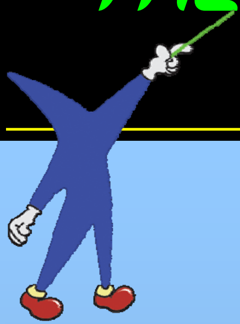
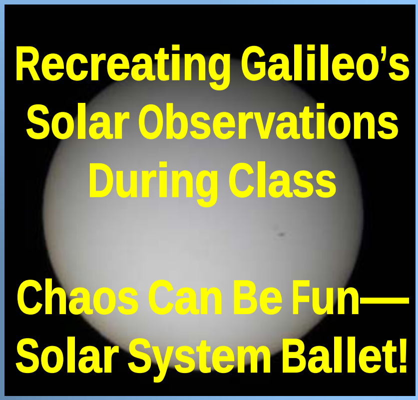
# The Classroom Astronomer

#9—Fall 2011

# Earth's Shadow Measures The Moon...


NASA Math—
Seeking Exo-Planets




Star Motions Activity with Three Sky Simulations

# ...Moons Measure Earth!


Plus...

Fall Sky Planning Calendar

RAP Sheet of Astronomy


Astronomical Teachniques - Increasing Accessibility

# My Views of the Classroom Universe

## Toe Dipping in the Online Pool

When the summer issue (*TCA* 8) came out, we were also in the midst of getting Clastro's little feet wet in the various pools of social media. We started the Green Laser Blog—which promptly got (temporarily) overrun by a pile of spam postings. Got ourselves our first Facebook page (and will work on another one, for our sister company Hermograph Press, soon). The FB site has garnered an international coterie of interested folks! Astronomy teachers from Turkey and Italy are quite a sizable minority!

But what has been much more interesting has been the response to our website polls. Our first question was simple: what five things do you think EVERYONE should know about astronomy? The answers were….very varied! The most common one factor was all should know about the sheer huge size of the universe, and which things are bigger than which other things.

Next we ran our first presidential poll. Who do you think will be the most supportive of science (and astronomy) and most supportive of science education? While not a large sample, it still was informative. Of the several million apparent Republican candidates, the only who got a vote — 1 vote — was Herman Cain. All other votes were for Barack Obama, save for one No Answer and one None of The Above. The comments were even more interesting, among them: "Where these people stand on science ...is not an important factor today...I wish it were." and "I cannot support a party that promotes Creationism in the classroom and seeks to end the James Web Space Telescope and Mars Rovers." We'll keep running the poll monthly, changing the list as people drop in, or drop out.

One other online thing, not really a social medium, but fun. Every two weeks we upload a detailed calendar of sky events, info from the magazine's planning calendar, and space history, all topped by suggestions of what to do with them during the two week's astronomy lessons! I'm a firm believer in letting the sky dictate what is taught. Over a semester or year you'll get to everything you have to teach anyway.


# In This Issue



*On The Cover: Clockwise from Upper Left—F. Checchin, D. Tiveron, G. Maltese—Gruppo Astrofili di Padova and K.J. An, China; J. Hill, USA; D. Willasch, Germany; J. Roth, USA.*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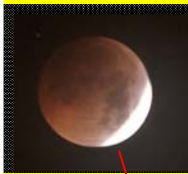


# The Lunar Parallax and December's International Measure The Moon Night

- Larry Krumenaker

**The ideal collaborative inquiry activity, joining forces to measure the Moon's distance via parallax. Join in for the December eclipse!**

So simple in concept even the ancient Greek astronomers knew *this*. For them, though, it was an abstract mind experiment. It couldn't be done in the real world. Their real world. But we can do *this*, today, in our reality.

*This*...is measure the Moon's distance and size. All it requires are two observations. The difficulty the ancients could not overcome was that the two observations had to be taken, and on opposite sides of the Earth. The procedure is called taking a parallax measurement and surveyors do it all the time. Parallax is simple to show: point your index finger upwards and at a distant object (a light post, something on the wall) and while doing that, put your hand straight out as far forward as you can. Look at your finger with just one eye. Now, switch eyes. The finger should appear to shift against the background by some angle. Switch back to your other eye. Move your pointing finger halfway in towards your eye, still pointing at the object. Switch eyes again. The shifting angle should be bigger. The bigger the shift, the closer the object.

