AJJAR – Astronomical Javascript/Java Applet Resource

Siobahn Morgan
Department of Earth Science
University of Northern Iowa
Siobahn.Morgan@uni.edu

Abstract

The AJJAR (Astronomical Javascript/Java Applet Resource) project involves the production of portable, multi-platform astronomical programs that could be used by students at any level. The modules are in a variety of formats and include some activities that are purely for demonstration purposes while others require student involvement. The programs are written in a variety of formats including Java and Javascript. On-line instructions and teacher activities have also been included for some of the programs. At the present time these resources are being used at the high school and the university level. Future plans involve the development of more activities with more student interaction.

Introduction

Astronomy is the one science that is almost entirely visual and involves objects that are constantly changing in their characteristics of the location. Because of these aspects, it is difficult to convey its true nature in a classroom setting without the use of films, computer animation, and models. Such demonstrations may provide some insight into the workings of the sky and the properties of nature, but they are still distant to many students, and may not be completely successful in fully conveying the various phenomena, physical laws, and observable characteristics that they are designed to address. Another limitation is the use of a variety of computer platforms that may prevent educators from using all available software packages. Currently, university textbooks on astronomy include CD-ROMs with supplemental material, usually Quicktime movies of phenomena or small planetarium programs. But again, this is usually a passive experience for the college student and such demonstrations are not always accessible or at an appropriate level for K-12 students.

To overcome these problems, the AJJAR (*A*stronomical *J*avascript/*J*ava *A*pplet *R*esources) project was started in the Summer of 2000. The project was initially funded by the Iowa Space Grant Consortium's Seed Grant program. Dr. Siobahn Morgan, Department of Earth Science, University of Northern Iowa is the project manager. Curriculum packages were written by Aaron Spurr, Malcolm Price Laboratory School, U. N. I. and De Anna Tibben, Ames High School, Ames Iowa. There were also several undergraduate and graduate students who helped in the preparation of material for the project, including Jack Northrup, Earth Science Teaching Major, U. N. I., and Katy Schaefer, Science Education Graduate Student, U. N. I..

The purpose of AJJAR was to provide a wide range of educational demonstrations of astronomical phenomena to students, through the use of a web browser. The modules function on a variety of platforms and can be used by a wide range of students, both K-12 and university level. Since the interface to the module would be via a web browser such as Netscape’s *Navigator* or Microsoft’s *Internet Explorer*, the platform, Macintosh or PC, is generally not an issue. Also, the size of each module is designed to be as small as possible to allow portability and quick interface speeds.

With the AJJAR material available on-line, the cost of obtaining the software is not an issue. Even in the case of students and teachers who do not have Internet access, the modules can still be run from a floppy disk, zip disk or CD-ROM. The only cost would be in the production of the media, which is generally very low.

Some of the results from the AJJAR project will be presented here as well as future plans for the project. Currently the AJJAR website is located at www.earth.uni.edu/~morgan/ajjar .

Currently Available Resources

At the present time, there are more than thirty Java applets available on-line as well as several dozen image-map files. These cover the most basic applications and include material that is covered at all grade levels. The resources are broken down into several categories which include, Lunar Events, Solar Motions, Gravity, Planetary Motion, Astrophysics and Constellations. A brief description of the modules is provided below.

Lunar Events

These would include the phenomena such as the phases of the Moon and eclipses. One of the most common misconceptions in astronomy is an understanding in what actually causes the phases of the Moon. Most often people believe that the shadow of the Earth darkens the Moon and causes it to go through phases [1]. The simple truth is that it involves the positions of the Earth, Moon and Sun. The AJJAR demonstration is shown below in Figure 1.

