CLEA Newsletter

Contemporary Laboratory Experiences in Astronomy

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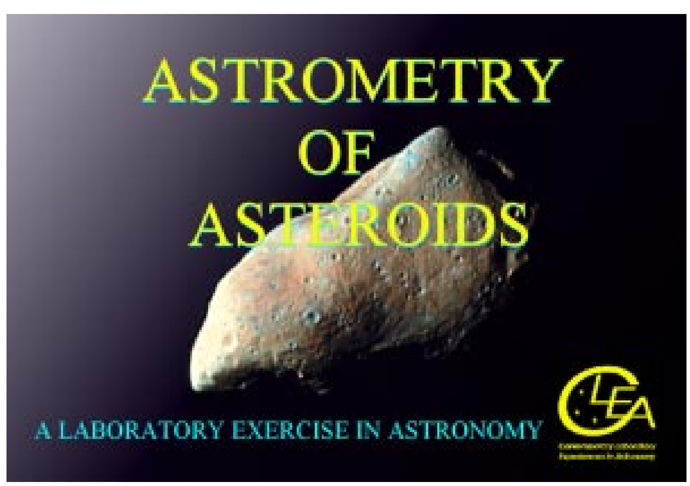
INDEX

New Astrometry Exercise Helps Students Know WHERE IT'S AT

Our recently released ninth laboratory exercise is a versatile program called ***Astrometry of Asteroids***. It is our first exercise involving the measurement of digital images produced by CCD cameras. In addition, it includes many features, simplified and streamlined for ease of use and clarity of operation, that are found in image analysis programs used by professionals. The exercise enables students to experience some of the thrills of discovery by blinking images to find moving objects. It also illustrates, in striking fashion, how positions of stars are measured against a reference frame of standard stars. Using these resulting measurements, the students are able to calculate both the tangential angular velocity and the horizontal parallax of asteroids.

We have developed versatile new software that lets students read in two different images of a star field, align the images by clicking on common stars, and blink the images to find objects that vary in position or brightness.



continued on Page 2

PROJECT CLEA

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Michael B. Hayden	*Co-Investigator*
P. Richard Cooper	*Co-Investigator*
Glenn Snyder	*Co-Investigator*
Glenn Snyder	*Software Developer*
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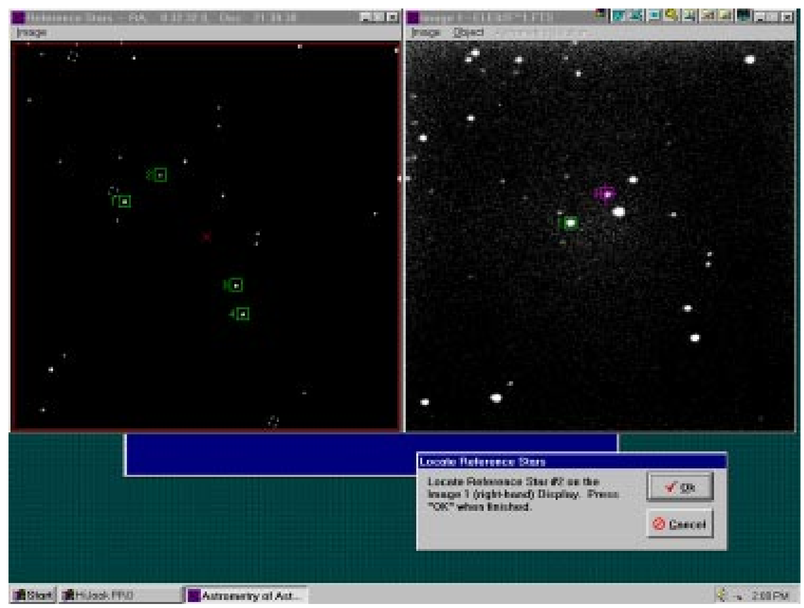
When interesting objects are found, students can call up charts of reference stars from the Hubble Guide Star Catalog (we provide a file with a subset of the Catalog, but a CD-ROM version can also be used). Simple mouse clicks can match stars on the images with the corresponding stars located in the Guide Star Catalog charts, and when an adequate number of stars are chosen, the program is able to calculate the celestial coordinates of the unknown objects on the image to high precision.



The new ***CLEA*** software allows students to match stars of CCD images of asteroids (right) with cataloged reference stars generated from the *Hubble Guide Star Catalog* (left).