What if you could somehow take your two eyes and move them farther apart? (Kids, don't try this at home….). Then the angle would get larger and you could also measure things that are farther away. You are limited to how small an angle —the parallax—your 3-inch-separated eyes can detect.

The Greeks knew this. Because they detected no parallax for the stars, they knew stars—and everything else—were beyond Earth's atmosphere at least. Even the Moon, presumably the closest object to us, had no detectable parallax from the Grecian city-states. What was needed was a larger baseline, the line between the two viewing places. The largest one we have to use for the Moon is the Earth's diameter. Unfortunately, Chinese food—and astronomers—were unknown to the ancient Greeks and even if they were known, no communication was possible to set up this experiment. Today, with email, the Web, and other means of communication, we can do *this*. And last June, it was tried.

## Measuring the June Lunar Eclipse

*TCA* contacted a number of persons last May to try this experiment from opposite sides of the upcoming June 2011 total lunar eclipse viewing zone. The borders of visibility were central Europe and the eastern edges of Asia and Australia. These would provide the largest possible baseline to have the Moon visible from two places at the same time. The key requirements asked of the photographers were: take every photo at the exact same moment—every minute ending with a 5 (:05, :15, 0:25, etc.) during a common period of visibility overlap (the Moon rises during the European photo session while setting during the Asian views), make sure there are stars visible in the photo—preferably a minimum of around 3 degrees or more of sky around the Moon, and the photo shows lunar maria features so we can match up Moon images.

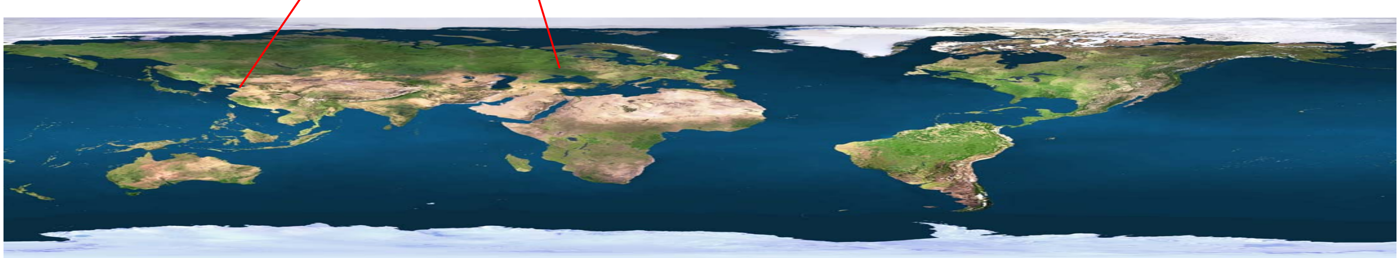
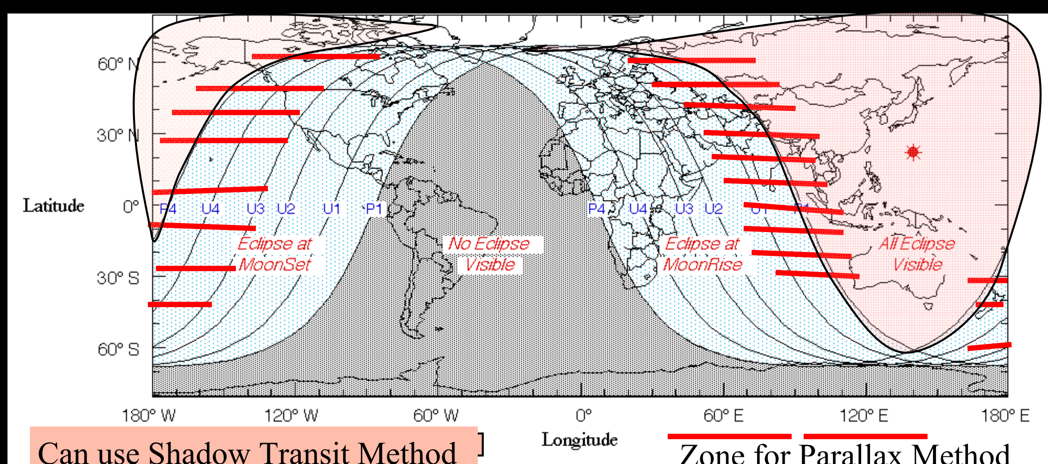


Figure 1. Worm's eye view of the Earth's surface with lines of sight from two eclipse observers' positions to their photographs of last June's total lunar eclipse. Not to scale, the arc is the lunar parallax angle, really only about $1^{o}$, not the large angle shown.


