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ASTRONET: planetary observations in remote collaborative web environment

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Abstract. In this paper we discuss the objectives, the key technical aspects and the main results of AstroNet, a Web-controlled telescope that can be simultaneously operated by small groups of users (2-20 in turn), like in a real astronomical observatory. AstroNet is the outcome of a collaboration between the Astrophysics group and the DIDA-Lab of the University of Salento and has been developed to respond to the increasing number of requests coming from schools and families about astronomy lectures and sky observation tutorials. In the last year, AstroNet permitted to about 1000 young students to perform rich observation experiences from both school and home, with the same global effort previously needed to offer a similar experience to about 100 people.
The recognition and the analysis of the main lunar geologic structures, the monitoring of the complex and diversified Jupiter atmosphere, the evolution of comets in proximity of perihelion are only some of the possible targets of observations and imaging sessions that are suitable to a great number of thorough analyses. Moreover, with the same instrumental equipment, even if with a more well-constructed approach, it is possible to start low cost scientific research projects in the field of asteroid photometry, variable stars or extrasolar planet transits.

Key words. Remote planetary observations

1. Introduction

From primary school to university, laboratories (hands-on activities) play an essential role in teaching physics and are an important resource for schools. Good pedagogical reasons, such as illustrating and validating analytical concepts, introducing students to professional practice and to the uncertainties involved in non-ideal situations, developing skills with instrumentation, and developing social and teamwork skills in a technical environment (Lindsay et al. 2007), illustrate the need for their inclusions in curricula. On the other hand, laboratory management can be resource-intensive and imposes significant logistics constraints to both managers (schools and universities) and users (teachers and students). As a consequence (in Italy, for example), school laboratories are usually unavailable for personal or group activities out of teaching hours, with negative consequences for disciplines like physics and astronomy in particular.

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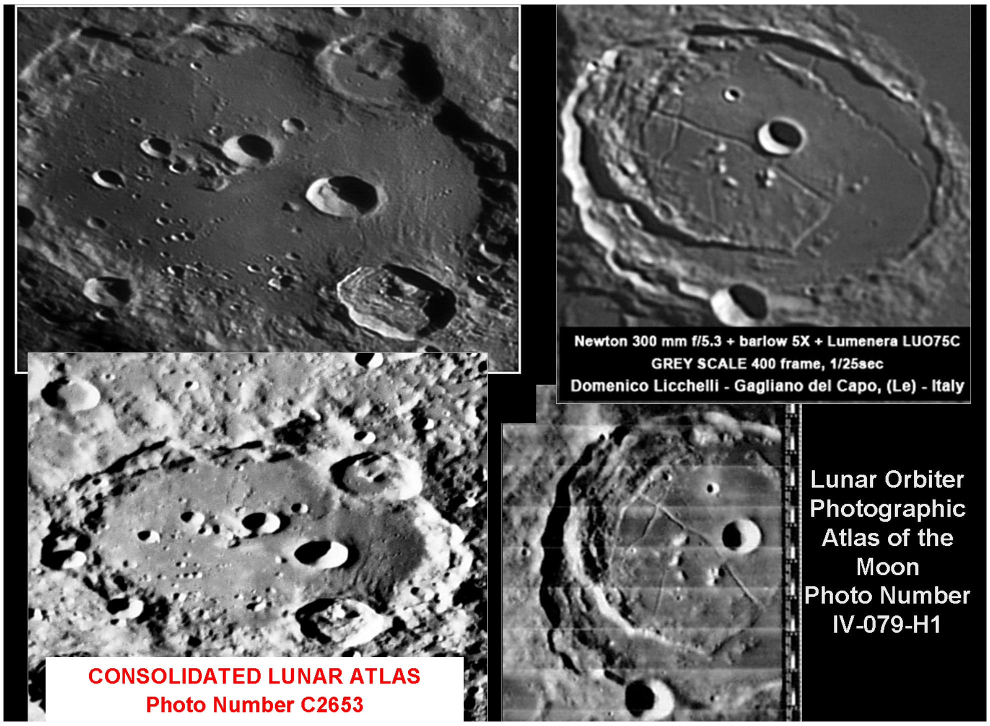

Fig. 1. An example of recent high resolution images of the moon taken with a small telescope compared with an older CLA image and a spacecraft one.

