

## FROM THE ATOM TO THE STARS: ASTROPHYSICS AT SCHOOL

### Some educational considerations about an astrophysical laboratory for undergraduate students in Italy

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#### 1 FROM THE ATOM TO THE STARS: ASTROPHYSICS AT SCHOOL

In 2002 the Istituto di Fisica Generale Applicata of the University of Milan and the high school "Liceo Ginnasio G. Parini" in Milan started to collaborate in order to set up an astronomical laboratory. The history of the two institutions shows some common points: Liceo Parini is a historical high school, the first in Milan, founded in 1774 in the centre of the city, within the Brera Palace. The Istituto di Fisica is also located in the Brera Palace where it gave birth to the Brera Astronomical Museum – which hosts both the collection of some instruments of the Brera Astronomical Observatory (founded in the Brera Palace in 1764) and a collection of astronomical and physical instruments of the University of Milan (XVIII to XX century) [1]. In 1935 the high school Parini was moved in a building close to the Brera Palace. It was equipped with a dome which in recent years was no more in use until it was restored.

The rationale to work together comes from these connections but, even more, it descends from the fact that for twenty years the Istituto di Fisica is engaged in the dissemination of scientific culture and educational activities for schools. [2]. Thanks to a sponsorship of the Province of Milan it was possible to restore the old dome located in the upper part of the building. The dome was soon equipped with a telescope (a 28 cm f/10 Schmidt Cassegrain reflector by Celestron), a spectrograph and a CCD camera (both commercial ones built by SBIG), partially thanks to a sponsorship by the company Auriga in Milan. It is a kind of equipment that makes the dome suitable for educational use.

As such instruments are not common in a high school context, there was no personnel able to carry on the laboratory, so the cooperation with the university was established in order to prepare the contents of the laboratory and solve the connected technical issues. This was made possible thanks to the previous experience the Istituto di Fisica acquired in carrying on a laboratory in the historical dome of the museum (the Merz dome, 1875, with the telescope made in 1863-65 and used by the famous astronomer Giovanni Virginio Schiaparelli). The laboratory of the Liceo Parini started in 2004, and every year it gives the possibility to 30-50 students to attend it.

The main experience aims to perform stellar spectral analysis and classification through the Harvard sequence: it is fully described in the paper "From the atom to the stars: astrophysics at school" by D. Cenadelli and M. Zeni

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presented at GIREP EPEC 2007 conference. Attention has been paid to the theoretical as well as experimental issues, as well as results and discussion. As a short summary we remind first that the preparation of the experience is done together with the reference teacher of the students involved in the laboratory. Then a series of about 5-6 lessons is made by the university researchers. It introduces the students to the theoretical framework, without any need of a special previous preparation (the suitable level of knowledge is the one corresponding to the last two years of the high school, age 16-18). After a practical introduction to the observational methodology and the calibration issues, the students carry out the observations during 10 to 20 nights of observation, obtaining about 100 stellar spectra. Analysis and interpretation follow, with the help of the teacher and the university personnel. After the classification is made, stellar radii are calculated. Although a small telescope is used and it is sited in the centre of a large city, the students obtain good results: the estimated stellar radii agree to the order of 10-20% with known results (see the above mentioned paper for details).

In 2005-2006, a national project, named "Progetto Lauree Scientifiche" started. It aims to foster among the students the interest for science, especially physics, mathematics and chemistry, and promote their choice of a scientific career at the university. Within this national project it was possible to promote other experiences in the laboratory: the "Laboratory on the 3<sup>rd</sup> Kepler's Law" [3] with the Jupiter-satellite system was carried out (and it will restart in 2009, after the period in which the best visibility of Jupiter will happen in summertime). In 2006, the occurrence of the Heliophysical Year suggested a "Heliophysical Laboratory" to be carried on, and in 2007 the "Moon Laboratory" started.

It is important to notice that such laboratory gives the students the opportunity to face experimental astronomy, an absolutely unusual experience for high school students in Italy and in many other countries. Taking into account that astronomy is a fascinating matter for young people, this turns out to be a good occasion to promote their interest for scientific items and to create a bridge between physics and astronomy.

As the laboratory is located in the school, and not elsewhere, it became part of the scholar curriculum. A teacher of the school was trained to carry it on, and thanks to the collaboration with the university the laboratory is now open not only to the students of Liceo Parini but also to some students of other schools in Milan and their teachers, aiming to become a reference school laboratory, and a meeting place for students, teachers and researchers of the university. This kind of structure in the end fostered a strong relationship between high school and university.

The methodology used deserves a consideration: in fact the students attend the laboratory following a "university-like" methodology, according to which each step of the laboratory has a great role: theoretical framework, instrumentation, training to experimental work, calibration, error analysis, interpretation, ... Moreover, each student plays an active role in the laboratory (especially in the data collection and analysis): it is greatly stimulating for the students and it leads them to learn how to work in group, like in a sort of research-équipe. This is useful not

only in the case of a future scientific career but, more generally, as a meaningful step in the educational process. Finally the selected items for the different experiences in the laboratory are particularly noticeable because they have a strong historical background but, in the same time, they are still present in the contemporary astrophysical research and it gains a strong interest by the students.

Of course, there is a number of open questions tied to this kind of laboratory. First, an experience like the spectroscopic classification is very demanding both in terms of required time and conceptual difficulty. Thus, it isn't suitable for each student in a classroom, as well as for their teachers. But thanks to the availability of such an equipped laboratory it is possible to prepare several kinds of experiences with different levels of difficulties and engagement for students, like the ones mentioned above (the Moon laboratory or the Heliophysical laboratory). Furthermore, one important point is about learning issues and the results on the students' achievements in the long run: we have not tested it in a structured way, but the results obtained via the informal questionnaires usually submitted to the students are extremely positive. But an open problem remains about what the students will retain in the long term.

Finally, it has to be remarked that it is sometime very difficult for the students to organise their participation to the laboratory (and in particular the turns to observe, the exchanging of data and the collaboration for analysis) but we also have to remark that such an experience often represents the first one in which students have to organise themselves in a structured group of work with both personal and shared responsibilities.

At the beginning we gave a short abstract on the history of this laboratory with the hope that it could be considered as an example to replicate it in other school contexts. Even if a school has no enough funding or technical, theoretical and experimental skills, our experience highlights that a good collaboration among the schools, the university and the local institutions allows to build up high level and well-equipped laboratories, useful for a lot of students of several schools.

## REFERENCES

- [1] The historical heritage preserved at the Brera Astronomical Museum can be reached at the web address [www.brera.unimi.it](http://www.brera.unimi.it). For the history of the Brera Astronomical collection and the catalogue: Tucci P et al. (2000). *I cieli di Brera: da Tolomeo a Balla* (Milan: Hoepli), only into Italian.
- [2] For information on some of the activities available every year for schools see the already cited address [www.brera.unimi.it](http://www.brera.unimi.it) (mostly into Italian).
- [3] Cenadelli D and Testa A 2006 *La Fisica nella Scuola* **XXXIX** (3) 122-133.