



L'ÉLECTROMAGNÉTISME, 150-1 UNE SCIENCE EN PLEINE ACTION !

Titre (français) : EUHOU MW – La radio-Astronomie en classe

Title (English): EUHOU MW – Radioastronomy in the classroom

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Abstract

The EUHOU MW project provides classrooms for direct observations of the Milky Way radio emission. EUHOU MW is based on a partnership between 11 European countries and coordinated by the Université Pierre et Marie Curie. It was supported by a Comenius funding, part of the Lifelong Learning Program of the European Commission. 6 telescopes were installed in five of the partnership countries. To control the telescopes and allows direct observation of the hydrogen content of the Milky Way, a team of software developers and researchers in Paris (LERMA) built a Web interface. The tools contained in this interface are designed for secondary schools. Appropriate educational resources were jointly tailored to enable teachers to fully understand and efficiently use these tools in their classrooms. This project is part of a strategy for the dissemination of scientific knowledge and astronomical concepts to young people (and their families) so that they understand the challenges of the new generation of instruments developed in astronomy: ALMA just being deployed and exploited, and SKA whose precursors are already built, in preparation for a full operation in 2020.

Context

Renewing the appeal of youth in science is a goal widely recognised and one of the major points discussed in the Lisbon agenda. Indeed, teachers need innovative tools to support the development of new methods of teaching to make science more attractive to their students. Our goal is to promote science education by the experience, by providing active learning methods and interactive use in the classroom. The project "EU-HOU - Connecting classrooms to the Milky Way" (EUHOU MW) is based on a dynamic developed at the interface between research and secondary education since 2004. Initiated through funding MINERVA / SOCRATES (2004-2006) for the development of multimedia tools for the secondary, the project EU-HOU has expanded in Europe with the support of the Comenius program (project-EUHOU-TTS 2008-2010) with the provision of pedagogical resources for teacher training. EU-HOU won the silver medal at the European Commission Conference "Innovation and Creativity in the Lifelong Learning Programme: Create, Innovate and Cooperate" held in Prague in May 2009. The project currently includes 11 countries: Belgium, Cyprus, France, Germany, Greece, Poland, Portugal, Spain, Sweden, Romania, United Kingdom, and support the community of teachers and educators developed since 2004.

