called to overhaul the Articles, if possible. The result of that convention was the creation of the US Constitution out of the wreckage of the Articles of Confederation. What I suggest is that, in the 2009 IAU General Assembly in Rio de Janeiro, the IAU should enact a sweeping series of reforms to bring the organization into the 21st century and address its faults.

One improvement would be to expand the base of members. Instead of limiting memberships to observatories (national member level), astronomers, and astrophysicists, it should be open to space agencies such as NASA, the ESA, and their Russian, Chinese, Japanese, and Indian counterparts as well and space scientists working for those agencies. This would greatly broaden the IAU membership and address one of the major gripes of Pluto advocates.

Also, three years is simply too long to go between meetings in this day and age. Instead, the IAU should have an annual meeting to settle issues. This would greatly increase the ability of the IAU to respond to new discoveries.

Naturally, with the large number of members, assembling all of them for meetings would be difficult. Fortunately, there is a solution. The IAU should operate as a representative system with one representative for a set number of members. These representatives should be directly elected by the membership, as should the IAU executive board members and president. With a manageable number of representatives, it would be easier to host meetings. Of course, IAU members who have a concern about an issue should be allowed to come to these sessions and present it before the full body of representatives and officers.

In order to shake the image of being an elitist group, the IAU should revamp their system of nomenclature to consider names that would be more acceptable to the tax-paying public who finance much of astronomy these days. For example, the IAU could have decided to name features on Saturn's satellite Mimas after characters and places in the "Star Wars" mythos since Mimas does bear an uncanny resemblance to the Death Star. Instead, they chose Arthurian mythology which most people know only in a highly distorted form from either watching "Monty Python and the Holy Grail" or by watching the final season of "Stargate SG-1". To make the change possible, the IAU should press for official legal exemption from copyrights. This is not unprecedented since the Internet Archive (http://www.archive.org) already has such an exemption.

Another reform should be that the IAU's authority on astronomical matters have the full weight of international law. That would give the IAU the necessary clout to shut down organizations like the International Star Registry for good. There should also be a mechanism for disciplining any IAU member who commits infractions of regulations.

These reforms would change the IAU into a much more responsive organization ready to face the world of 21st century astronomy.

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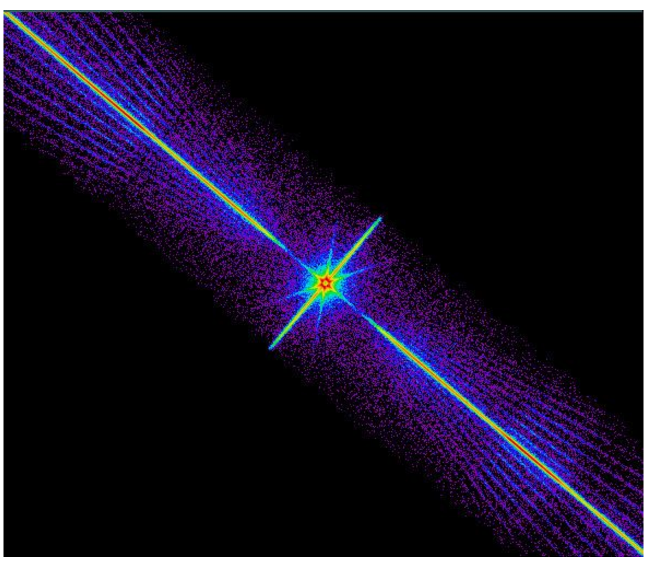
X-Ray Rainbow



Credit: J. McClintock et al. (CfA), CXC, NASA
http://antwrp.gsfc.nasa.gov/apod/ap020928.html

Astronomy Picture of the Day September 28, 2002

A drop of water or prism of glass can spread out visible sunlight into a rainbow of colors. In order of increasing energy, the well known spectrum of colors in a rainbow runs red, orange, yellow, green, blue, indigo, violet.

X-ray light too can be spread out into a spectrum ordered by energy ... but not by drops of water or glass. Instead, the orbiting Chandra X-ray Observatory uses a set of 540 finely ruled, gold gratings to spread out the x-rays, recording the results with digital detectors. The resulting x-ray spectrum reveals much about the compositions, temperatures, and motions within cosmic x-ray sources. This false color Chandra image shows the x-ray spectrum of a star system in Ursa Major cataloged as XTE J1118+480 and thought to consist of a sun-like star orbiting a black hole. Unlike the familiar appearance of a prism's visible light rainbow, the energies here are ordered along radial lines with the highest energy x-rays near the center and lowest energies near the upper left and lower right edges of the image. The central spiky region itself is created by x-rays from the source which are not spread out by the array of gratings.