In the last decade, thanks to the availability of relatively low-cost, high-quality telescopes on the consumer market, amateur astronomy is enjoying a boom. The popularity of CCD's for astronomical imaging has grown exponentially and skilled non-professional astronomers have made also significant discoveries. The same resources can be used in an educational context. It is well known that students learn best through direct experience, and it is hard to overestimate the excitement and engagement of a student who has managed to see for the first time through a telescope Moon's craters or Saturn's rings. It is evident that an image a student has taken himself has a much greater educational impact than one found in a textbook or downloaded from the Internet. For most of the planets and satellites, the knowledge we have of their global properties comes from the observation of their surfaces and their atmospheres. Even if at present students can access to a several Gb of planetary images, most of they taken by dedicated spacecraft, it is much more exciting to reveal the subtle detail of a lunar rille or the evolution of the martian polar cap in his own images. For example, by studying the lunar surface they can have an idea of some of the major events that characterized the first billion years of solar system evolution (Fig. 1). The Moon is completely saturated with impact craters on its highland surface while on the dark maria the number of craters per unit area is much lower. This simple observation implies that the maria have been exposed to space for less time than the highlands, and hence have had less time to accumulate impact craters.

All planetary atmospheres show evidence for temporal variations, on very different time scales, diurnal and seasonal. The inclination of Mars' rotation axis generates strong seasonal effects. Jupiter and Saturn show a cloud structure along parallel belts and zones. These striking features result from the fast rotation of the

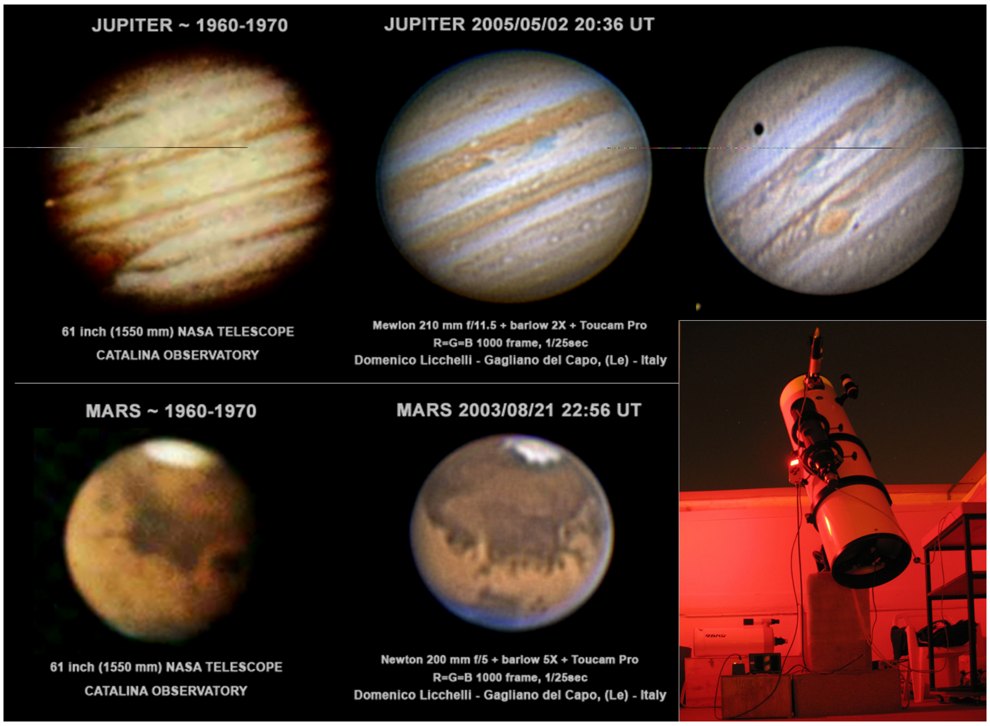

Fig. 2. Planetary atmosphere imaging is now accessible with good result even with an off-the-shelf telescope and a webcam.

