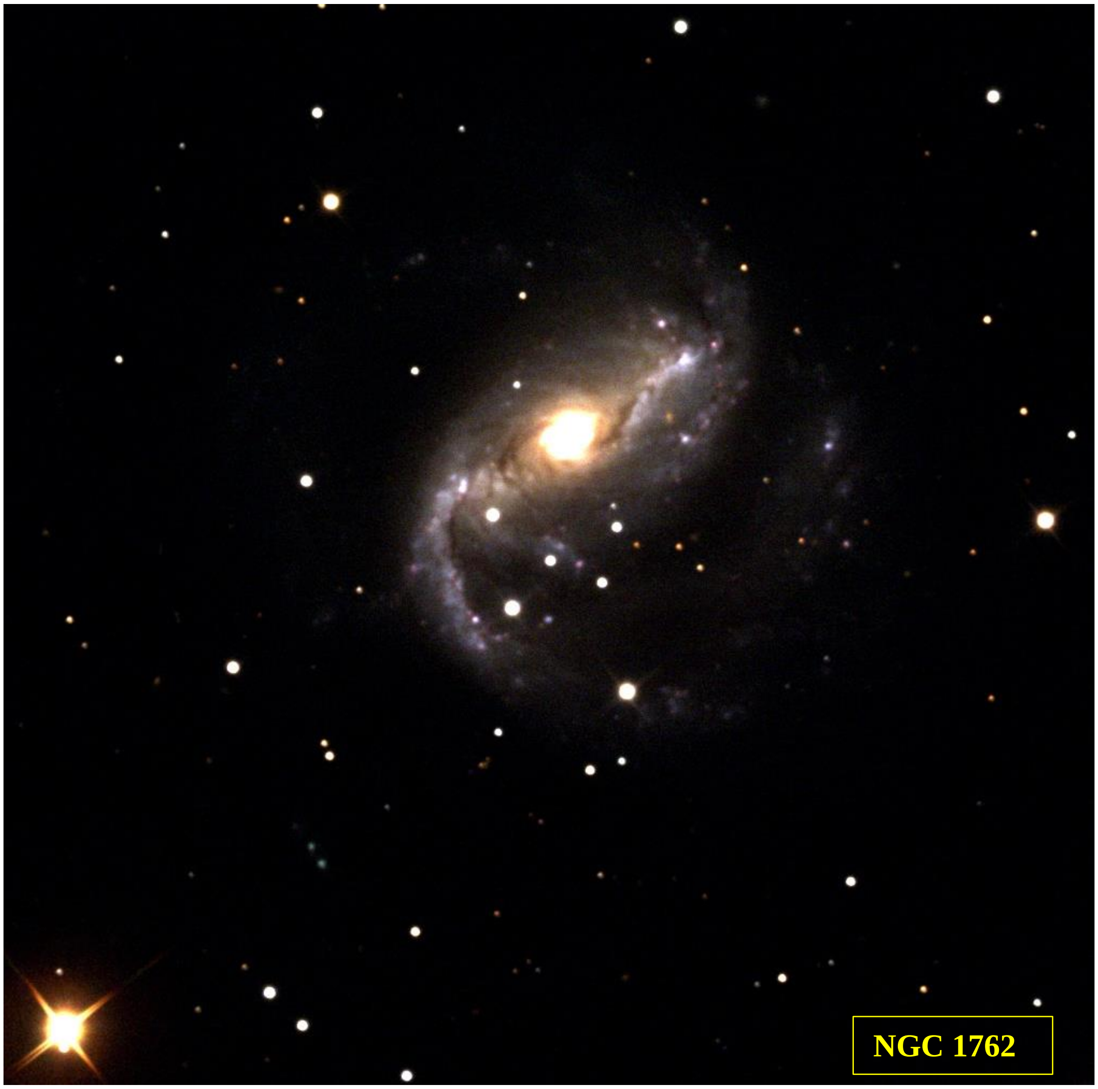
Cosmos in the classroom



An offer to share the sky through educational activities

INSTITUTO MILENIO DE ASTROFÍSICA

Cosmos in the classroom

We propose you to share with us the wealth of superb astronomical skies of Chile to open a window to the universe, in real time, in your own classrooms. Due to its very particular geographical conditions the North of Chile carries the mixed blessing of hosting the Atacama Desert, the driest desert in the world. A good side of this is an outstanding number of clear nights per year (more than 340 on average). These conditions have prompted an explosive development of astronomical observing infrastructure including internet connectivity. There are now a few observatories that can offer remote online access. This allows any person in the world to reach and control a sizable telescope in a superb site, only with a computer running any standard operating system.

