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"Closing in" the Circle with New Researchers in Astronomy

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Abstract

Having high school students work with professional astronomers in a favorable environment, such as in a research institute or university physics department, may lead to surprising results. This article describes a program in which high school students in Argentina worked with astronomy researchers on a common project and then published their findings.

Where is the best place for a new physician to do his or her special practice before graduation? The usual answer to this question is, of course, a hospital. What about a teenage prospective astronomer? In this short article, we want to point out that a six-month *stage* within an astronomy group might help high school students to become acquainted with fundamental aspects of astronomical research, and at the same time, have lots of fun.

With the financial support of Fundación Antorchas (http://www.fundantorchas.retina.ar/), a local private science foundation, the Institute for Astronomy and Space Physics in Buenos Aires announced in late 2003 that several educational *stages* were available. Research subjects spanned a broad range from satellite surveys and natural resources to numerical simulations and galaxy formation. To apply, students had to be in their final year of high school, 16 or 17 years old, and ready to spend a few hours a week doing science.

The tutorship that I conducted was on observational astronomy, and I will now concentrate on my *stagiaires*. The application to get the position included handing in a CV, a high school certificate with marks of the previous year, and a letter of motivation stating clearly the student's interest in science in general and in observational astronomy in particular. Dozens of applications had to be reviewed, and a list of five finalists remained for the second round, which was a personal interview with me.

I must say that it was a difficult selection. Many extremely motivated students had to be left aside. In the end, we filled the two positions available, taking special care to select those two students who would work well in a group of three (tutor included). We wanted to reproduce in a small-scale educational "experiment" what real scientists do in their research: discuss with colleagues and senior researchers and work together on a common project.

Last year was Venus's transit year, and so it was no surprise that my students chose this topic as their research subject. A rare astronomical event was just months ahead: on June 8, 2004, Venus's black disk was about to transit in front of the Sun for the first time in 122 years, and we all were the first living witnesses of this peculiar conjunction. Quite soon, we realized how to make the best use of the grant offered by our private science foundation: we bought a telescope and a solar filter.

The students began reading about and investigating the Solar System, the physical conditions of the different planets, and, of course, their movements and the occurrence of planetary transits. They searched the literature from 19th-century texts (e.g., Flammarion 1880)—and even older ones, where they found the first speculative hints about the atmosphere of Venus—to the most recent popular stories published in astronomy magazines (e.g., Westfall 2004) and Web sites (e.g., Fred Espenak's site http://sunearth.gsfc.nasa.gov/eclipse/transit/venus0412.html). They also followed short introductory courses delivered on a couple of Saturday mornings by fellow researchers of our institute.

Focusing on Venus's transit, they realized that most of the literature focused on northern hemisphere observations, which did not help in our project. Thus, they decided that it was necessary to "run" simulations of the astronomical event themselves. They learned how to use standard astronomical software for this task and succeeded in simulating the appearance of the transit as seen from our city.

They found the real trajectory of the silhouette of the planet to be a straight line on the disk of the Sun, going roughly (as seen from Buenos Aires at latitude 34 South) from 4 o'clock to near 12. In contrast, typical northern hemisphere predictions were several degrees different. For example, for New York City, at latitude 40 N, it was 74 degrees (40 + 34) rotated clockwise compared with what we saw from our location.

From the total transit, just the last part of it was observable from our latitude (the transit was under way at sunrise also for New York), and it took place right above the horizon, which made the contacts' timing a mission impossible because of the black-drop effect (Westfall 2004). Nevertheless, the picture we got was nice and reflects the remarkable distortions in the disk of the Sun due to the turbulent atmosphere during that partially clouded cold winter morning on the River Plate (see Figure 1).

Figure 1. Photograph of the last Venus Transit (June 8, 2004) taken by our group from the shores of Buenos Aires city. We used a Yashica FX-3 2000 camera with solar filter mounted on a Maksutov-Cassegrain Meade ETX-125 telescope. Exposure time 1/1000 second at ISO 100.

During their research, the students found that there is an unexpected "conjunction" between the transit of Venus and the cinematograph (Sicard 1998) and decided to pursue the issue further. They then rediscovered the works of the French astronomer Pierre Jules Janssen and his attempts to make use of early astronomical imaging devices to record this rare astronomical event. For that, Janssen had invented the "photographic revolver" and traveled to Japan in 1874 to capture the first Venus transit of the 19th century.

Janssen's machine turned out to be the forerunner of the chronophotograph employed by the French physiologist Etienne-Jules Marey and also by Eadweard Muybridge in 1878 in his studies of animals—horses in particular—in motion (Muybridge 1899). Soon afterward, it led in 1891 to the kinetoscope of Thomas A. Edison, and finally, to the Paris *première* by the Lumière brothers in December 1895.

The main astronomical show of the 19th century, when Venus took away its thick cloud veil and let its silhouette be seen after getting in the spotlights of the Sun, opened the doors to the cinema, one of the main artistic revolutions of the 20th century.

The science-and-society connection was simply too interesting to be confined to a footnote in a scientific report. The students then decided (and I supported the view) to explore the connection further and attract attention by writing a short article on the transit of Venus. The article, written in Spanish, was published in the science section of one of Buenos Aires' mass-circulation newspapers, *Página 12* (Capdevila & Linares Moreau 2004, http://www.pagina12web.com.ar/suplementos/futuro/vernota.php?id_nota=829&sec=13).

Conclusions

Quite unexpectedly, the astronomical stage of my students closed a full circle that began with the investigation of a brand new subject (for them) and ended with the publication of an original short paper.

Let me now briefly enumerate the different steps that they followed. First, they began by choosing an interesting topic. Then, they made a detailed study of all the literature at hand and consulted libraries and databases. After this came the research work: some algebra and trigonometry to understand parallax computations, and lots of historical literature to understand the importance of the transits for estimating the Astronomical Unit—Edmond Halley's pioneer works of the 1710s, James Cook's travel log to Tahiti, and, of course, Janssen and his photographic revolver.

Every week, the students had discussions with their colleagues and with me. They then prepared a review report of everything that they had learned and presented their studies to an audience composed mainly of other students of the same age—a sort of peer presentation. With the feedback, they perfected their knowledge on the subject and sent the short note to the newspaper explaining the relevant connection between the early astronomical imaging methods, the invention of chronophotography, and the birth of the cinema. They also posted an extended review (http://www.cielosur.com/alejandro/alejandro.htm) in an electronic Latin American astronomical journal.

The students succeeded in reproducing, on a small scale, an educational project what we (researchers and teachers) normally do during our scientific activities. A happy end point (or should we say the beginning of a future scientific career?) we could not have foreseen when we started to work together.

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