Measure the Moon's distance and size with December's lunar eclipse!

Collaborate with students and observers in multiple countries.




The last opportunity before 2014!

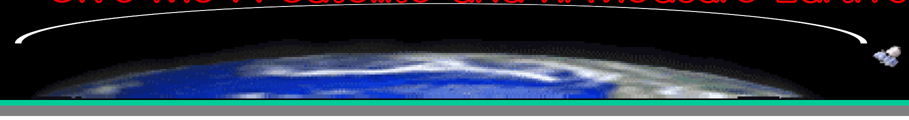
Base image courtesy Jet Propulsion Laboratory

**SUMMARY**

1. Take photographs of the eclipsed Moon, showing stars, from two widely separated locations (1000s of miles apart) at the same moment.
2. Overlay the photos, matching up lunar surface features.
3. Measure the shift of one star between the two places using the Moon's 30' diameter as your ruler.
4. Use the Geobytes website to find out how many miles or kilometers apart the two observers were.
5. Use the three equations to find out the real distance between the places through the Earth (the Chord), the distance to the Earth's center, and the Moon's distance.

# Archimedes Updated - Give Me A Satellite and I'll Measure Earth's Mass!

- Bernhard Beck-Winchatz



**Eratosthenes measured Earth's size. Archimedes said he could move it. Here is how you can measure Earth's mass at night!**

It was just a few thousand years ago Archimedes said, "Give me a Lever and I can move the Earth!" Archimedes probably couldn't have imagined either man-made satellites in orbit around the Earth, or the huge size of the Earth's mass. Today's students may be used to the existence of satellites. Yet, in my experience, very few students understand the nature of their orbits even though technologies based on orbiting satellites allow us to navigate, communicate, and predict the weather. Orbits are also one of the most important concepts in astronomy. They are responsible for the phases of the Moon and the positions of the planets. They are also a great example for the unifying nature of science by demonstrating how the same scientific principles we are familiar with in our daily lives (gravity and inertia) also control the motions of objects in space.

It is a lot of fun to simply predict when a satellite will be visible and then go out and watch it appear at the predicted time and location. But you do not have to stop there: The motion of a satellite is determined by Earth's gravity and the size of the satellite's orbit. The greater the force of gravity that pulls the satellite toward Earth, the faster it has to move to stay in orbit. Thus, observations of the angular altitude A and angular speed $\varpi$ of a satellite allow you to determine the height of its orbit and the mass of Earth.

The main purpose of this article is to discuss two ways to engage students in collecting and analyzing data during visible satellite passes. Satellites in low-Earth orbit are easy to observe and are so close to circular that we will not have to deal with the technicalities of the eccentricities of ellipses. If you live in a rural area, all you have to do is go out after sunset or before sunrise and look up; you will see dozens of satellites crisscrossing the sky over time. The International Space Station (ISS) is visible even from the most light-polluted cities. If observing the real sky is not an option for you and your students, desktop planetarium programs such as Stellarium (www.stellarium.org) allow you to conduct realistic observations of satellites on the computer screen or in a digital planetarium's dome.

The two things we can obtain from satellite observations are the height of the satellite above the Earth OR the mass of the Earth. If you have one, you can get the other.

### How High, How Fast?

Two factors are critical in this exercise. The first one is the angle the satellite travels over a period of time, and the angular and linear speeds of the satellite that that implies. Let's take this in three simple steps.

1. A simple way to measure the **angle θ** is to use your hands. For most humans the angle subtended by a fist seen at arm's length is approximately 10°. Alternatively, you can also build a simple cross staff to measure the angular change in position, or take note of bright stars near the satellite's path and determine the angle using a star chart or desktop planetarium software.

