Winter 2009/10
Issue 88

# BPAA Quarterly

Battle Point Astronomical Association
www.bpastro.org Bainbridge Island, WA

## Events Calendar

(Unless otherwise noted, all events are at the Edwin Ritchie Observatory, Battle Point Park)

### DECEMBER

December 2 ○
7 p.m. BPAA Board Meeting

December 6
John Rudolph Memorial Planetarium Fund Kiwanis Brunch, Wing Point

December 8 ◑

December 12
7 p.m. "The Stellar Circle of Life," Planetarium Show and Star Party

December 13
Geminids meteor shower peak

December 16 ●

December 19
7:30 p.m. Member's Meeting

December 21
Winter Solstice (9:47 PST)

December 22
Ursids meteor shower peak

December 24 ◐

December 31 ○ ('Blue Moon')

### JANUARY

January 3
John Rudolph Memorial Planetarium Fund Kiwanis Brunch, Wing Point

January 7 ◑
400th Anniversary (1610) Galileo Galilei's discovery of Jupiter's moons

January 9
7 p.m. Planetarium Show and Star Party

January 13
7 p.m. BPAA Annual Meeting & board election; open to all members

January 15 ●

January 16
7:30 p.m. Member's Meeting

January 23 ◐

*Calendar con't page 2*

## Bright Stars and Blue Moon

*The Constellation Orion from* Uranometria

CALENDAR NOTES: The brightest stars shine in the winter sky. Capella, Betelgeuse, Rigel and Sirius are standouts, along with those beautiful and familiar constellations of winter, Cassiopeia, Orion, and the Pleiades. The Big Dipper stands on its handle all winter long and serves as a guide to many familiar star patterns.

Mars is the planet to follow this winter. During December Mars doubles in brightness. Look for Mars early in the month in Leo, and near Cancer later in the month. Opposition occurs on January 29, 2010. Opposition is the best time to observe a planet since it is visible almost all night and at this point of its

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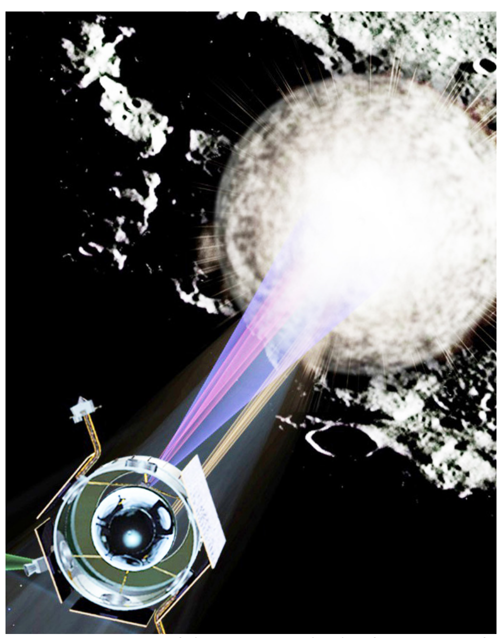
## LCROSS

### or, Why did I get up at 3:30 in the morning?



*Artist's conception of the LCROSS shepherding spacecraft viewing the impact caused by the Centaur booster. Trust me, the plume wasn't that big.* (Courtesy NASA)

On October 9th at about 4:35 PDT The Lunar CRater Observing and Sensing Satellite (LCROSS) mission slammed into the surface of the Moon. The mission used the spent upper stage of a Centaur rocket to create debris and a shepherding craft to analyze it.

The intent was to confirm the presence or absence of water ice in a permanently shadowed crater at the Moon's south pole.

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January 29
Mars at Opposition

January 30 ○

**FEBRUARY**

February 3
7 p.m. BPAA Board Meeting

February 5 ◑

February 6
7 p.m. Planetarium Show and Star Party

February 7
John Rudolph Memorial Planetarium Fund Kiwanis Brunch, Wing Point

February 10
Deadline for Spring issue of BPAA Quarterly

February 13
7:30 p.m. Member's Meeting

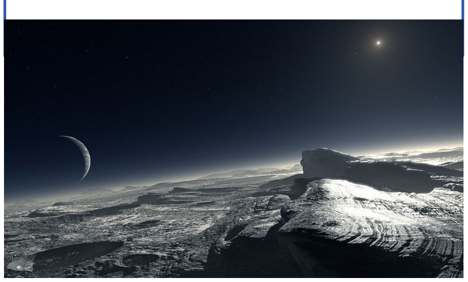
February 13 ●

February 18
80th Anniversary (1930) Clyde Tombaugh's discovery of Pluto

February 21 ◑

February 28 ○

Any member who is planning to observe can invite others to join in by sending an e-mail to *bpaa@yahoogroups.com*. To join our e-mail group, send an e-mail with your name to *bpaa-owner@yahoogroups.com* and we can enroll you. If you want to have web access to the messages and files, you can join the Yahoogroups by clicking the register link for new users on *http://groups.yahoo.com/*. Request to join at *http://groups.yahoo.com/group/bpaa/*.The system will send us a message, and we'll approve your request after we verify membership.