About us

- The undersigned, Alejandro Clocchiatti, is a professional astronomer working at the Institute of Astrophysics of Catholic University of Chile (PUC) since the late nineties, and associated as well with the Millennium Astrophysical Center (MAS) and the CATA Center for Astrophysics.
- Clocchiatti is in charge of the CATA 500 telescope, a 0.5 meter telescope located at *El Sauce Observatory*, under the umbrella of MAS and the technical support of Obstech Company.
- As a professor of the Institute of Astrophysics, Clocchiatti also coordinates access to the Teaching Observatory of PUC which also hosts a couple of 0.4 meter telescope that offer remote internet access. The PUC observatory is south of the Atacama Desert, closer to Santiago city, but still a great astronomical place for teaching purposes.
- Dr. Clocchiatti collaborates with Dr. Sung-Chul Yoon, who works at the Department of Physics and Astronomy of Seoul National University, who is kindly helping us to get in touch with your school.
- The following links provide information about our institutions and activities:
  - www.astrofisicamas.cl/en/
  - astro.uc.cl/en/
  - www2.astro.puc.cl/ObsUC/index.php/Main_Page
  - obstech.cl/

The advantages for Korean Schools

The weather pattern of the Atacama Desert is such that most of the good nights occur between September and April, almost perfectly synchronized with the academic year north of the equator. In addition, the difference in time-zones between Chile and Korea means that in Chile we are observing the stars when young people in Korea are in the classrooms.

Hence, it would be perfectly normal for a professor or students in Korea, *during a class*, switch-on a computer, open a remote desktop, access the software that controls our telescope, and issue specific commands to point at a given place in the sky, obtain images, download them at once, an continue working for a given project (science, artistic imaging, etc.). If preferable, the telescope could be locally operated in Chile by a night assistant in contact with the Korean teacher and students through an on line communication software (Skype, Google's hung-outs, etc.). Another advantage for Korean Schools is that our services will be free. Operations of the CATA 500 telescope in Chile are being partially supported by funds from a Korea-Chile grant, administered in Chile by MAS. We feel that it is a fair retribution to open this possibility to Korean young citizens.

The advantage of working with us

We are a large team of astrophysicists, educators, engineers and technicians, with strong interest in education. We work in coordination to design and conduct activities that start from observing objects in the sky but work down from them to reach many dimensions of learning. These typically include geometry, mathematics, physics and computing, but provide insights and motivations to deepen our knowledge of history and general culture. (Astronomy is a truly multidisciplinary STEM discipline!) There might be other observatories and telescopes scattered around the world where you can request images. We, however, are more than a telescope and a detector. We are a team of astrophysicists, educators, engineers and technicians who do care about education. We know it is fun to open the telescope and obtain the images, but also know how to go from the pleasure of the aesthetic to the thrill of computation and the deeper messages of the science.

Why are we doing this?

It is, in the short run, retribution to Korea for her support to run the CATA 500 telescope: We feel that giving something back is the right thing to do. In the middle term, it is a challenge we impose on ourselves: We want to test this model of teaching support and specific activities by working with one of the most demanding educational systems in the world. In the long term, we would like to strike reciprocity deals with other observatories in Korea to be able to access telescopes there when Chilean students are in the schools. As 21st century astronomers, we aim for a future where all the students of the world can share all of the sky, in real time.

Are you interested in a demonstration?

Dr. Clocchiatti will be visiting Seoul from June 25th to June 29th and will be happy to visit your school and provide a real time example of how the "Cosmos in the Classroom" remote observing activities work. If interested, please get in touch by e-mail with Dr. Alejandro Clocchiatti (aclocchi@puc.cl) with copy to Dr. Sung-Chul Yoon (yoon@astro.snu.ac.kr), to coordinate a demonstration at your place.