Contacts & Schedules

EMAIL CONTACTS

president@asterism.org
President of AAI

editor@asterism.org
Editor of *The Asterism*
Ray Shapp, Editor
Deadline for submissions to each month's newsletter is the first Friday of that month.

membership@asterism.org
AAI Membership Chair

trustees@asterism.org
All three Trustees of AAI

ray@asterism.org
Ray Shapp for the website

exec@asterism.org
Executive Committee plus Trustees

QOs@asterism.org
All Qualified Observers

Info@asterism.org
AAI president, corresponding secretary, and computer services chair

research@asterism.org
Research Committee

technical@asterism.org
Technical Committee

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DOME DUTY

August 22	Team A
August 29	Team B
September 5	Team C
September 12	Team D
September 19	Team E

FRIDAYS AT SPERRY

August 22, 2008
Open Star Clusters: A Journey Through the Galaxy Mary Ducca

August 29, 2008
"Ask Dr. Lew" Dr. Lew

September 5, 2008
"What's Up? A Down to Earth Sky Guide" Kathy Vaccari

September 12, 2008
Space Missions Updates Ray Shapp

All schedules above were accurate at time of publication. Please check www.asterism.org for latest information (click on "Club Activities")

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DR. LEW'S SEMINARS

See Dr. Lew Thomas for possible up-coming seminar topics.

(Choice of topic at Dr. Lew's seminars is determined by participants' interest)

Special thanks to Gordon Bond for the "Theater in the Sky" page design.

☆☆☆

Special thanks to Justin Shapp for the design of the masthead and other graphics.

☆☆☆

Theater in the Sky

by Ron Ruemmler

September 2008 finds a still difficult Venus very low in the west guiding us to a whole host of slowly departing evening objects. After dark, only Jupiter satisfies the planet hunters.

The first evening of the month introduces the characters for a full month of challenges. Look very low in the west just after sunset for **Venus** and the extremely thin crescent Moon. The brilliant planet is to the right and slightly above the Moon. Both objects will set well before the end of twilight. If you catch them, take binoculars and look for **Mercury** just above the midpoint between the Moon and Venus. Finally, directly above the Moon and forming an equilateral triangle with the Moon and Venus, look for **Mars**. The Red Planet may not be visible until the other players have almost set.

Mars and Venus move toward each other for ten days passing within a third of a degree on the 11th. At 1.7 magnitude, Mars is at its dimmest of the year. At magnitude -3.9, Venus is 170 times brighter than Mars which, for all practical purposes, will soon be invisible until next spring.

September Sky Calendar

1 Mon 7:27pm Sunset; If Moon becomes visible, Ramadan begins
1 Mon 8:30pm Mercury, Venus, Mars, and the Moon have all set; look earlier!
3 Wed 9:00pm Saturn passes beyond the Sun into the morning sky
7 Sun 10:04am First Quarter Moon
9 Tue 9:00pm Jupiter upper right of Moon
11 Thu 12:00am Mercury at maximum elongation from the Sun
11 Thu 8:00pm Mars one-third degree below Venus
12 Fri 10:00pm Uranus at opposition from the Sun; "visible" all night
15 Mon 5:14am Full Moon
17 Wed 8:00pm Attractive Mercury-Mars-Venus-Spica formation
22 Mon 1:05am Last Quarter Moon
22 Mon 11:44am Autumnal equinox; Fall begins
26 Fri 6:50am Thin crescent Moon just to right of Regulus
27 Sat 6:50am Very thin crescent Moon to right of Saturn
28 Sun 7:20am Extremely thin Moon (21 hrs before New) far below Saturn
29 Mon 4:12am New Moon

Mercury began shadowing Venus since the beginning of last month, and it will continue doing so for most of September. On any evening, when you can find Venus, look a few degrees to the lower left for Mercury. In contrast to Mars, Mercury is nearly zero magnitude and may be visible without optical aid.

An amazing pattern appears on the 17th. Venus is at the top of a perfect baseball diamond, with Mercury at home plate, Mars is at first base, and the star, **Spica**, is at third. The bases are about five degrees apart.

Don't forget to check to the south for **Jupiter** any time before midnight. The Giant Planet and Venus will march toward each other for three months heading for a wonderful conjunction at the very end of November. After disappearing agonizingly slowly from the evening sky, Saturn passes behind the Sun on the 3rd, and then jumps quickly into the morning sky by the end of the month. Look for it on the 27th near the very thin crescent Moon.

The outer gas giants, **Uranus** and **Neptune**, are both at their most visible for the year, above the horizon for most of the night.

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