*Artist's Image of the surface of Pluto (courtesy ESO)*

CALENDAR, con't from p.1

*Mars (courtesy NASA)*

orbit is closest to Earth, making it appear bigger and brighter. On New Year's Eve, we will experience a so-called 'Blue Moon,' the second full Moon in the same month.

Winter also brings us meteor showers. I'm not at all sure why I continue to mention winter meteor showers in this column. I am unable to recall the last time I actually witnessed a meteor shower from my back yard in the winter. It's rather like Linus in the pumpkin patch waiting for the Great Pumpkin to arrive. Do I really imagine the skies will clear for a glimpse of the showers? For those of you with Linus-like proclivities, give it a try on December 13, when the Geminids meteor shower peaks. Look in the northeast after midnight and you will allegedly see 60 meteors per hour. The Ursids shower peaks on December 22, but only at 10-15 per hour.

Join us for our member's meetings on December 19, January 16 and February 13. The member's meetings are on Saturday evenings, starting at 7:30 p.m., one week after the planetarium shows and public star parties.

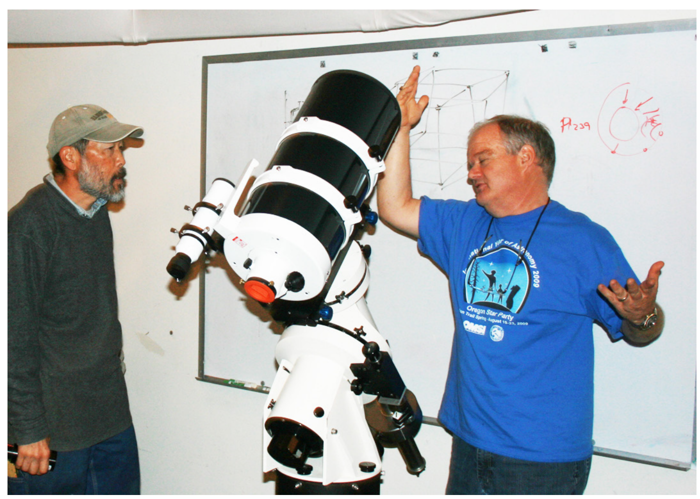
The format is informal, providing members with an opportunity to share their experiences, seek advice from experienced astronomers, and simply socialize and get together.

Oh, and there will be the occasional work party, for Observatory projects that need to get done. If the skies are clear, members will be able to star gaze with their

**It's rather like Linus in the Pumpkin Patch waiting for the Great Pumpkin to arrive.**

own telescopes, or with club-owned telescopes, of which there is now quite an array.

And don't forget BPAA's Annual



*Doug Tanaka and Steve Ruhl discuss hardware at a BPAA Member's Meeting.*

Meeting on January 13. This meeting is for all members and includes election of officers.

Please note that the planetarium shows will start at 7:00 p.m. in December, January, and February. We're sticking with the later start time to accommodate both visitors and volunteers who find the later time easier to fit into their schedules.

*—Diane Colvin, BPAA Events Manager*

# Preserving Battle Point Park's Dark Sky

PRESIDENT'S MESSAGE: I just returned from a three-week tour, mostly by train, of Europe. And like most astronomers who travel in Europe, I noticed immediately the effects of dense population and the resulting light pollution. Most Europeans have never seen the Milky Way. But unlike most of Europe, much of North America still has a night sky to protect. Even in the Seattle area and especially in parks like Battle Point we have a chance to save what little dark sky we have left. The Bainbridge Island Metropolitan Park & Recreation District board is currently in the process of developing a Master Plan for Battle Point Park that could affect the amount of light pollution in the park and our use of the park as a viewing site.