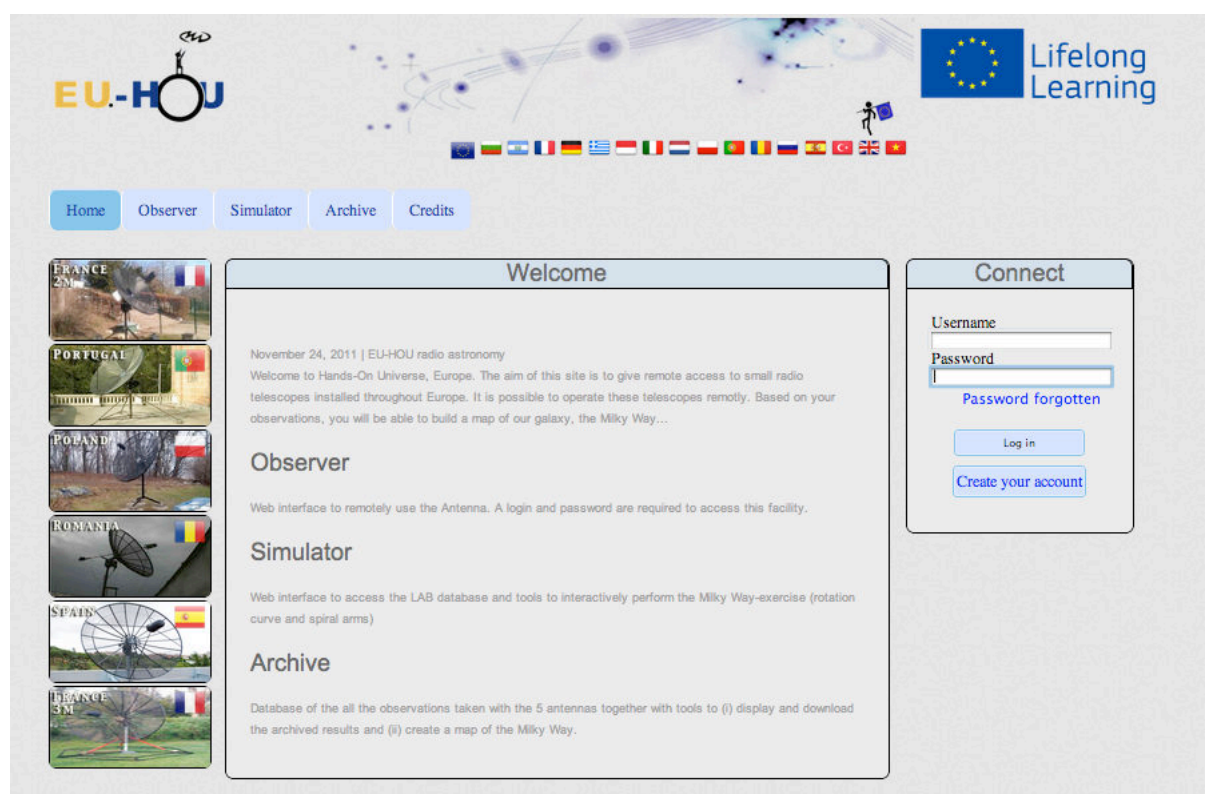
The goal of the project "EU-HOU - Connecting Classrooms to the Milky Way" is to create the first network of radio telescopes (5 antennas of 3m in diameter and 1 antenna of 2.3m) dedicated to education. Not only it enables European students to explore our galaxy the Milky Way in real time, with live telescopes over the Internet, but it also offers them a series of educational exercises for classroom use based on investigation and scientific inquiry (Inquiry Based Science Education or, IBSE). We publish our tools by distributing 10,000 CD-rom in European secondary schools, by circulating an exhibition in introduction to radio astronomy, and by supplying teaching exercises at www.euhou.net. Our website is available in 11 different languages, and our Facebook page <http://www.facebook.com/EuropeanHOU> allows teachers to share their experiences.

One of the goals of the project is to allow volunteer teachers to familiarize themselves with the educational tools developed by the consortium and benefit from the feedback of our users. Training workshops were organised and

welcomed European teachers on two-days training sessions held in Portugal and Cyprus, as well as a training session of five days held in Germany. Our resources were also presented during a day devoted to astronomy at a EU-HOU training sessions held in Paris. The training sessions were constructed to put an emphasis to investigation and questioning that are at the heart of our educational resources, inspired by state-of-the-art research. Immersed in a group of colleagues, science teachers find themselves in a situation of questioning the researchers, like a student. In addition, a kinesthetic activity was designed to explain to secondary students the physical dynamics of the Milky Way. No prerequisite in astronomy is required. The excitement and curiosity from the students are enough to arouse interest, and they naturally generate questions and the desire to learn more.

1. Teacher training sessions

With the help of the teachers, the project EU-HOU is designed for students in secondary education. It aims to show them that science is at their hand, by presenting an approach based on experimentation, questioning and applying the scientific method to learn science by doing science. To do this, EU-HOU exercises develops tools so that the students, guided by their teachers, can solve real research problems. These exercises are designed in close collaboration between researchers and teachers, which ensures both scientific and educational quality. The handling, processing, analysis and measurement of the data are done using SalsaJ, a software developed specifically for the project. These educational resources - and the SalsaJ exercises - are published in English and in the other languages of the partnership (and more) to be directly usable in classes by students.



Screenshot of the interface to control the radio telescope at www.euhou.net

The project's success depends on the involvement of teachers. This is why training sessions for teachers are organized at European level and in English. These workshops offer a method to go from a deductive to an inquiry-based reasoning. In this sense, no prerequisites in astronomy are required.