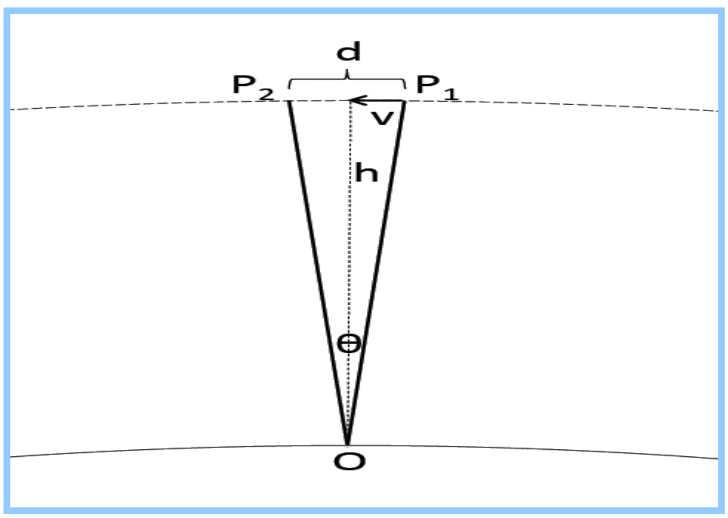



Figure 1. An Earth-orbiting satellite, seen near the zenith of observer O, travels from $P_1$ to $P_2$. The height of the orbit is *h*. The angular distance between $P_1$ and $P_2$ is θ.

2. The **angular velocity $\varpi$** is defined as the angle θ between two points on its path across the sky, divided by the time it takes the satellite to travel from one point to the other. To measure the angular ve-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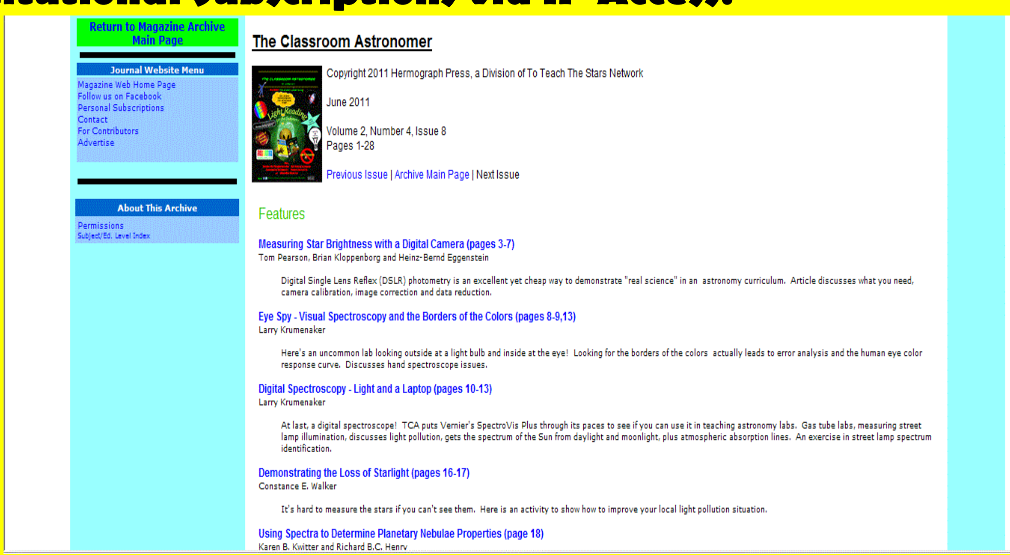
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Features

Measuring Star Brightness with a Digital Camera (pages 3-7)
Tom Pearson, Brian Kloppenborg and Heinz-Bernd Eggenstein

Digital Single Lens Reflex (DSLR) photometry is an excellent yet cheap way to demonstrate "real science" in an astronomy curriculum. Article discusses what you need, camera calibration, image correction and data reduction.

Eye Spy - Visual Spectroscopy and the Borders of the Colors (pages 8-9,13)
Larry Krumenaker

Here's an uncommon lab looking outside at a light bulb and inside at the eye! Looking for the borders of the colors actually leads to error analysis and the human eye color response curve. Discusses hand spectroscope issues.

Digital Spectroscopy - Light and a Laptop (pages 10-13)
Larry Krumenaker

At last, a digital spectroscope! TCA puts Vernier's SpectroVis Plus through its paces to see if you can use it in teaching astronomy labs. Gas tube labs, measuring street lamp illumination, discusses light pollution, gets the spectrum of the Sun from daylight and moonlight, plus atmospheric absorption lines. An exercise in street lamp spectrum identification.