*Earth at Night (courtesy NASA)*

The good news is that Bainbridge Island does have local light pollution ordinances. Also, it appears that most members of the current Park board are not in favor of night lighting in the park—at least that is what they stated at a recent board meeting. This does not mean that there will be no attempt to bring lights into the park. It will happen, if not during this current planning process, certainly in the future. And that is why it is important that every BPAA member be prepared to attend any public meetings where the issue of lights in the park is under consideration. We also must as members be prepared to write letters to local newspapers in opposition to any lights in the park that might destroy the best chance many Bainbridge Islanders have to see and learn about the night sky. Lights would also change the neighborhood surrounding the park, increasing noise and traffic.

Where will the threats to our local night sky come from? There may be requests from soccer groups to increase field time on the recently expanded and improved soccer fields. After all, hundreds of thousands of our tax dollars were used to install these fields. Proponents could argue that failing to maximize use of the fields wastes tax money. The roller hockey group could also request lights at night. Or, how about a skateboard site complete with lights?

It has been suggested by park staff that an outdoor permanent stage facility be installed using the Ritchie Observatory as a backdrop and the elevated ground to the north for seating for concerts and other entertainment. This may sound okay, and in fact events like these have been held for the past several summers. But then it was further suggested that nighttime concerts could be held, complete with laser lights I guess. Using the stage for outdoor movies was also mentioned. The two latter uses would prevent the use of our Observatory and the surrounding ground for viewing on nights when these events were being held.

It has been suggested by some that we should compromise and agree to lights on certain nights. Sounds fair to a non-astronomer, but we can't predict when a clear night, or a significant astronomical event, will occur and therefore this is a non-starter as far as I am concerned. Others have suggested that we trade our "dark sky nights" for permission to install a sundial or funds for a rest room or other improvements to the Ritchie Observatory. I don't feel the BPAA should ever agree to trade away "dark sky nights" or agree to lights of any kind at Battle Point Park. We should stand on principle to protect the environment from light pollution for astronomers, for the neighbors who live near the park, for anyone who wants to enjoy the night sky, and for future generations.

The final public meeting on the Battle Point Park Master plan is scheduled for December 15, at 7:00 p.m. at Bainbridge Commons. More information is available on the Park District's Web site *www.biparks.org.*
*—Harry Colvin, BPAA President*

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It's possible to create rocket fuel from water by separating the oxygen and hydrogen, a key stepping stone to Mars and beyond. The mission grew out of the Lunar Reconnaissance Orbiter (LRO) program, slated to map the moon in high detail for the next series of moon missions. When NASA upgraded to a larger rocket for LRO, LCROSS made use of the excess capacity.

## Great Expectations

After the success of the Deep Impact and the multiple impacts into Jupiter, NASA put the publicity machine in full gear for LCROSS—all night star parties at Ames, press-kits and "LCROSS Impact Party Toolkits." They claimed that the impact should be visible with a moderate size amateur telescope (8" and up).

After missing Deep Impact, and Levy-Shoemaker hitting Jupiter, I just had to see this. On the evening of October 8th, I got the telescope out, calibrated it, and set the alarm for 3:30 a.m. NASA said that the ejecta plume should be several kilometers high and about 5 arc-seconds in size on earth. A decent telescope should be able to split a double star of about 1 arc-second, so I expected to see it, though I would have to be ready and looking in the right spot.

## The Impact

The Northwest weather conspired against me. On the morning of October 9, conditions were marginal with a lot of moisture in the atmosphere. I opted to view the impact via the Web. Watching the video from the shepherding spacecraft, I could not see the ejecta plume. I have since watched other videos, most notably the one from the 200" Hale Telescope (Palomar). Now this telescope is a little bit bigger than mine and they have adaptive optics to compensate for atmospheric distortions. If anyone could see it on Earth, they could. Zip. Zilch. Nada. Nothing. I didn't see a thing and no one else did either, though I have heard claims.

After reviewing the videos from the shepherding spacecraft, I can now see the ejecta plume —but only after seeing it in the infrared first. It is barely apparent in the visible spectrum to a telescope that is about 300 km from the impact site. After looking over the stream of propaganda generated by NASA, it's obvious that what was publicized by NASA was the upper limit of what was expected.

## A Digression into Impact Crater Research

One of the things that got me out of bed at 3:30 a.m. was my past experience with impact craters.

In one of my first professional jobs, at a place called Physics International, my group worked with NASA to study impact craters. There was a lot known about the motions of nuclear craters, but not much about the motions of impact craters. We were attempting to take an empirical model for nuclear cratering, called the "Z-Model," and determine if it could be used to predict the motions of impact cratering. To evaluate the model, we did a detailed finite-difference calculation of an impact and analyzed the motions in the calculations against those predicted by the Z-Model.

