SF2A 2012
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TOOLS FOR TEACHING RADIO-ASTRONOMY

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Abstract. In 2011, the worldwide radiotelescope ALMA (Atacama Large Millimeter Array) has started preliminary operations. Radio-astronomy is thus entering a new golden age, a fantastic opportunity for widening formal and informal educational training and public involvement, for making a science impact on young people. The EU-HOU consortium has developed a small radiotelescope network (6 antenna) spread over Europe and directly accessible from the web via a remote control interface. These antenna are mostly dedicated to high school teachers in the context of the COMENIUS European commission Lifelong Learning Program: "Connecting classrooms to the Milky-Way". However, such small antenna can also be used to teach at University and introduce students to radio-astronomy principles.

Keywords: Galaxy: kinematics and dynamics, Miscellaneous: Science Education

1 What is EU-HOU ?

The present project is part of the COMENIUS European commission Lifelong Learning Program (2010-2012). It is coordinated by Anne-Laure Melchior and Roger Ferlet (University Pierre et Marie Curie, UPMC), in the framework of the EU-HOU consortium (Hands-On Universe - Europe) whose main goals are to (i) raise the attractiveness of science education, (ii) participate to the development and modernisation of learning technics in EU schools and (iii) promote scientific methods/knowledge. The EU-HOU consortium has been structured through the 2004-2006 MINERVA project that involved 8 European countries. This first project was then followed by a COMENIUS program (2008-2010) involving 14 European partners. The actual project was built in the perspective of the future large radio-Submm facilities: ALMA[i] (Atacama Large Millimeter Array), SKA[ii] (Square Kilometer Array). It involves 11 countries and is focused on radio-astronomy. The consortium has delivered education material (updated versions of the SALSA-J software, exhibition on Radio-Astronomy, exercices), organised teachers training sessions, and built a radiotelescope network for teachers and schools.

Fig. 1. Radio-telescopes installed in the Paris Observatory campus.

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[i] http://www.almaobservatory.org/
[ii] http://www.skatelescope.org/

2 A radiotelescope for high school students

The main purpose of *Connecting Classrooms to the Milky Way* was to develop the first European network of radio-telescopes for education, enabling European schools to explore the Milky Way via the HI emission line through the Internet (with a simple web browser). The scientific drivers, for setting up such tools, are (i) to derive the Milky-Way rotation curve and to discuss the need of dark matter (ii) to map the Milky-Way spiral arms structure and to discuss our place in the Universe. In order to do so, we provide the teachers with a multilingual (i) scheduling system to access the telescope (ii) remote access to the 5 telescopes (iii) archive to retrieve and/or analyse previous observations (iv) simulator to perform the exercise offline, with higher quality data (from the LAB[iii] (Leiden-Argentina-Bonn Survey) survey (Kalberla et al., 2005).

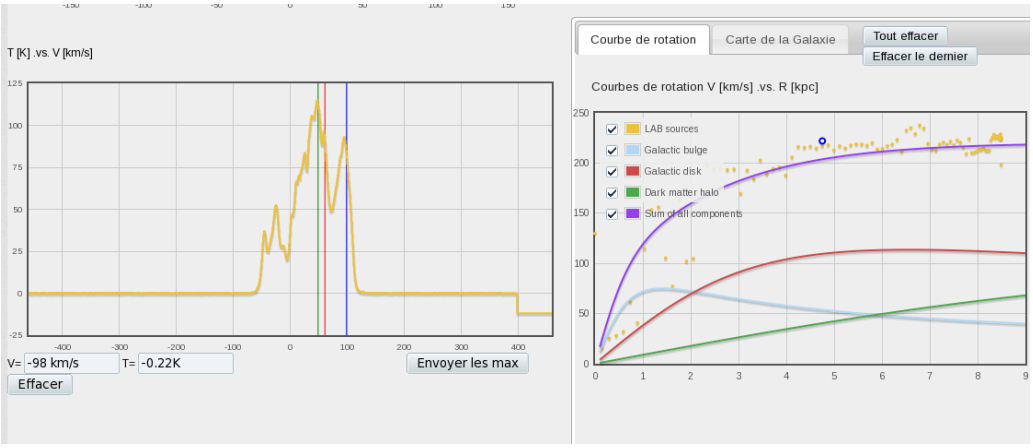

Fig. 2. Milky-Way rotation curve derived from HI observations with the EU-HOU-Simulator.