giant planets associated with convective atmospheric motions. The zones are cloudy regions of ascending motion, while the belts, more free of clouds, are regions of subsidence. This type of circulation is similar to the Hadley circulation on Earth. Another striking peculiarity of the dynamics of the giant planets is the presence of cyclonic or anticyclonic features which consist of columns of ascending motion rising above their immediate surroundings and which are colder than their environment. The most famous of these features is the great red spot in the southern hemisphere of Jupiter (Fig. 2).

The visual observation has been replaced now by the digital imaging techniques that allow to minimize, within certain limits, the harmful effects of the atmospheric turbulence and, above all, to supply objective and easily measurable data that do not dependent, for instance, on the visual acuity of the observer. The technical combination of a webcam with image stacking and processing tools, controlled by a modern personal computer is truly staggering. Any student can now take planetary images that would have been the envy of professional observatories only 20 years ago. The principle on which the planetary digital imaging is based, is to acquire thousands of frame in very short times and then select and elaborate only those less ruined from seeing. The result, however, abundantly repays of the supported efforts in order to obtain it. As a matter of fact, the main orographic structures of the Red Planet, the main albedo spots, the polar cap eroded by increasing temperature of summertime, as well as clouds near the North Pole and the terminator are evident. Images of this type are also sufficient in order to follow the beginning and the possible evolution of sandstorms, that on Mars can also spread on a global scale.

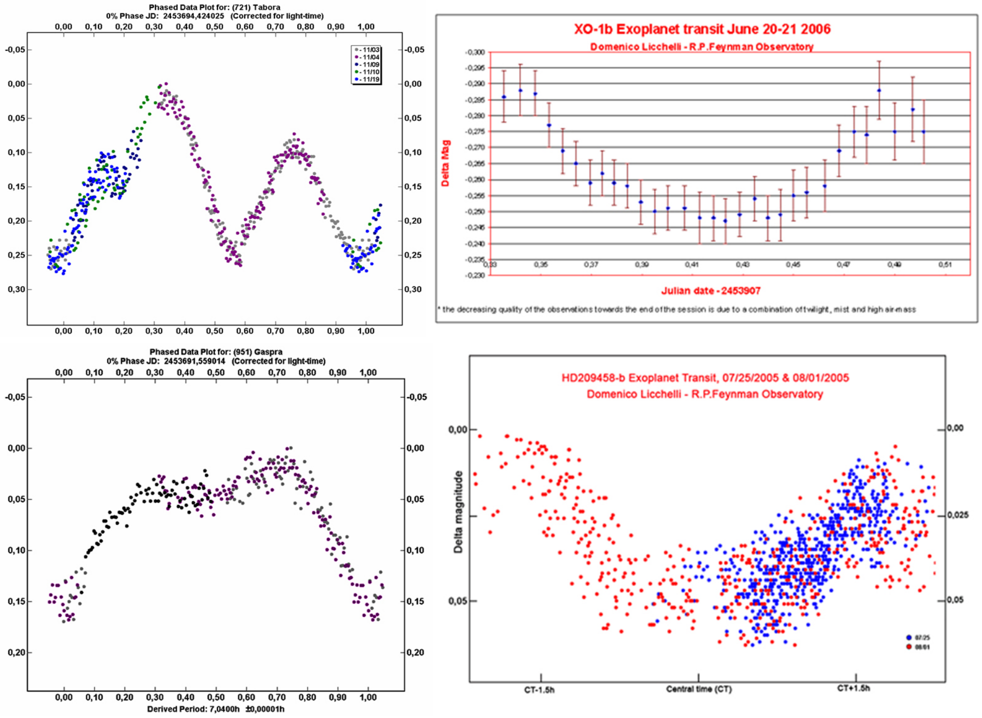

Fig. 3. Some example of asteroid lightcurve and exoplanet transit photometry obtained at R.P.Feynman Observatory.