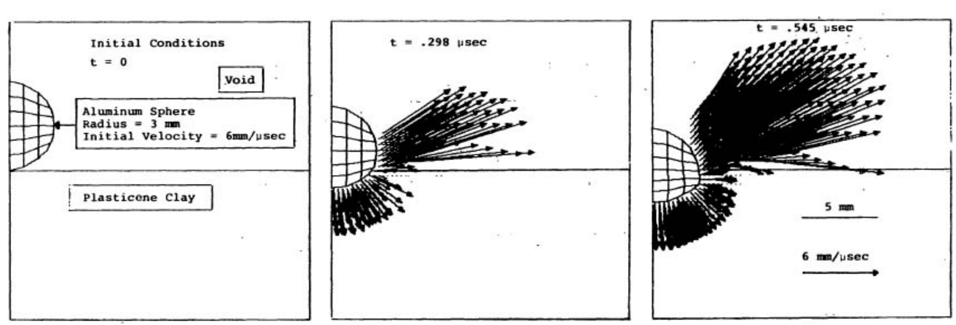
Peter H. Schultz was our technical liaison with NASA. Now, Pete is Professor of Geological Sciences at Brown University. A recognized authority, he's been researching impact craters for years.

He was a principle investigator for the Deep Impact space probe that crashed into the comet Tempel 1. You've seen him on NOVA, the Discovery Channel, or the Science Channel talking to Neil deGrasse Tyson about impact craters or the Deep Impact mission. He was on the committee that determined the impact site for LCROSS and predicted the LCROSS impact.

Back in 1979, Pete worked for NASA's Lunar & Planetary Institute. He had us validate our calculation with experiments at the NASA-Ames Vertical Gun (AVG). The AVG was established as a national facility in 1979. We were the first to use it.

### Calculations and Tests at the AVG

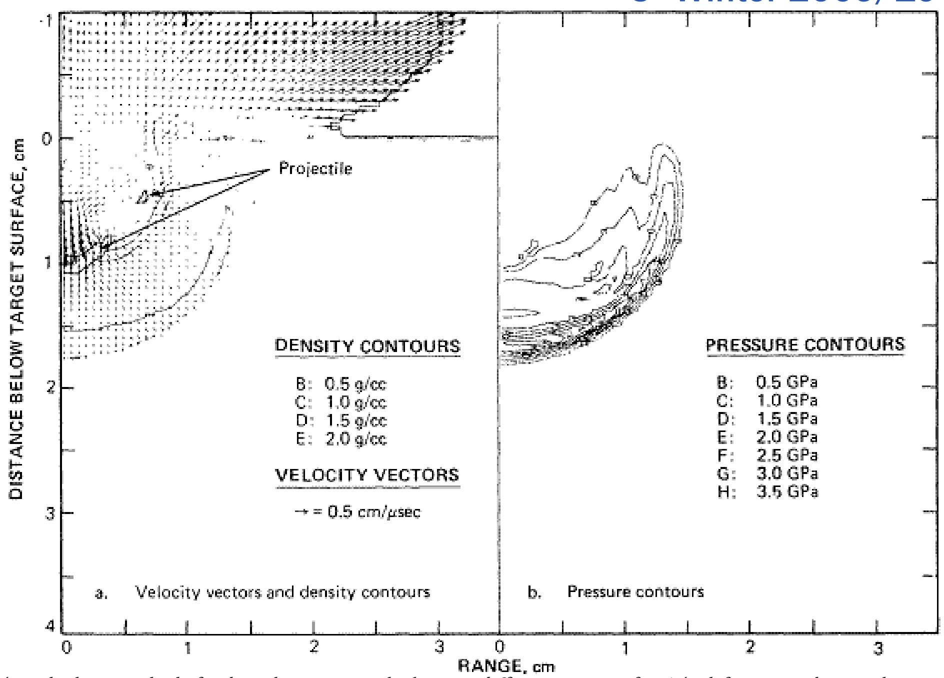
Being the most junior and the cheapest labor, I got to do the calculation and conduct the tests at the AVG. The more senior folks looked at the calculations and wrote the papers.