Sets of images supplied with the program allow students to locate a faint near-earth asteroid and to calculate its angular velocity. Other images supplied with the program include pairs of asteroid images taken simultaneously by telescopes at opposite sides of the United States. These images graphically show the effect of parallax on the position of the asteroid against the background of more distant stars: a nearby asteroid shifts by 10 to 20 pixels as seen from opposite sides of the country. While annual stellar parallaxes are much too small to be seen just by blinking images, these asteroid parallaxes leap out at the viewer, making it possible for the first time to illustrate how astronomers measure parallax of distant objects from images of star fields.

The usefulness of ***Astrometry of Asteroids*** goes beyond the exercises for which we supply images, charts, and laboratory manuals. Users with access to their own telescopes can read in images in several of the popular image formats and use the software to measure precise positions of stellar objects. Patterned after the remarkable MS-DOS program ***Astrometrica*** by Herbert Raab, the ***CLEA*** image measuring utility offers small observatories the opportunity to make their own asteroid discoveries and to produce precise astrometric measurements for scientific research as well as education.

CLEA Wins Educational Software Award

In January, 1998, Glenn Snyder, our software wizard, traveled to New Orleans to the annual meeting of the American Association of Physics Teachers where he accepted an award for ***CLEA***'s ***Radio Astronomy of Pulsars*** software, one of three winners in the 1997 Educational Software contest conducted by the journal *Computers in Physics*. The citation, in the November/December 1997 issue of the journal, noted the ease of use and attractiveness of design of the software. "As with other ***CLEA*** simulations," the journal noted, " this useful program allows large classes to gain hands-on appreciation of an important astronomical subject. Future telescope operators might even use this as a pre-training device".

This is third time ***CLEA*** has been cited in the annual *CIP* contest. Four ***CLEA*** exercises won a full award in 1996, and the ***CLEA*** *Classification of Stellar Spectra* was given an honorable mention in 1994.

New User-Friendly Web Pages Now On-Line

If you have visited the ***CLEA*** web pages recently, you have noticed we have undergone an extensive face-lift. The original ***CLEA*** web pages were written before "Netscape" was a household word; they were hard on the eyes, and it was hard to find important information on them. Now, thanks to our student assistants Andy Danner and Jay Henniger (both Gettysburg College physics majors), we have entered the modern Web era. The new pages feature easy-to-follow steps. Each lab exercise has its own page, from which you can directly download software and manuals (now in .pdf format, which most users find more convenient than Postscript). You can also download evaluation forms, and give us on-line feedback directly from the website. Copies of the newsletter are available on-line, too (you're probably reading this on our website right now), as are short news items of general interest to our users. We try to keep the site as up-to-date as possible. Let us know if you have any suggestions to make it even better.

The ***CLEA*** website address is
http://www.gettysburg.edu/project/physics/clea/CLEAhome.html

✍ Tips From Our Readers

Tuvia Bar-Noy provided some helpful comments on the *Revolution of the Moons of Jupiter* exercise, offering a different way to use ***CLEA*** software. (Thanks again Tuvia for your suggestions!) The exercise is divided into the following three stages.

1. Quantitative approach to Kepler's 3rd Law

Let's assume that the orbit is a circle. What parameters will identify the orbit of a certain moon? Since this lesson comes after the students have learned circular motion, they'll say that each orbit is defined by its radius and period. Before we attempt to measure the radii and periods, they are asked to think about the relationship between the radius and the period; if one moon's orbit has a larger radius, will its period be bigger or smaller than a moon with a smaller orbital radius? Intuitively, they say that a larger orbital radius will mean a bigger period, since it has a longer way to go. This assumption can be checked by seeing the more distant moon (Calisto) needs more time to go around Jupiter than a closer moon. After this is verified, the students are asked; if Calisto has an orbit twice as big as Ganymede, will its period be twice (or x3, or x4) than Ganymede's?

2. How do we measure periods, and distances in space?

We do not know the distance of the Jupiter System to us, so even if we could measure the angles (Jupiter-our eye-moon), we could not calculate the distances between Jupiter and its moons. After a while the students realize that they could use the "natural" measuring stick they have on each screen - Jupiter diameter. Now we show them that instead of measuring distances with a ruler on the screen, the simulation gives us the distances in units of JD.

What is the best way to measure orbital radius? Bring the moon to the extreme right (or left) of its orbit, and measure the distance. (Let's not take any measurements yet until we determine how to measure the periods.) The periods can be measured by seeing how much time is passed from the moment a moon is at its extreme right, until it returns to that same position. However one can see that although most students will agree on the extreme distance, most will not agree on the time it takes to happen. At this point, long times hardly seem to change the location of the moon. At what point is it easy to set the exact time? When the moon is exactly in front of Jupiter? After a while we agree to measure r(t) for a period of long enough that Calisto will make one period. Now we have to see how to carefully find out the orbital radius and the period.