2. The AstroNet project

Operating a telescope successfully still requires knowledge and experience often beyond that of many high school teachers and most high school students. Moreover, observing celestial objects requires telescopes and expensive CCD cameras that most high schools could not afford. So we tried to give a response to the question: can we provide students with inexpensive access to high-quality telescopes even if the school and the observatories are not located near each other? The answer is the AstroNet project, a Web-enabled collaborative telescope oriented to increase the occasions of practical astronomical experiences offered to the students of secondary schools, also in case of no dedicated staff and low resources. With this project we want to make protagonists the students, under the guide of a teacher, in the choice and search of an astronomical object to observe through a telescope, in the tracking of the instrument, the acquisition and processing of the images and in the analysis of data. The aim is to make the students aware of the importance of the observational methods and the data processing, to have knowledge of telescopes, focal plane instrumentation and their correct use. Further goals are to make understand the importance of the analysis of physical characteristics of the observed objects and to propose research projects or request observations on several telescopes at Fiorini Observatory located in Lecce (Italy) on the roof of the Physics Department and at R.P.Feynman Observatory, the own private observatory of one of us, located in Gagliano del Capo (Italy). The main telescope at Fiorini's Observatory is a 200mm Newton-Cassegrain reflector at f/5-15, currently in Cassegrain configuration. In parallel it is installed an Pentax SDHF 75 mm apochromatic refractor. The mount is an AstroPhysics 1200GTO. A CCD SBIG Research STL1301E coupled with a filter wheel (equipped with BVRI, RGB and narrow band filters), an Atik 16HRC camera and a Canon EOS 350D photo camera complete the equipment. This setup was used primarily for real time observation and didactic purpose.

The main telescope at R.P.Feynman Observatory is a 300 mm Newtonian reflector at f/5.3, supported by a 210mm Dall-Kirkham at f/11.5. In parallel it is installed a 80 mm semiapochromatic refractor. The mount is a Gemini G41 Plus Observatory. For the astronomical imaging is used a Starlight SXV-H9 CCD camera with a filter wheel (equipped with BVRI, RGB and narrow band filters), a Canon EOS 40D and a Lumenera LU075C. This setup is devoted to asteroid photometry (Delbò et al., 2006; Licchelli, 2007a), exoplanet transit search (Licchelli, 2007b) and high resolution planetary imaging (Fig. 3).

The first examples of remotely accessible telescope were logistically very simple - a single apparatus made remotely available to a single operator by means of software for connecting remote desktops to experimental equipment. Thanks to the growth of the Internet, this approach has rapidly become widely available and this paradigm has supported the early stages of research on learning outcomes. The students can participate to the astronomical observation sessions directly from school through the Internet. The main differences between AstroNet and the other remote access projects to instruments for astronomical observation can be sum up in three points. 1) It is possible to have completely access via Web and it does not require the installation of any other software on the computers of how may want to participate to the observation activities, besides the Web browser. 2) It is a collaborative/cooperative project: the participants share the astronomical observation experience in the sense that everyone is able to see and hear all the other participants while he manages the telescope and CCD camera. It is up to the supervisor to allow the telescope control to who makes a request (one at a time) while the others attend or take part with voice or in chat in the web session. 3) AstroNet allows the management of any device coupled with the telescope, provided with the hardware or software computerized interface.

As far as the first point, AstroNet is based on the streaming capabilities of Adobe Flash Media Server (FMS) software in order to allow all the participants to receive and transmit their own audio/video flows, coming from WebCam and microphones, in the same way to what happens in a multi-conference. The video coming from the instrumentation in the observatory ("The Sky 6" software to guide the telescope, the software for the CCD camera, the video signal coming from the high sensibility camera coupled with the finder) are also acquired, compressed and send in streaming to all the group by means of FMS.