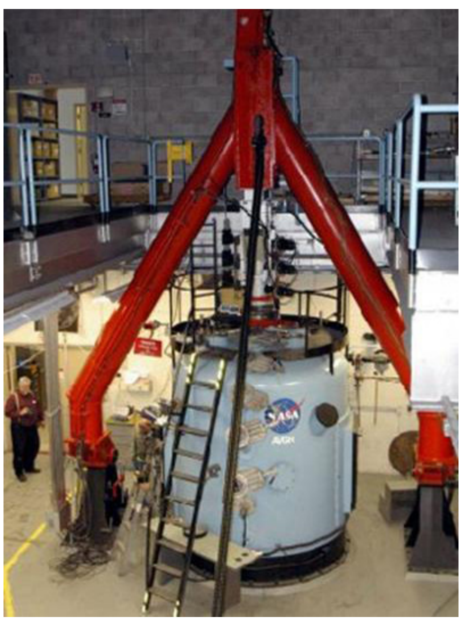

*Initial and velocity vectors of early motions*

The calculation was set up to mimic the optimal conditions at the AVG— a ¼" aluminum sphere traveling 6 km/sec into modeling clay. These calculations ran overnight on the biggest computers of the day. The next morning, I would get the results, make adjustments to optimize the solution and put it in for the next night. I kept on repeating this process, ad nauseam, until everyone declared victory, the energy had dissipated, the velocities were not significant, or I ran out of computer time.

Once we completed the calculations, we looked at how the data differed from the predictions of the Z-Model. This is most of what




*The calculation a little further along. We are looking at different aspects of it. The left picture shows velocity vectors and the density of the material around the developing crater. The right picture shows the progression of the shock wave through the target.*



*NASA Ames Vertical Gun in firing position.*

is reported in the papers in the bibliography. It was supplemented with small-scale half-buried high-explosive sphere experiments and other calculations.

### Firing the AVG

'Running' the tests might be a misnomer. I lugged the targets around (we used a lot of clay), kept a log, got the targets into the chamber and waited for the chamber to get down to the appropriate vacuum. After the shot, I got to clean up the mess and set up the chamber for the next shot. We did the same shot over and over, trying to get it right.

When the gun fired my projectile at 6 km/s, many things had to occur at the right time. I needed:

1. A good load. This was not your standard rifle. This was a light gas gun that had a power charge, a hydrogen load, a sabot to hold the projectile, and used shock-tube physics to accelerate the projectile.
2. A well-timed shutter on the gun. After the gun was fired, the only thing that I wanted to hit the target was the projectile. A shutter at the end of the gun kept the combustion products from reaching the target.
3. A good, well-timed camera run. The high speed camera ran 8000 frames per second. It went through a roll of film pretty fast.
4. A good, well-timed set of flashbulbs. The camera was not much use if I couldn't see the crater formation.

All of these issues bit me. The projectiles were too slow. The shutter fired early, slowing the projectile and damaging the gun, or late, covering the target with black power and other things. The film broke .

Eventually, we overcame these issues and got good results. Some of our work is still cited in current papers.

Pete is still using the gun. Recently, I saw him on TV using the AVG to shoot projectiles into clear blocks of Lucite. He was watching the formation of the crater. Sounds familiar.

Most recently, Pete has used the AVG to verify the predictions of the LCROSS mission. See http://www.nasa.gov/mission_pages/LCR OSS/multimedia/vertical_gun.html. You can see Pete's explanation of what happened to LCROSS at ttp://www.youtube.com/watch?v=mqKoQ6EQKn0, about halfway through. I agree with what Pete says in the video but I think there is more to it.

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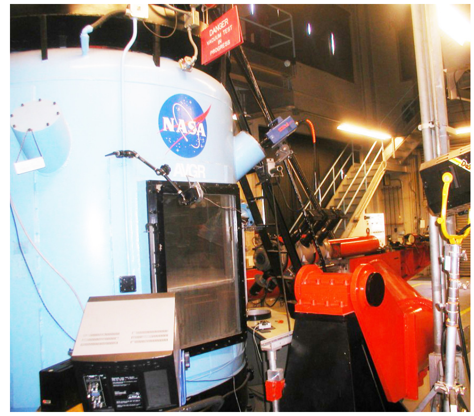
## LCROSS Results

Pete inside the AVG test chamber after a shot. This one is sand. One of my jobs was to clean up this mess and get it ready for the next shot.



The AVG test chamber. When I was conducting tests, the camera was set up just outside this window. The red & black mount is the pivot for the gun. The gun is lowered for loading, raised to the desired angle, then a vacuum applied to the chamber prior to the gun being fired.

NASA seems to confuse the expected "flash" with the ejecta plume. If you listen to the You Tube video, they say you get a bigger flash if the material is rocky and less of a flash if the material has a higher water content. What NASA sold was an ejecta plume. They themselves said the flash was hidden from Earth by the crater walls. The flash occurs in the first instants of the impact, the result of a small highly compressed point.The materials are fully vaporized and escape as a plasma, hence the flash. High water content could mitigate the flash by the heat of vaporization of the water, but what we were expecting to see was the ejecta plume. The plume is the result of material, some of it melted but most solid, being lifted as a result of the impact energy and resulting shock wave.