Because we do not *catch* the moon at its extreme right and left points of the orbit, and since we see that the extreme-right = extreme-left, we will take the farthest point measured, and call it *the orbital radius*. (This works well for Callisto and Ganymede, but we must be careful when looking at Io and Europa.) In order to determine the period, we graph the data. We measure the period using the maxima (or minima). For greater accuracy, we try to find where the period passes through zero, and to measure several periods.

3. Discovering Kepler's 3rd Law

Assuming that all the students obtain similar (and accurate) results, we average the data to get the radius and the period for each moon. Looking at the results they realize that they were correct in assuming that a larger R will give a larger T (See lesson #1). Plotting R(T) however does not yield a straight line, which means that R is not linearly proportional to T. Thus we try some other ratios R^2/T, R/T^2, R^3/T etc. Now that we have discovered Keplers 3rd Law (for Jupiter's Moons). We emphasize that R and T for each min does not depend on the moons mass or own radius, since we have no knowledge about it. In order to finish ***discovering*** the 3rd law at this point, we calculate the ratio for another system and for moon-planet systems.

✍ Tips From Our Readers

ADC2CLEA Now Reads 4 CDROMS

Jeff Bondono, of Shelby Township, Michigan, has been keeping up with the Astronomical Data Center. His new versions of ADC2CLEA now convert spectrum files from the Volumes 3 and 4, as well as volumes 2 and 1 of the popular *Selected Astronomical Catalogs* CD-ROMS to a format readable by our ***Spectral Classification*** exercise. These four disks offer users a wealth of spectra of galaxies, stars, and nebulae, taken in the UV, visible, and IR. The software is available from the ***CLEA*** website, auxiliary software page: **http://www.gettysburg.edu/project/physics/clea/auxsoft.html** or directly from Jeff, whose new home page is **www.eaglequest.com/~bondono**

The CDROMS can be obtained by contacting the:

Astronomical Data Center
NSSDC Coordinated Request and User Support Office
NASA Goddard Space Flight Center
Code 633.4
Greenbelt, MD 20771 USA

Some of the earlier disks are available in FITS format. Therefore, when requesting disks, be sure to request the ASCII version of the disks because Jeff's program only reads the ASCII format. Please let us know if you find it useful, and if you develop any new exercises using the alternate spectra, we'd love to see them.

Updates to CLEA Software

Important! Users of Windows NT 3.5/3.5/4.0

The *Radio Astronomy of Pulsars, Version 0.71* exercise has been slightly modified and now runs successfully under Windows NT 4.0. However, users of WinNT 4.0 should be aware of the following:

1. All users of NT 4.0 are ***strongly*** advised to install Service Pack 3 (or higher), if they have not already done so. The latest Service Pack for NT 4.0 can be downloaded form the Microsoft Web Site: **http://support.microsoft.com/Support/NTServer/Content/Servicepacks/** or **ftp Site: ftp.microsoft.com at bussys/winnt/winnt-public/fixes/usa/nt40/ussp3**

2. Users may encounter difficulty with a sound feature of the program, including a possible system hang when the sound starts. If this occurs you need to install an upgraded sound driver. If your sound card is a SoundBlaster you can download the latest driver from Web Site **www.soundblaster.com**. Be sure you get the driver that is specifically for WinNT 4.0. (Of course, while you are waiting for the driver upgrade you can work around the problem by turning off the sound feature in the options. (See page 9 of the Software Users Guide for this exercise.)

We have no reports, positive or negative, at this time concerning the operation of this software under versions of Windows NT (3.5 or 3.51). If you install this software on **ANY** version of Windows NT, including 4.0, please let us know your experiences.

On the Road With Project CLEA

Since that last issue of the newsletter appeared a year ago, *CLEA* has been very busy spreading the word. We've given day-long and half-day-long workshops to groups of 10 to 30 high school and college teachers at a number of locations around the country. Among our recent workshops:

- → Wright Center for Science Education at Tufts University, Medford MA, as part of a workshop in astronomy for high-school teachers. (June, 1997)
- → Wake Forest University, Winston Salem, NC, as part of the summer meeting of the American Astronomical Society. (June, 1997)
- → The Adler Planetarium, Chicago, IL in conjunction with the annual meeting of the Astronomical Society of the Pacific. (July, 1997)
- → The University of Denver, in conjunction with the summer meeting of the American Association of Physics Teachers. (August, 1997)
- → Dutchess County Community College, Poughkeepsie, NY, in conjunction with a meeting the Northeast Region of the American Association of Physics Teachers. (November, 1997)
- → Yale University, New Haven in conjunction with a meeting the Northeast Region of the American Association of Physics Teachers. (November, 1998)

Larry Marschall also was invited to give a talk on *CLEA* at the joint meeting of the APS/AAPT Southern Ohio region at Miami University, Oxford, OH, in October, 1997. A packed hall of about 150 people attended, and our mailing list in Ohio expanded greatly as a result.