The website is accessible at `http://euhou.obspm.fr/`. Any teacher can go to this page and register. Once he has open an account (under the control of a local administrator), he can book a free time slot on any antenna of the network. The connection to the Observer page (the remote control interface) will be possible during this time slot only. Simple input are required: position on the sky, observing frequency, integration time. The interface provides the users with interactive maps in Az/El and Galactic Long/Lat coordinates. A web-cam shows the telescope moving in real time. Once the observation is done, the spectrum is displayed and the user can, if he wants, remove a baseline and/or redo an observation. This spectrum can then be directly retrieved from the Archive. There, further analysis can be done. The user can select some peaks in the HI spectra. These peak velocities, together with the galactic coordinates of the pointed region can be translated into a rotation velocity and a radius (by simple geometric arguments) and/or into a x/y position in kpc on the face-on Galaxy plot. Those two outputs are directly computed by the interface from the selected peaks and compared to professional data outputs and to models of galaxy potential wells and spiral arms (see Fig. 1).

3 A radiotelescope for the University

On the Paris Observatory campus, 2 radio-telescopes have been installed. With a diameter of 2.3m and 3m, they have a beam size of 7° and 5.4° respectively. The antenna are equipped with an heterodyn receiver, working at 1.4 GHz around the atomic hydrogen HI frequency. This instrumentation has been bought to CASSICORP `http://www.cassicorp.com/`, an American company, and was designed by the Haystack Observatory `http://www.haystack.mit.edu/edu/undergrad/srt/oldsrt.html`. On top of the main goal of the project, we used the antenna to teach students from the University. In the next subsections, we will describe the different projects we achieved in the last 2-years.

[iii] `http://www.astro.uni-bonn.de/en/download/data/lab-survey/`

Fig. 3. Homepage of the radio-telescope network remote control interfaces.

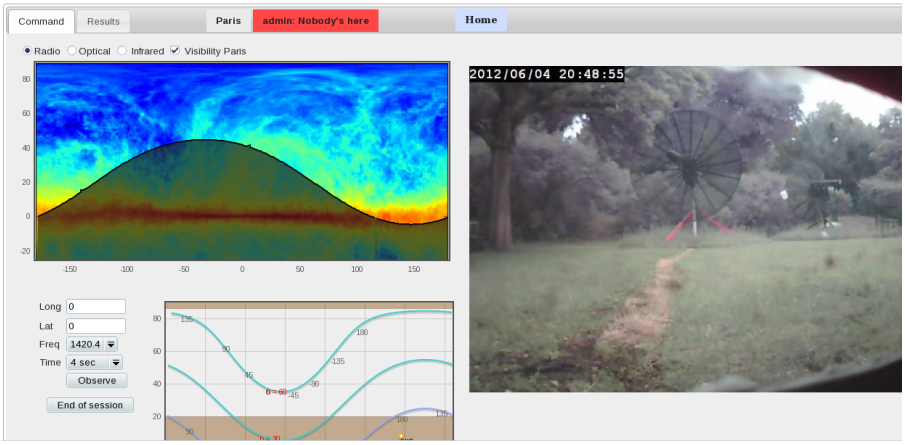

Fig. 4. Remote control interface.

3.1 Student work: One year

A. Radiguet, from the 'Licence Professionnelle - Programmation en environnement réparti' IUT d'Orsay - Paris XI worked during one year within the EU-HOU team (2-3 days/week). As a software engineer, he participated to the design and did all the implementation of the antenna remote control interface, the scheduling/booking system and the account manager. The EU-HOU interface was designed in javascript, php and python, like a wrapper that uses the original control system commands. We started from a list of requirements and produced the final software deliverable. Such a project of evolution/improvement of the radio-telescope was particularly well suited for long-term work with engineering students. In the future, we can think of new projects of this kind: design and build a new receiver/backend, create the associated software...

3.2 Student work: One/two months

It is also possible to use the antenna for teaching astrophysical technics and data analysis methods to students from University. Since 2010, several students have been involved and worked with the antenna at the Paris Observatory. From the UPMC Master 1: *Physique et Applications*, K. Noel spent 1.5 months at LERMA in 2010 (setup of the antenna and the control system, first calibrations and monitoring). From the UPMC Licence 3 *Physique Fondamentale*, C. de Roulhac/A. Bouvet spent one month with us in 2011 (improvement of the data analysis methods and HI mapping of the Milky-Way). Finally, P. Luzi/G. Quinsac spent respectively one and two months at LERMA in 2012 (Milky-Way rotation curve, gravitational potentials and matter distribution inside and outside the Solar ring).