Teachers training session in Portugal (9-13 April 2011)

2. Radio-telescope Network

A radio telescope network has been installed throughout Europe. The wavelength observed by these telescopes is 21 cm, which corresponds to the emission of atomic hydrogen. Hydrogen, the simplest atom of the universe, is everywhere and in large quantities, especially in the Milky Way. It is very easy to observe, regardless of where the telescope is. A first prototype has been installed in the gardens of the Observatoire de Paris. It has been assembled successfully and is fully operational since January 2011. The second French instrument was received November 20, 2011 at the Observatoire de Paris. The U.S. supplier no longer produces the mount that secures the antenna to the ground. So the French team ordered a mount from the Laboratoire Kastler Brossel (LKB), a Univ. Pierre & Marie Curie laboratory with a mechanics utility room. The LKB supported the implementation of the blueprints (which were then made available to partners) and construction parts. The parts were delivered March 21, 2012 at the Paris Observatory premises and the Paris team has supported the application of paint, and assembly. On October 25, 2011, Poland received their telescope. The engine block and the receiver were first assembled in a laboratory to be tested, then the antenna was assembled on 1 December 2011. In Portugal, the construction of the telescope was completed in March 2012. It was first installed on the roof of the municipal swimming pool of Pampilhosa da Serra, before being relocated to the radio astronomy station of the international GEM (Galactic Emission Mapping) project. In Spain, the antenna was assembled on the roof of the Complutense University of Madrid. Its construction was completed in late December 2011. In Romania, the telescope was mounted on the roof of the University of Craiova. The University has launched a study to build an astronomical observatory in the botanical garden of the campus.



Both antennas assembled at the Observatoire de Paris



The construction of the antenna took only 3h30 in Poland.



The Mayor of Pampilhosa da Serra (Portugal) and the Secretary of State for Local Government, opening the procession that visited the school for the opening of the antenna and other astronomical equipment, the solar telescope LUNT for example. They are followed by NUCLIO, IT members and the public.



The Spanish antenna, on the roof of the Complutense University of Madrid, with Miguel Calvo who was assisted by two students to assemble it.





The radio-telescope being assembled on the roof of the Craiova University (Romania).