The most exciting invitation of the year was a speaking engagement at the 3rd annual Australian Conference on Computers in Physics Education. Larry Marschall flew to Brisbane in early April, 1997, where he enjoyed some marvelous hospitality and conversations with astronomy and physics teachers from the Australia/New Zealand/ Papua New Guinea area. Thanks to John Davies and Ian Moore, local hosts at Queensland University of Technology, everything went without a hitch. Copies of the paper we presented there, which describes current and future *CLEA* projects, can be obtained by writing us at Project *CLEA*.

Help Us With Our Evaluation Today!

You can help us greatly by taking a few minutes to fill out the new *CLEA* on-line evaluation form which we are using to survey our users and to get an idea of how they are using our exercises. You can view the form on your own computer at **http://www.gettysburg.edu/project/physics/clea/CLEAeval.html** . Just enter the pertinent information and then send it to us by clicking the send button at the end of the form (don't forget this last step). We will be eternally grateful to you.

In addition, there are a series of questionnaires for students, and pre-and-post tests you can use for each of our exercises, available for downloading at **http://www.gettysburg.edu/project/physics/clea/cleaforms.html** . You can use the questionnaires to sample how students like the exercises. The pre- and post- tests help assess whether and what students have learned from the CLEA exercises. We would appreciate getting the results of any surveys you conduct with your classes using these forms.

Comments From Our Users

Evaluation of *CLEA* software is an essential component in the success of our project. Your (and your students) responses aid us not only in developing new labs, but also provides us with demographic information and continues to help us in refining the current modules. Below is short list of user comments that we have received via email correspondence. Some responses are brief messages emailed directly to us, and others are excerpts from our user evaluation form located on our web site at **http://www.gettysburg.edu/project/physics/clea/CLEAeval.html** . We want to thank all of our contributors, and all of our users for their continued support of Project CLEA.

Robert Welsh, Carver High School of Engineering and Science, Philadelphia, PA
(Taken from the on-line instructors evaluation form) "*Overall impression*: I'm extremely pleased with my student's response and success with the Jupiter Lab. *Strengths*: allows for a rigorous analysis of Kepler's and Newton's equations as related to orbital motion. *Weaknesses:* Possibly a bit more mathematical analysis on the part of the student."

Stephan Mahan, University of Tennessee, Knoxville, TX
"The CLEA labs are very well written. However, the student manuals are a bit long. We are using several of these labs this year in our Astronomy sequence."

John Wiess, Carlton College, Northfield, MN
"We used these labs last term in the Observational class I was lab asst-ing. We had a lot of cloudy days, so we ended up using more than we had hoped (no Offense!). We were quite pleased with them. We did a little bit of editing, but they went quite well. The students were happy with them, and learned quite a lot. Nice job!"

Gary Kutina, from Elgin IL
"I have been using your labs in my Ast.10 class at Harper College in palatine, IL. I have really enjoyed the Jupiter moons and Hubble labs. I will have to try the others. Thanks again for developing something like this."

Guido Morvillo, Staten Island, NY
"Excellent educational Software. Thank-you for your efforts."

Josef Breutzmann, Wartburg College, Waverly, IA
(Taken from the online instructors evaluation form) *Overall impression*: I am extremely impressed with the labs. *Strengths*: (1) They connect very naturally to the course topics. (2) The student manuals are well written and explain things well. *Additional comments*: As a non-astronomer teaching astronomy, I'd be lost without outside aid such as NSF or Chatauqua workshops and having to construct my own lab materials. Our labs are far and away the best materials I've found. I also think the student's fascination with computer technology makes them avid users of your labs. Some of the same objectives of course could be achieved through "paper' labs but the computer simulations add a degree of realism that not only grabs their interest but in fact enhances learning.

John McKnight, College of William and Mary, Williamsburg, VA
(Taken from the online instructors evaluation form) *Overall impression*: I have looked over and played with all of the products and am impressed with their quality and sophistication. If the planned computerization of our labs goes though, I'll recommend their use in our introductory astronomy labs. I have recently taught that course and would be happy to replace 4 to 6 of the exercises with your programs. *Enables things you couldn't do w/ students before?* As written above, they got some feeling for actual astronomy data taking and data reduction.

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