Demonstrating the Loss of Starlight (pages 16-17)
Constance E. Walker

It's hard to measure the stars if you can't see them. Here is an activity to show how to improve your local light pollution situation.

Using Spectra to Determine Planetary Nebulae Properties (page 18)
Karen B. Kwitter and Richard B.C. Henry

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**for release information and pricing!**

# Space for Math in the Classroom - Searching for Exo-Planets

**Does your science class lack for interest in math? How about digging through NASA's press release archives for more than pictures?**

NASA is perhaps one of the most famous resources for downloading spectacular pictures of the universe. It also issues dozens of press releases each month about astronomical discoveries from black holes to the search for Earth-like planets. But more than being just 'eye candy' these pictures and press releases provide fodder for student inquiry using mathematics.

In 2004 I created the Space Math@NASA program (http://spacemath.gsfc.nasa.gov) to show the many behind-the-scenes ways in which simple mathematics can enhance our understanding of what these pictures and press releases are saying. I had none of these resources available to me in grade school as I struggled with math, while passionately interested in astronomy. So I decided as an astronomer to create a multitude of examples that modeled the explicit connection between the medium of math and the excitement of space science.

And no, you do not have to be a Rocket Scientist or use calculus all the time! For most of the really cool discoveries, all you need are basic skills like working with percentages, volumes of simple solids, and a bit of scientific notation. The more than 400 problems posted span a wide range of math levels. The majority are targeted at middle school students, although there are plenty adaptable for high school students in Algebra 2, Geometry and Calculus. Many problems ask the student to use a ruler to determine the scale of an astronomical image, and then use this to create a histogram of, for example, crater diameter frequencies which astronomers use to estimate an object's age. There are problems requiring geometric analysis, such as the paths taken by shock waves reverberating inside the Sun. Others involve statistics, probability, Venn diagramming, algebraic manipulation and numerical substitution. There are also a number of calculus-level problems, such as for determining the mass of Comet Tempel-1 (a volume integration) or the number of stars in the sky (integrating a power-law function).

I've also created 20 problem books, containing related exercises. The most popular math problem books at SpaceMath@NASA are 'Algebra-2,' a space math supplement, and perhaps not unexpectedly, 'Black Hole Math'. Any student looking for a science fair project will surely find some promising leads with many of these problems.

A very short list of the Top-10 problems in April, 2011 is shown in the table. Most of them are suitable for pre-algebra students!

| Title | Skill | Title | Skills |
|---|---|---|---|
| (71) Are the van Allen belts deadly? | Area of rectangle | (408) The speed of a TSunami | D = V x T |
| (160) Relative sizes of stars | Proportions,scales | (185) The ISS - Follow that graph! | Graph analysis |
| (102) How fast does the Sun spin? | Scale; d=Vx t | (67) Unit conversion exercises | Unit conversions |
| (157) The Space Shuttle Trajectory | Parametric eqns | (409) The 2011 Japan Earthquake | Algebra 1 |
| (260) Famous unit conversion errors | Unit conversions | (172) The stellar magnitude scale | Logarithmic numbers |

As an example, let's have a look at a series of problems to explore the theme of searching for Earth-like planets!

## Problem 1 - Habitable Zones

When an astronomer has determined a planet's distance, D, from its star, and the star's luminosity, L, they can easily determine what the equilibrium surface temperature, T, of the bare planet will be using a simple algebraic equation involving taking the fourth-root of a quantity. Students can manipulate this equation to model planets at differing distances and with different albedos, A, to discover where the 'liquid water' Habitable Zone lies for which surface temperatures are between 273 and 373 K. Here's what the equation looks like:

# Using Galileoscopes to Duplicate Galileo's Solar Observations

- James Hill

**A daytime activity that combines inquiry and history!**

Galileo's first telescope was produced in 1609 and it and several improved versions in 1610 revealed a new view of the universe. Galileo's first observations of the Sun in August of 1610 were just one of his cosmos-shaking discoveries. He found dark spots on the Sun that went from East to West across the face of the Sun in 13 days. They then became foreshortened, disappeared for about an equal time and reappeared on the East side again. This implied that sunspots were part of the solar surface and that the surface rotated about a nearly north-south axis with a period of about 27 days.