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An example of activity:

The activity that we present as an example is one of the more challenging and demanding, but it shows the multiple dimensions spanned by astronomical observing with modern detectors. It is geared to senior High School students who already have, or are eager to obtain, some knowledge of basic statistical concepts and have, or are eager to obtain, some fluency in computer programing simple numerical tasks (using any of the widely distributed high-level programing languages). It would be also well suited to university students in early stages of science education.

Colors of the stars and their temperature

Although it is not widely recognized stars do have colors. The colors of the stars work exactly as those of a hot piece of iron or a flame. The cooler they are the redder the color and the hotter they are the bluest they shine. So, color can be regarded as a bias in the production of radiation. Actually, the piece of hot iron (as well as the stars) produces light with all the colors. But, when it is very hot the bulk of radiation shifts to the blue and when it is cooler it shifts to the red. This realization gives us a strategy to "measure" colors: measure separately the light of the stars in the blue and red parts of the spectrum, and take the difference. To select the light of a particular color we put a filter, essentially a piece of colored glass, in front of the detector.

The universe provides us with star clusters, which are spectacular objects to play with the previous concepts. They are congregations of stars, from thousands to tens of thousands, which remain together tied by their own gravity as they move around the Milky Way.

The activity is to aim the telescope at one of these clusters, take image sets in three different colors (red, green and blue, to obtain an RGB image) and then work with them. The activity has many levels, which can be accessed or not depending on the stage and formation of the students, and the pedagogic goals that the teachers have in mind.

Each of the images taken is a digital array of three dimensions [x, y, z] where [x, y] describe the position of the pixel in the image and z the intensity of the light that fell on the pixel. Working with the images is intrinsically a computational challenge. There are packages of software in public domain already prepared to do this kind of work. If the schools plan to develop the computational skills of their students, the astronomical images offer a perfect sand-box case to do it. If the pedagogic goal is "do it all" then the tasks and concepts involved will be:

1. Digitally cleaning the images

   Astronomical grade detectors are very sensitive but typically carry many little defects. Also, each pixel has a slightly different sensitivity. In order to obtain a good working image some calibration and cleaning steps have to be taken.

Each of the image sets taken includes special images used for cleaning and calibration purposes. They are called "calibration images". Preparing and using the calibration images requires to take averages of their [x, y, z] arrays and subtracting, multiplying or dividing the results into the individual images of the star clusters. Concepts involved are those of basic statistics (averages, dispersion, deviant values, etc.)

2. Combination of star cluster images.
   Astronomers do not take just one image for doing science. Small defects in the detector chips that cannot be corrected for in the previous step, plus the presence of cosmic rays, and even human made lights (like artificial satellites that pass in front of the telescope) are nuisances which routinely appear on science images. The strategy for solving this is to take many images of the same object and combine them. Again, this stage consists of working with the [x, y, z] arrays, finding stars in them, aligning the stars of different images, and then combining the signal. Concepts at work are simple transformation of Cartesian coordinate systems and, again, basic statistics as before.
   Steps (1) and (2) would leave us with beautiful images of the star cluster in three different colors.
3. Working with the astronomical images
   a. A first result is to combine the three images into one RGB pseudo-color image which can be digitally displayed and/or printed with high resolution in photographic grade paper. This is, already, a cool result that allows us humans to perceive by eye the typically small differences of stellar colors and makes most kids that we know really proud[1]. The image of the galaxy NGC 1762 shown on the cover of this document is an example of a CATA 500 image produced through this kind of processing.
   b. A more serious result requires some programing, or using specific software to add-up the signal around each star of the cluster. Out of this one gets a measurement of the flux in each color and can do some science answering questions like: How is the distribution of stars with temperature? (Are the cooler stars more frequent than the hotter noes?) How does stellar brightness relate with color? If we organize the stars according to brightness *and* color: Do we find some order? Are there "families" of similar stars in the cluster? Think again of the hot rod of iron: Can we make inferences about the relative sizes of different families of stars from the brightness *and* color we measure?

[1] A simpler, pre-digested, activity suitable to younger students in earlier stages would be to do the observations, but, after that, directly provide the students with the clean images in the three different colors (RGB) to allow them to concentrate in the combination.