Personally, I believe that the models overestimate the ability of the impactor, the Centaur stage, to couple its kinetic energy into the target. I do not know the models used but most cratering estimations are done with empirical models, like the "Z-Model." These are simple equations that either are based on simple physical principles or correlate with experimental data. A full-up finite-difference cratering calculation is rare.

The problem is the Centaur stage is a structure and not an impactor. The structure of the Centaur absorbs a lot of energy as it collapses and the energy coupled to the target is over a large impact area. Additionally, the velocity of the impactor is relatively low (about 2 km/s) which may put it outside of the models. The Deep Impact experiment was designed to be a penetrator and eject lots of material. A spent rocket hitting the surface of the moon is more akin to an empty airplane crashing into the desert at full throttle than a meteor impact.

But having a show on Earth was not the point of the mission. The real question to be answered was "How much water is on the south pole of the Moon?" On November 13, 2009, the LCROSS mission scientists announced that there is a significant amount of water ice on the moon. It may not have put on the show the NASA publicity people predicted, but LCROSS provided the data it was designed for. —*Stephen Ruhl, BPAA Education Officer*

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"Dynamic Cratering Flows Generated in Laboratory-Scale Impact Experiments,"

# Looking for Life in the Universe

We are in the middle of an astrobiology revolution. Speculation has long been fierce about life beyond Earth, but until recently, there was no way to scientifically address the question.

We now know that other stars have planets around them—about 400 planets have been discovered in the last 15 years. We've found life in amazing places: 'extremophiles' deep underground, in scalding hot springs, and around black smokers in the depths of the ocean.

One-celled life-as-we-know-it does not need much, just liquid water and an energy source. Both conditions are turning up on Mars, Europa, and even on Enceladus, the sixth largest moon of Saturn, which erupts with water geysers, and may be warmed by tidal forces exerted by Saturn, far beyond "the habitable zone."

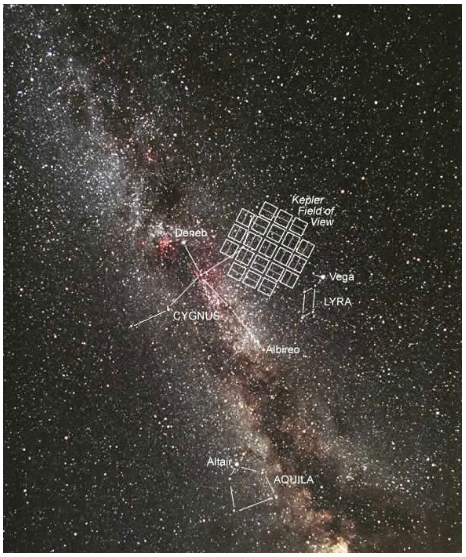
Scientists considered life in the Universe recently at two public talks in Seattle. UW astronomer Dr. Don Brownlee and Dr. Jill Tarter, Director of the SETI Institute's Center for Research, discussed "Is Anything or Anybody Out There?" Dr. Woody Sullivan, another UW astronomer, examined possibilities in "Is There Life Out There?" Sullivan said "As for microbial life, I've become a convert. I think the odds are that fossil or living evidence [of extraterrestrial microbial life] will be found in the lifetime of the people in this room." Tarter said "Extremophiles—the new aliens on earth—make the universe appear more biofriendly."

Most stars—at least 10%, probably more than 50%—have planets. "Life is tremendously adaptable," said Sullivan. No one knows whether "it is easy to make life or difficult," said Brownlee. And how common is life? "We have absolutely no idea," admitted Brownlee. Astrobiologists are looking for biosignals—"the grandest hope we have right now is to detect a non-equilibrium atmosphere—carbon dioxide or methane," he went on. Earth's history suggests microbial life is easy, but animal life may be hard—it took four billion years to develop here. No one knows if this is a normal progression, because we only have a sample of one.

SETI (The Search for Extraterrestrial Intelligence) searches for signs of intelligent life with radio-telescopes, crunching the data with linked home computers as well as their own hardware, looking for patterns indicating technological life. Of course, SETI can only detect life that operates some kind of transmitter. Brownlee pointed out that we are "pretty stranded in the Universe. Beyond 100 light-years, no communication on a human scale is possible." Tarter replied that though advanced civilizations may be beyond our reach, they may not be beyond our knowledge—just as we know about the ancient Greeks, although we can't hold a conversation with them. And as far as electromagnetic signals are concerned, she said we've looked at about one eight-ounce glass of water's worth, compared to the ocean that is out there.