Galileo was probably wary of publishing his findings at the time because a "blemished" Sun went against the Aristotelian teaching of the day that the heavenly bodies were perfect. Aristotle had also asserted that all motion was centered on a fixed Earth. For the Sun to rotate contradicted this view, as did other observations Galileo made. Galileo's challenges to scholastic cosmology are well-known.

## Why the Sun? How To Observe It Safely??

Students are in the classroom during the day so observations of the Sun are a logical choice for scientific investigation, data collection, and discussion of the uncertainties of experimentation. It also provides a hands-on introduction that will motivate further study of the Sun, stars and other area of astronomy. An ideal tool to observe the Sun and bring history to life is the Galileoscope. This plastic telescope comes as an easy-to-assemble kit from Galileoscope.org. Any other small telescope can work in this effort, too. No matter what device you use, you MUST take regards for eye safety! Any telescope concentrates light and will fry the human eyeball quickly and cause permanent blindness.

## Making a Safe Solar Filter For Your Galileoscope-Type Instrument

Protection can be assured with the appropriate solar filters. The best source for a high quality aluminized Myler film is the Baader AstroSolar filter material, available from Astro-Physics in sheets that can be cut and made to fit the objective end of the telescope using cardboard and black tape (see image to the right). The URL for the film is [http://www.astro-physics.com/products/accessories/solar_acc/astrosolar.htm](http://www.astro-physics.com/products/accessories/solar_acc/astrosolar.htm) One sheet that is large enough to make at least six filters and costs $43.00. Be sure to get the Density 5 Visual filter material for visual use. Baader also makes a photographic filter that allows shorter exposures but passes too much light for visual use. If you want to use digital cameras to record the Sun on consecutive days, obtaining the density 3.8 film might be the better option. If you have both filters, be sure to label them prominently so they don't get mixed up in use.

## Duplicating Galileo's Observations of the Sun's Rotation

Once you have a telescope with a solar filter, all you have to do is draw or photograph the Sun at the same time each day and note the motion of the spots. Examples of solar observation forms can be had online and in *TCA*'s resource area. Sketching the Sun, rather than just imaging it with a camera, is a worthwhile exercise. When you sketch an object you have to "see" details that you would not otherwise notice.

# Star Motions With Sky Simulators

- Bruce Palmquist

**A basic concept for all levels of students—rising and setting of stars—can be taught with three simulations.**

State and national standards vary but certain things are almost always in them. One of those certain things are the risings and settings of stars, how they occur, and how they change with time or Earthly location. The best way to teach is to use the real stars and really observe. Alas, not only are clear nights not always available when your lesson plan calls for them but your class doesn't meet at night. Even one-night observing sessions may not be possible and it's rather unlikely you'll get students to join you for an observation at 4AM.

Hence we need a way to simulate the sky phenomenon. Simulations speed up observations. We can do a night in minutes, jump ahead in time for a month, six months, a year in the space of a class period. Simulations, or sims, come in a variety of forms. For this exercise, we have the choice of three different, yet important formats.

## Simulations Bring the Sky Indoors

**Free planispheres available online (some assembly required!)**

*Uncle Al's Star wheel:*
www.handsonuniverse.org/activities/uncleal/

*Sky and Telescope:*
www.skyandtelescope.com/letsgo/familyfun/Make_a_Star_Wheel.html

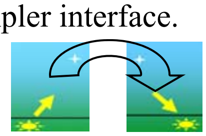
*National Research Council of Canada:*
www.nrc-cnrc.gc.ca/eng/education/astronomy/constellations/planisphere-2.html

First, if you can't observe the real thing, the ideal is to have something hands-on. This may be low-tech but it's worked for years—a **basic planisphere.** It's the best initial, low-cost investment for someone interested in learning the night sky. There are many paper or plastic planispheres available. For the activity we're going to do, I used The Night Sky by David Chandler for $40^0$-$50^0$ north latitude. ($11.95, www.davidchandler.com/nightsky.htm). Others are listed in the box to the left. The planisphere's big advantages are extreme portability, usable day or night without a battery or power-brick, and to set it up, you put it in your hands and you're done.