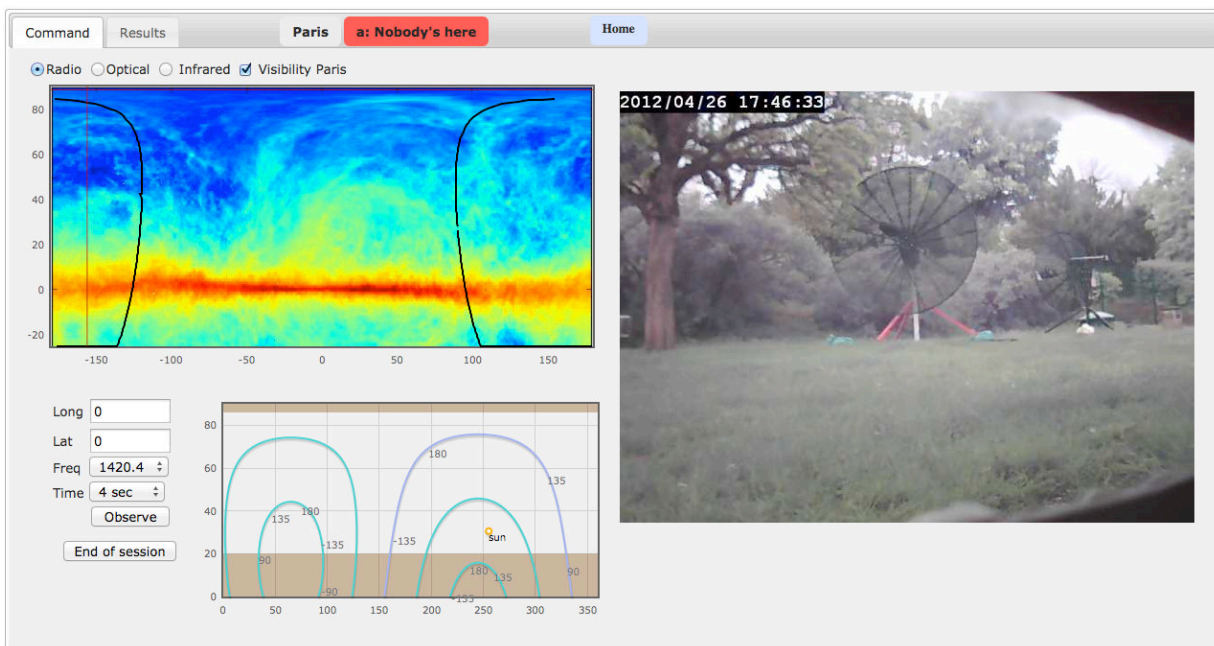
3. Remote control from a web-interface

3.1 Remote Observer

To communicate around the world with these telescopes, a Web interface was designed. This interface provides a map of the Milky Way that can be displayed in different wavelengths, with which you can interact by clicking on it. The aimed position is translated from the local coordinates of the telescope (which depend on the location of each telescope) to the Galactic coordinates and vice versa. Indeed, one of the highlights of our network of radio telescopes is that the user can connect to any instrument, according to its availability, and thus access to different parts of the sky. French students can easily use the telescope installed in Romania, and vice versa. In addition, the advantage of radio observations is that they are available at all hours, day and night, and even in bad weather, because the atmosphere is transparent in this domain of wavelength.

Much effort was provided in early 2012 to improve the web interface. Ultimately, its use is transparent to the user, who have an access from the main site www.euhou.net. The interface provides three tools: the observer, the simulator and the archives. With regard to the observer, we built a booking system architecture and account management. The user can freely create an account linked to an e-mail address in the language of his choice. After an automatic check, the request is sent to the language administrators. If the desired language is not available, the request is sent to a super-administrator (currently P. Salomé and Y. Libert). Each partner hosting a SRT manages the time allotted for users. As they are responsible for their antenna, and very involved in their developments, they have priority in the booking of their own instrument.

When the account is created, the user is asked to explain his motivation that is read by the language administrator to help him take the decision to validate the account. Once the account is validated, the user has access to the booking interface of all the SRT of the network. Observations of one hour up to 4 hours are possible. For practical reasons, the reference time taken in this interface for each telescopes is the Coordinated Universal Time UTC. It is mandatory to reserve at least one hour before the start of observations. The end of the sessions is announced 5 minutes before the end. All software development have been fully designed by the development team in Paris, which guarantees a lot of flexibility and independence. The software developed by the French team of developers that must be installed locally are being deployed on each antenna network using a method established in consultation with the project partners. Accordingly, the local installation takes less than an hour.



The observer interface. The data collected by the SRT are sent directly to the user.