The choice to adopt FMS for the management of audio/video flows requires that every participant is equipped with Adobe Flash Player, suitably installed on own computer. The wide diffusion of this plug-in, available for every operating system and Web browser, and installed on most of computer connected to the Internet, make AstroNet completely accessible as application-oriented web service, and it does not require the installation of additional software to who wants to participate in the astronomical observation session (Fig. 4). Using FMS for the streaming, AstroNet is a direct access user service also in the presence of Firewall, provided that the FMS standard communication ports are qualified.

In order to allow the remote control of the telescope and the CCD camera guide applications, it was instead necessary to develop a specific facility able to direct again, towards to mentioned applications, the keyboard and mouse commands captured on the computer of the customer from time to time qualified by the supervisor for the telescope management. Such facility is written in ActionScript and Javascript for the client part, and in Active Server Pages (ASP) and VisualBasic 6 with access to the Windows Application Programming Interface (API) for the server part. The communication between client and server occurs on the door number 80 by means of post of demands for ASP pages with parameters, and is begun from the client, therefore commonly it is not blocked from firewalls.

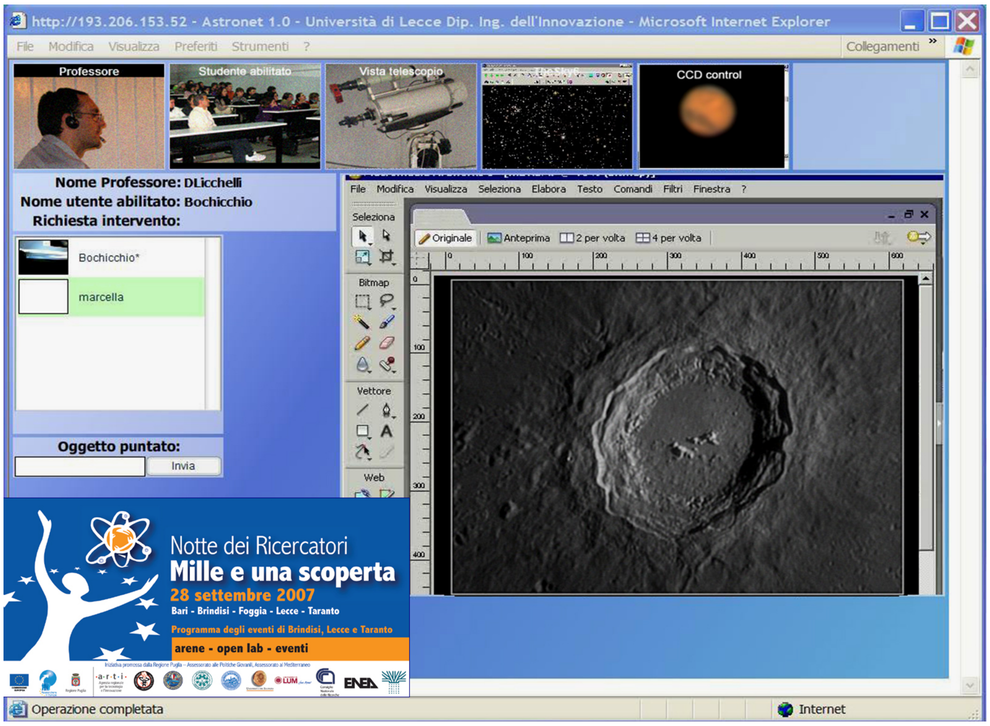

Fig. 4. AstroNet webpage during a public demonstration of the project.

3. Conclusion

More than one thousand students have participated altogether at the remote observations and imaging sessions. It has certainly been an initiative that enjoyed a huge success as also confirmed by the quality of the output (pictures, films, written compositions) produced by the involved students. The effort of the Astrophysics group and DIDA-Lab to bring knowledge outside the world of the universities and to interact with the region, has been well understood and many people are firmly hoping a greater frequency in proposing this type of initiatives. In particular, pressing requests have been from the teachers of the schools involved in this initiative who have seen in the observation events a natural compendium of the lessons in the classroom.

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