These days, one can use a computer program that accurately simulates star motions. There are many such **planetarium programs,** not to be confused with shows you see under somebody's dome with a projector. The example I will use is **Stellarium,** a free program available for Windows, Mac OS X and Linux. Go to www.stellarium.org, click on the label for your operating system in the upper right-hand corner, download and follow the installation steps for your computer. When you open the program, you'll notice that Stellarium has a very clean, uncluttered interface. When you move your curser to the lower left-hand corner of the window, a control panel will open up on the lower left side or the lower left bottom.

Stellarium has no option for web-only access, which is our last sim format. For one of *these*, head to a computer lab and log into www.worldwidetelescope.org, the website of **World Wide Telescope** (WWT). The WWT is an integrated set of maps and images blended together into a simulation of the nighttime sky. While it can be downloaded onto Windows-based computers, we will cover the web client which can be run directly from the web on a computer running Windows or Mac OS X. In this way it can be used on more computers. It also has a simpler interface.

## The Rise and Set of A Star



The assignment is simple. We will observe the rising of the bright star Altair for January 15$^{th}$ and determine what time that occurred. We'll then go forward in time and find out what time Altair sets. Students will be asked to predict (and write down this prediction) for when they believe Altair will rise and set on January 16$^{th}$. This might be a good time to poll the students for results, and perhaps come to some in-

# The Solar System Ballet, or Chaos Can Be Fun!

- Inge Heyer, Timothy Slater and Stephanie Slater

**Whether they are elementary or secondary students, or student teachers, a human orrery can be fantastic fun!**

By its very nature, much of the astronomy taught today is characterized by abstract spatial relationships. From the large-scale structure of the universe to the three-dimensional forces that describe the internal workings of stars, learners must use spatial thinking in order to grasp and understand concepts in astronomy. At the same time, because many students have underdeveloped spatial thinking skills, successful teachers find ways to encourage students' learning of complex ideas by distributing and supporting their thinking during the teaching process.

This assignment, like many that work well to help students visualize complex interactions, requires students to move their bodies to act out objects' motions. Such a teaching strategy helps novice students manage the complex motions occurring in 2 or 3 dimensions. Moreover, this activity assists students in understanding the difference between planets and moons, and to understand exactly what kinds of objects are in our Solar System. While many students can say words like "solar system," "planet" and "moon," allowing your students to act out the roles of each is a very effective means of moving them toward more accurate scientific understandings.

Successfully teaching dynamic Solar System concepts can be rewarding for the students and the teacher. This is particularly true for early elementary level students, who care not so much about the finer details, but because getting to move their bodies to represent revolving orbits is fun. Showing students a video is better than simply lecturing about it, but if students are able to express it with their bodies, they have a much better chance to understand and remember the targeted concepts much more easily. And, as we have discovered through teaching this way for many years, they will also enthusiastically tell their friends and families about it (even though grandma may not be too keen on playing the part of the fast-moving comet).

At the beginning of the activity, we ask participants to list the names of the planets, possibly in order (most of them do). They can either do this on a piece of paper, in groups, as a class, on a word wall, or wherever, and it can be done before or after the activity—we suggest doing both. Afterwards one could ask more details, how do the planets and moons move, how are the first four different from the second four, how do we know the Earth is round? The older ones should describe it in words, the little ones in pictures (and we get loads of those after many classes).

You will need the following equipment: computer/laptop, LCD and projector screen, if you like, for showing images of solar system objects; Styrofoam balls, beach balls, or other planet models of different sizes; strong flash light for the Sun, if you like. Optionally: labels for the planets; industrial size (25ft+) tape measure; blank paper; pencils; planet distances chart + copies; planet sizes chart + copies. Of course you need some empty space in the class room (or, better yet, go outside).

## Planets and Comets and Moons, Oh My!

The details of the activity presented here were developed in Hawai`i, so we usually start out by what the Hawaiians call "talking story" about the planets. Indeed, in Hawai`i talking story is an important part of life and engages students readily. We show pictures of the planets (more detail for grades 4+, less for the little ones), and relate the appearance and environment of each planet to things they know from the Earth/Moon system. We look at the whole collection and see the difference between the first four (little

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