So we continue to search: under the ice of Europa, on Mars—the Mars Science Lab will test for evidence of microbes—for Earth-like planets, with the Kepler Space Telescope; for signals, with the Allen radio-telescope array. Meanwhile, our first television signals—baseball games and FDR's speeches—are now out beyond Aldebaran. "The Twilight Zone" has reached Mu Arae, and "Lost" can be seen on Alpha Centauri.

*—Vicki Saunders, BPAA Newsletter Editor*




*Space Telescope Kepler's field of view (NASA)*

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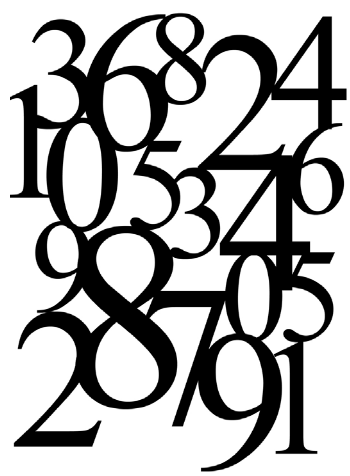
# Numbers SEEING STARS/ASTRONOMY 0.001

Numbers—we use them every day. Where did they come from? How did we start using them? What are they? When did you start counting? Was it when you were asked how old you were and your parents beamed with pride as you held up three fingers? That was an astounding leap of imagination—to be able to equate your age with a hand signal that has nothing to do with the passage of time.

It is the same leap that our ancestors made—how many years ago?—50,000?—when they recognized the difference between singular and plural (me and other), equivalence within concrete groups (me and my siblings), when they counted quantity (my family is me plus you plus you plus you), and when they noticed change and its results (my big brother died; now I must do his work). Numbers helped them use the Sun and the Moon and the stars to tell time and place and control their surroundings. Their curiosity must have been caught by the sheer possibilities of numbers.



"Number," the dictionary says, is "a symbol or word … showing how many or which one in a series." Numbers are marks representing an abstract quantity. We measure time with them, we determine the location and size of our property, we pay our bills, we count when Easter will come. But they're only the idea, not the thing.

Originally, it seems, we began to use numbers when the awareness of the passage of time—the differences between present, past (our memory), and future (our fear of what could happen again)—first dawned on us. This is related to our memories of the rhythms of day and night.

Our curiosity led to watching the changes in the sky, and then to making a record of them—counting in order to lessen uncertainty. At some very early point we understood that there was a relation between the number of times the new moon appeared and when spring would come. We also soon understood that the relation was not exact. Our uncertainty was increased, for instance, by the full Moon being "eaten up" in the middle of a night (what had we done to deserve that?), and then slowly reappearing. (Uncertainty also led to our watching how much food we needed to survive the winter—and to business management—numbers again!)

Over the millennia we've tried a variety of ways to group quantities of numbers. We've wanted the group to be easy to understand and easy to use. Most of the groupings have some astronomical source, and all are still reflected in our numerical references: base-one, base-ten, base-seven, base-twelve, base-sixty, and base-three hundred sixty.

My guess is that the first numbering "system" was a base-one: one new Moon, recorded with a mark or a stick or a stone, then one more new Moon and one more scratch or a stick that didn't get thrown away. Maybe from there people jumped to a base-twenty system as they used their fingers and toes to keep track. Fingers and toes didn't get thrown away, and you could carry your records with you. Counting with toes puts this system back before we thought of shoes. (Did that technical innovation give rise to the base-ten, decimal system ?)

A base-sixty numbering system (sexagesimal) used by the Babylonians around 2000 BCE was used by astronomers well into the period of the Renaissance. We still use it when we count minutes in an hour. While in our current decimal system moving a number one place to the left increases its value by a factor of 10 (1→10→ 100), and moving it one place to the right decreases its value by a factor of ten (1→ 0.1→ 0.01), in the sexagesimal system moving the number left or right changes the value by a factor of 60.The convention is to indicate a separation of places by a comma and the difference between whole numbers and fractions by a semicolon: for example, the sexagesimal number 2, 43; 30 in decimal notation is 163.50.