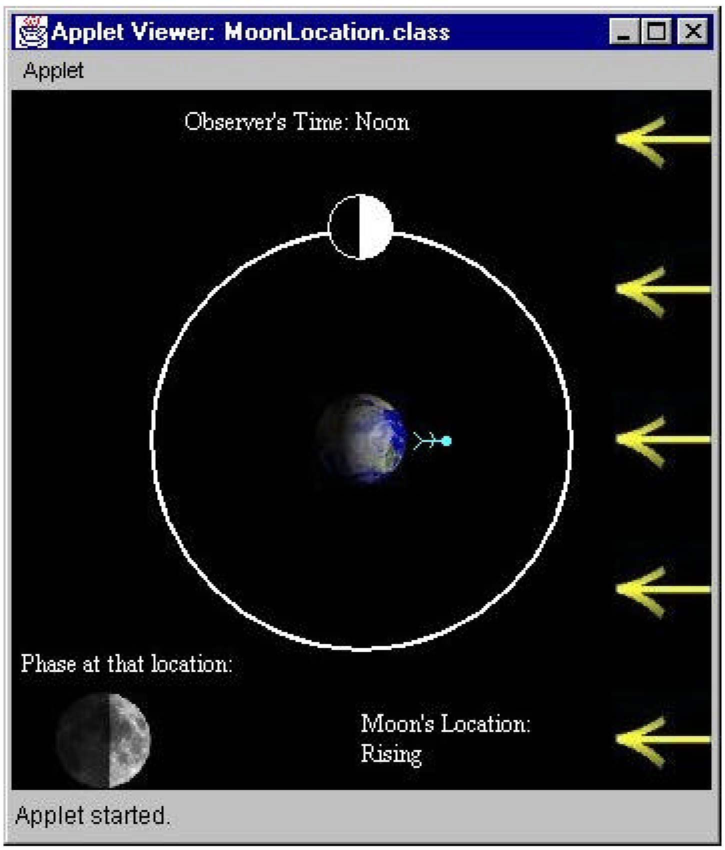

Figure 1. Lunar phases demonstration applet.

The applet allows the user to do several things such as changing their location on the Earth and changing the location of the Moon in its orbit. The phase of the Moon is displayed in the applet along with what the Moon is doing for that particular configuration. The only item of information that is missing is the name of the Moon's phase, which the user must determine as part of the activity. This applet is also available in a simpler form that shows only the phases at particular locations without the observer. The use of this applet allows the students to understand several concepts such as the dependence of the time of day and your location on the Earth, what it means when an object is "rising" or "setting" and of course how the phases of the Moon depend upon the configuration of the Earth, the Moon and the Sun.

Solar Motions

The motion of the Sun, including the seasonal variation of its path, make up the next set of modules. Along with the phases of the Moon, the cause of the seasons is a common misconception. A simple survey of 23 students at Harvard, as they were standing in line to receive their diplomas, showed that only two of them properly understood the cause of the seasons [2].

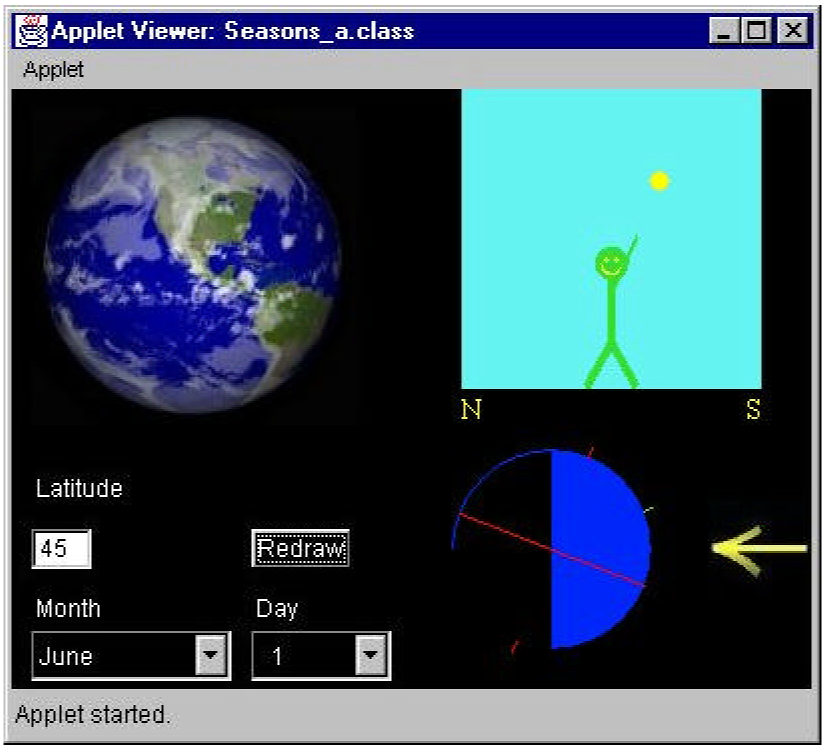

Figure 2. The changing location of the Sun over the Earth is illustrated here. The upper left panel shows the portion of the Earth that the Sun is located above. The upper right panel shows someone pointing towards the Sun. The controls are found in the lower left to change the latitude or the day of the Earth. The lower right panel shows the orientation of the Earth to the rays of the Sun and also the observers location.