3.3 Student work: Half a day (practical exercises)

A set of three practical exercises of 3 hours each have been prepared and proposed to L2 students in 2012. The first exercise consists in getting familiar with the antenna and its software plus doing an antenna temperature scale calibration and introducing some basics of radio-astronomy. The second one is based on the measurement of pointing offsets and the determination of the beam size. The third one focuses on the observation of HI emission in the Milky-Way: determination of the Milky-Way rotation curve and mapping its spiral arms. A set of python scripts is provided to perform the data reduction and analysis.

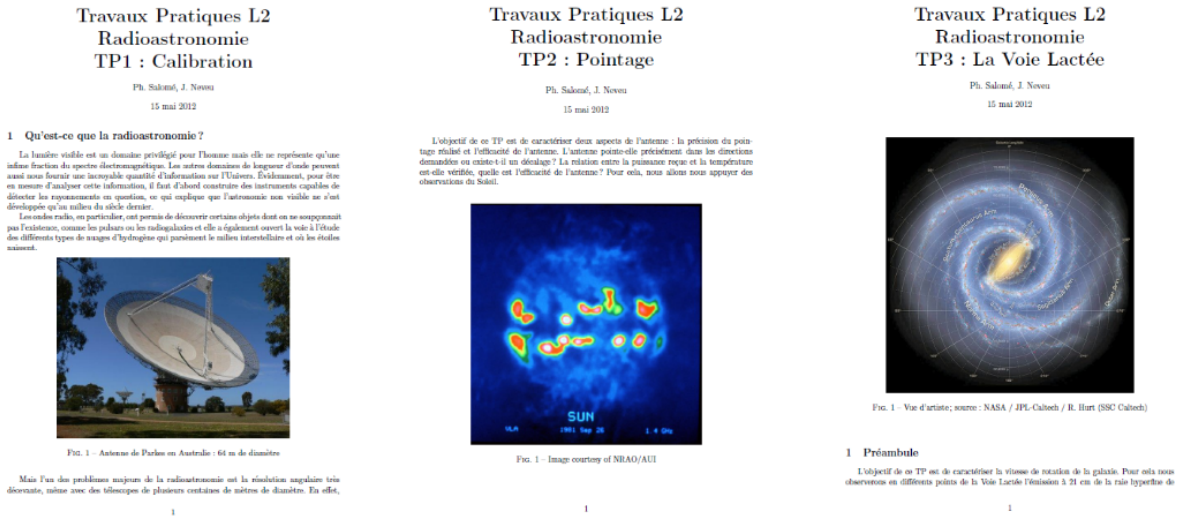

Fig. 5. Practical exercises UPMC L2, 2012

4 Next

The EU-HOU remote control interface will be used in the context of the Paris Observatory teachers tutoring in 2012/2013 *(UFE)*. In order to extend the use of these facilities, short training sessions could be organised to introduce these new tools to astronomer tutor. Observing the Milky-Way in HI could thus be integrated in the activities proposed to teachers as part of the existing *(UFE)* multimedia material.
After the pilot study of 2011/2012 with a small group of students, a practical exercise with the radiotelescope will be included in the LP210 UPMC Licence 2 for all students in 2012/2013. This is just a beginning and obviously, the radiotelescope could also be used by many other students (ie *Ecole Doctorale 127 Astronomie et Astrophysique d'Ile de France*)
The UPMC prepares a place dedicated to practical exercises in astronomy (for observations in the optical and in the radio wavelengths). This station will be installed on the roof of the Paris University building (*75005, Jussieu*). At least one of the two antenna, now hosted by the Paris Observatory, will move to the University campus by 2014/2015. Teaching activities will then be adapted to the new organisation.

We would like to thank all the partners of this project: France - UPMC; Spain - Universidad Complutense in Madrid; Portugal - Nuclio Ncleo Interactivo de Astronomia; Greece - National Observatory of Athens; Cyprus - Lykeio Agiou Ioanni; Poland - Jagiellonian University; Romania - University of Craiova ; Belgium - Royal Observatory of Belgium; United Kingdom - Cardiff University; Sweden - Stockholm House of Science; Germany - Frderverein Astropeiler Stockert e.v.
This project has been funded with support from the European Commission. This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

References

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