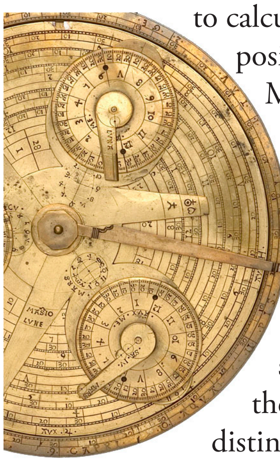
| Sexagesimal | Decimal translation | |
|---|---|---|
| 2,43;30 | 2 x 60 | = 120 |
| | 43 | = 43 |
| | 30/60 | = .50 |
| | | =163 .50 |

The theory of its origin is that it reflects the conjunction of the Sun, Jupiter, and Saturn every sixty years. (How many times did it take for that pattern to be repeated before we

*Enūma Anu Enlil*

began to notice it? And then how many more times was it before we attached any importance to it? And if the usual age span was 30 years, who kept track?)

Enūma Anu Enlil, a late second millennium BCE Babylonian tablet, gives the times and places that the planets can be seen and the length of visibility of the Moon for the 30 days of the month. The Babylonians were careful observers, but their records were only simple arithmetic. It wasn't until Hipparchus and Ptolemy and some others came along that the Greeks added geometry to calculating the positions of the Moon and the planets.



*15th Century equatorium for calculating the positions of Mercury, Venus, Mars, Jupiter, Saturn, and the Moon. Courtesy the Museum of the History of Science.*

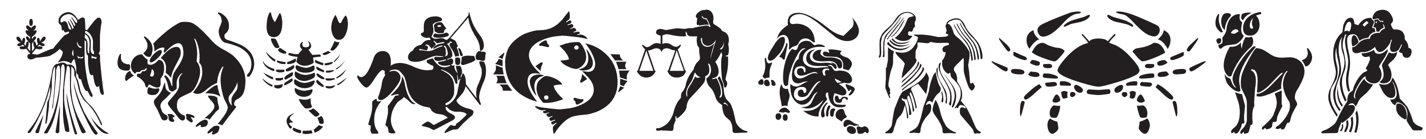
The base-seven came from the seven "wandering sheep" that the astronomers distinguished from the fixed stars: the Sun, the Moon, Mercury, Venus, Mars, Jupiter, and Saturn. People gave these regular wanders a special place in their legends. That place continues in our seven-day week, and in the names of each of the days (but with old Germanic names substituted for Mercury, Venus, Mars, and Saturn).

A base-twelve system is recorded by 5th century BCE Babylonian astronomers. They divided the heavens into the constellations through which those celestial sheep wandered. At first the astronomers counted eighteen constellations, each one with three stars. However, the areas of the constellations weren't of equal size, so they went to a simpler twelve (though they still aren't equal). If they'd chosen thirteen months, each of twenty-eight days, plus one free day, we could have an evenly divided calendar. But, thirteen isn't as convenient a number as twelve to multiply or divide. (Was it that reason, or were people even then superstitious about the number thirteen?) These twelve became identified as the constellations of the 'zodiac,' meaning a belt. We know them now as Pisces, Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpios, Sagittarius, Capricorn and Aquarius. More recently, in the early 20th century CE the International Astronomical Union has officially recognized that the sheep wander through one more constellation between Scorpios and Sagittarius, that of Ophiucus.

When Middle Eastern astronomers were trying to put together a system to predict the appearance of the new Moon in the fifth century BCE, they knew that the Moon and the Sun and the stars didn't line up in nice agreement with our numbering systems. The Moon goes completely around the Earth relative to its position with the stars (a sidereal month) in 27.3 days. But it takes the Moon 29.5 days (a synodic month) to go from one new Moon to the next.

To make the mathematics less complicated, the astronomers and the government officials decided that all the moon-months should be counted as having thirty days. That made a full year of 360 days, a number that can conveniently be divided by 1, 2, 3, 4, 5, and 6 and their multiples. It also made a neat circle of 360 degrees. Unfortunately, 360 does not fit the Earth's timing. Nor does it fit the Moon's. The Moon doesn't go around the Earth in either 30 days, or in 27.3 days, or in 29.5 days. In fact, the sidereal month is 27 days, 7 hours, 43 minutes, and 11.6 seconds. The synodic month is 29 days, 12 hours, 44 minutes, and 2.8 seconds. On average. Except that our Earth's rotation is slowing down little by little in part thanks to the friction of the tides, and the Moon is likewise slowing down. (Would anyone have wanted a system based on 27;7;43.11.6?)

If we've created our numbering systems on our astronomical observations, and if our Earth is slowing down, does this mean that our measures of time are also slowing down?—*Anna Edmonds, Newsletter Editor Emeritus*



*The twelve signs of the zodiac.*

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