The modules show this phenomena as well as the changing path of the Sun as seen from various locations. These modules require a higher level of knowledge, since the results are dependent upon several items to be input including the latitude of the observer and the date. For younger students, these modules can be used more for demonstration, but they can also be used for experimentation by the students.

In the most complex module several things are illustrated including the part of the Earth that the Sun is located above, the tilt of the Earth relative to the Sun's rays and a person pointing to the Sun. This is shown in Figure 2.

Gravity

The laws of gravity are very important to astronomy and these modules are very numerous. Some involve solving simple problems given a set of conditions. Most of the examples are in the form of how the gravity varies on other worlds compared to the Earth, since this is the most common reference that students have for gravity. There are several animations of the effects of gravity. These include the "jumping" activities. In this case students can go to other worlds in our solar system (including the Sun and the Moon) and see how high they would be able to jump on those worlds. This is shown graphically by a little person jumping up to the appropriate height. An actual test of their jumping abilities on the Earth is used as a baseline for comparison. Another version allows the students to define the conditions for the world they are on, such as the mass and radius in terms of the Earth. While advanced students could use algebra to numerically determine how high they would jump, younger students would be able to determine the relative importance of mass and radius on surface gravity.

A program based upon a BASIC program's calculation of impact crater characteristics is also included in this section. The BASIC source code [3] was modified for several different parameters such as the effects of an impact caused by different density material and impacts occuring on different worlds, the Moon and Mars as well as the Earth. Since this program was used by students in my astronomy course, I centered the impact crater initially on my office on the U. N. I. campus. The size of the crater and the range of destruction are provided to the student as they change the size, velocity and trajectory angle of the impactor. A comparison to the effects of an impact under different gravitational conditions can be illustrated by having it strike the Moon or Mars. Needless to say, this was a very popular homework activity.

Planetary Motion

The main component of these applets are demonstrations and activities involving Johannes Kepler's Laws of Planetary Motion. There are several different levels of complexity for the applets that range from simple demonstration to the determination of the mass of the star that the planets are orbiting. In the cases of the first two laws of planetary motion, the shape of the orbit is important in understanding the concepts. In both cases the orbit shape is controlled by a sliding control, to allow easier control. The second law is presented in several different ways, including information on velocity of the planet as it moves around the star and the concept of "equal areas swept out in equal times" which is a common way of phrasing the second law. A demonstration showing the "equal areas" concept is shown in Figure 3. A wedge is displayed at times showing how the shape of the orbit makes the shape of the wedge differ, though the size of the wedge remains constant. Users can also see that the planet moves at a greater speed when it is closer to the Sun.

Kepler's third law describes the relation of the average size of the orbit to the period of the orbit. This is presented in a variety of ways, including text only formats where the student must determine the size of the orbit given the period and also the case where the mass of the star can be calculated given the orbital parameters. A graphical version allows the students to measure the size and period of the orbits to determine the mass of the star. In some of the graphical displays, two planets are shown in orbit, which illustrates the effect of the differing orbital size to the period of the orbit.

While several of the planetary motion modules are very quantitative in the way that the material is presented, they can also be used for purely demonstration purposes.

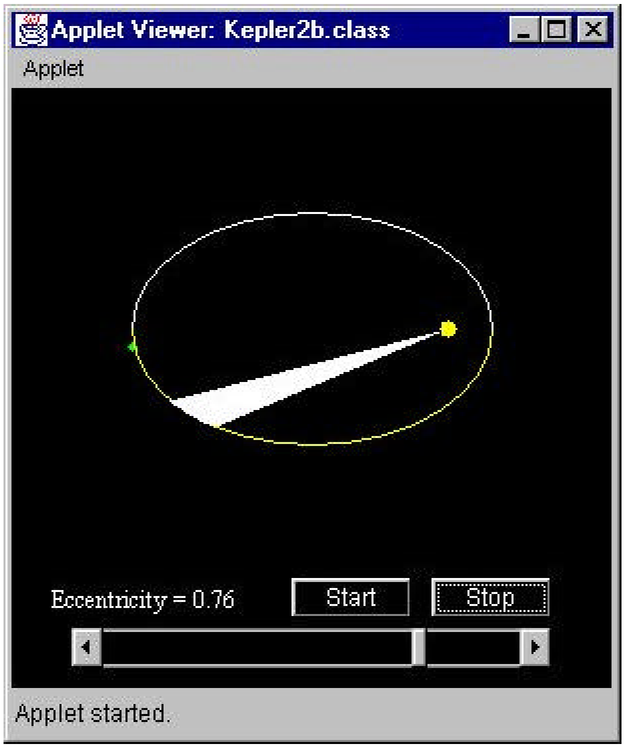

Figure 3. Kepler's second law is illustrated. A planet (green dot) in orbit about a star (yellow dot) for a rather elliptical orbital path. The white wedge is drawn on the screen periodically to show how the area "swept out" for a given time interval remains constant.

Astrophysics

These programs are intended for the high school astronomy student or for college level students. Several of the modules describe the physical nature of black bodies (radiation laws) and the fundamental graph used in stellar astronomy, the H-R diagram. This diagram can be used to show the range of stellar parameters, such as temperature and radius over the diagram. Another program demonstrates the tidal stretching that would occur as someone nears a black hole.

Constellations

Several click-on constellation charts are also provided. These allow students the chance to learn about the constellations and some of the stars and other objects located within them. There are two forms of the constellation charts, one with only stars, the other with stars and Messier objects. These objects are common targets for amateur astronomers and include many different types of objects, including galaxies, star clusters, star forming regions and the remains of dying stars. In the Messier object charts, images and information on the objects are provided at the click of a mouse.

Future Development

The first phase of the project is complete with some simple Java and Javascript programs available for use. We hope to expand this project over the next few years by including more modules that test students' knowledge and skills. This could include the following:

- Given the size and period of the orbit of a planet or binary star, determine the masses involved (quantitative skills, measuring and algebra)
- Place a star in the appropriate place on the H-R diagram given two of the following - temperature, radius or luminosity (algebra skills, graphing skills)
- Determine the velocity of a star or galaxy based upon its spectra (measuring, algebra skills)
- Input values for the orientation of an eclipsing binary system to match observed light curves (algebra, spatial skills)
- Identify stars and constellations (memorization skills)
- Determine the tilt of a galaxy based upon its rotation curve and how those two are related. Use the rotation rate to determine the mass of the galaxy (algebra, trigonometry, spatial skills)
- Parallax shift measurements that can be used to determine distances (algebra skills)
- Click-on maps of the Moon showing the major features, as well as a quiz on those features (memorization, qualitative comparison)
- Identification of solar system objects (memorization skills)
- Identification of different types of galaxies (morphology - shape skills)
- Comparison and identification of various types of a nebula (morphology - shape skills)

We will continue developing the modules and supporting material and will make it accessible to educators over the Internet or via other methods that are most appropriate. It is hoped that this site would be used by educators and programmers to develop more modules and enhance those already existing, since we intend to make the source code freely available. Instructor feedback will also be sought to enhance the modules and to provide modules where they are needed in the curriculum. Future funding will be sought from NSF and NASA as well as U. N. I.

References

1. Callison, P.L. and Wright, E.L. (1993). The effect of teaching strategies using models on preservice elementary teachers' conceptions about Earth-Sun-Moon relationships (ERIC Document Reproduction Service No. ED 360 171)

2. Schneps, M.H. (1987). A Private Universe [Film]. (Available from Pyramid Films and Video , 2801 Colorado Avenue, Santa Monica, CA 90404)

3. Goldman, S. J. (Ed.). (1996). When Asteroid Meets Earth. Sky and Telescope, 90-92.

Acknowledgements

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