3.2 Simulator

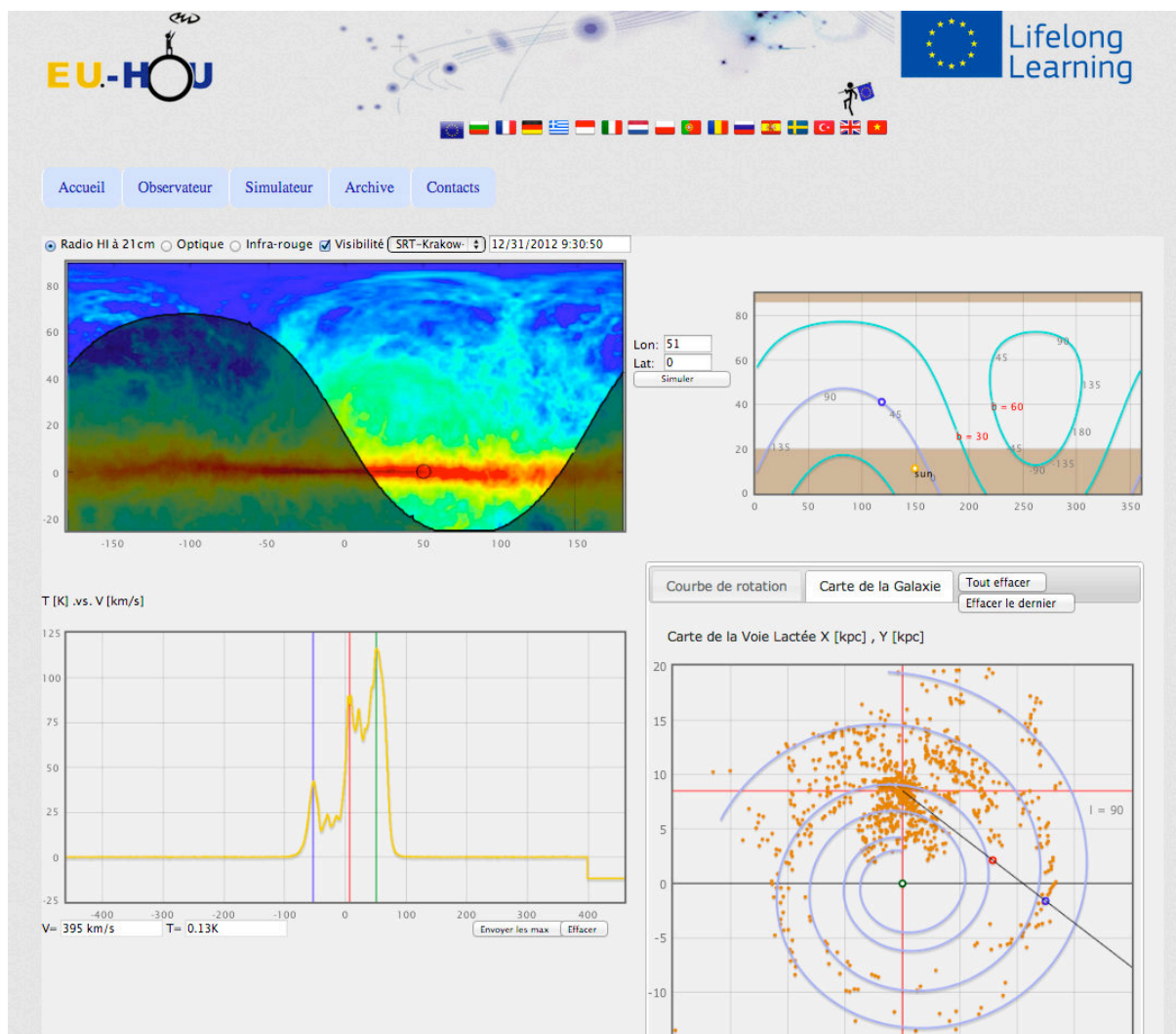
The simulator is an educational platform where you can retrieve the professional observations of big radio telescopes in the Netherlands and Argentina, which have mapped the entire Milky Way at the 21 cm wavelength, the emission of atomic hydrogen. The German partner, Peter Kalberla, was part of the team responsible for this Galactic survey. With this tool it is possible to simulate a radio observation with high quality data. It allows teachers to prepare their live observations and also to access to the parts of the sky that are not available during their booking time. With the simulator, preparing students with a live observation is very easy, and they can even predict the shape of the spectra they will obtain in live mode. The simulator has been designed to recreate the conditions of observation in real time. With the professional data, the students can also do the exercises proposed in the interface: reconstruct the spiral structure of the Milky Way and search for the Dark Matter.

3.3 Milky Way Spiral Arms

The data collected from the Milky Way emission in real-time with the observer or with the simulator is already very interesting for young people. But it is necessary to go beyond the mere pleasure of making observations. The students should be able to analyse, measure and interpret their data in accordance with a scientific method. That is why EUHOUMW developed pedagogical exercises based on these data. Indeed, several hydrogen clouds can be detected on the line of sight of the telescope (each clouds correspond to a peak) and the velocities of these clouds can be deduced, owing to the Doppler effect. With simple geometric assumptions, it is possible to retrieve the position of the clouds of gas inside the Milky Way. By making several observations, it is thus possible to reconstruct the spiral structure of the Milky Way.

3.4 Milky Way Rotation Curve

Another exercise proposes to build the rotation curve of the Galaxy: this is a plot of the velocity of the Galactic gas versus the distance to the Galactic Centre. Each observation gives a point on this plot, and with a series of measurements it is possible to reconstruct the whole shape of the curve. In the exercise interface, the students have the possibility to compare their result to the theoretical curves. A manual and detailed explanations of these exercises were designed in collaboration with Alexander Rudolf, an American professor from the Polytechnic University of Pomona (California, USA) specialised in IBSE methods (invited Professor at UPMC).



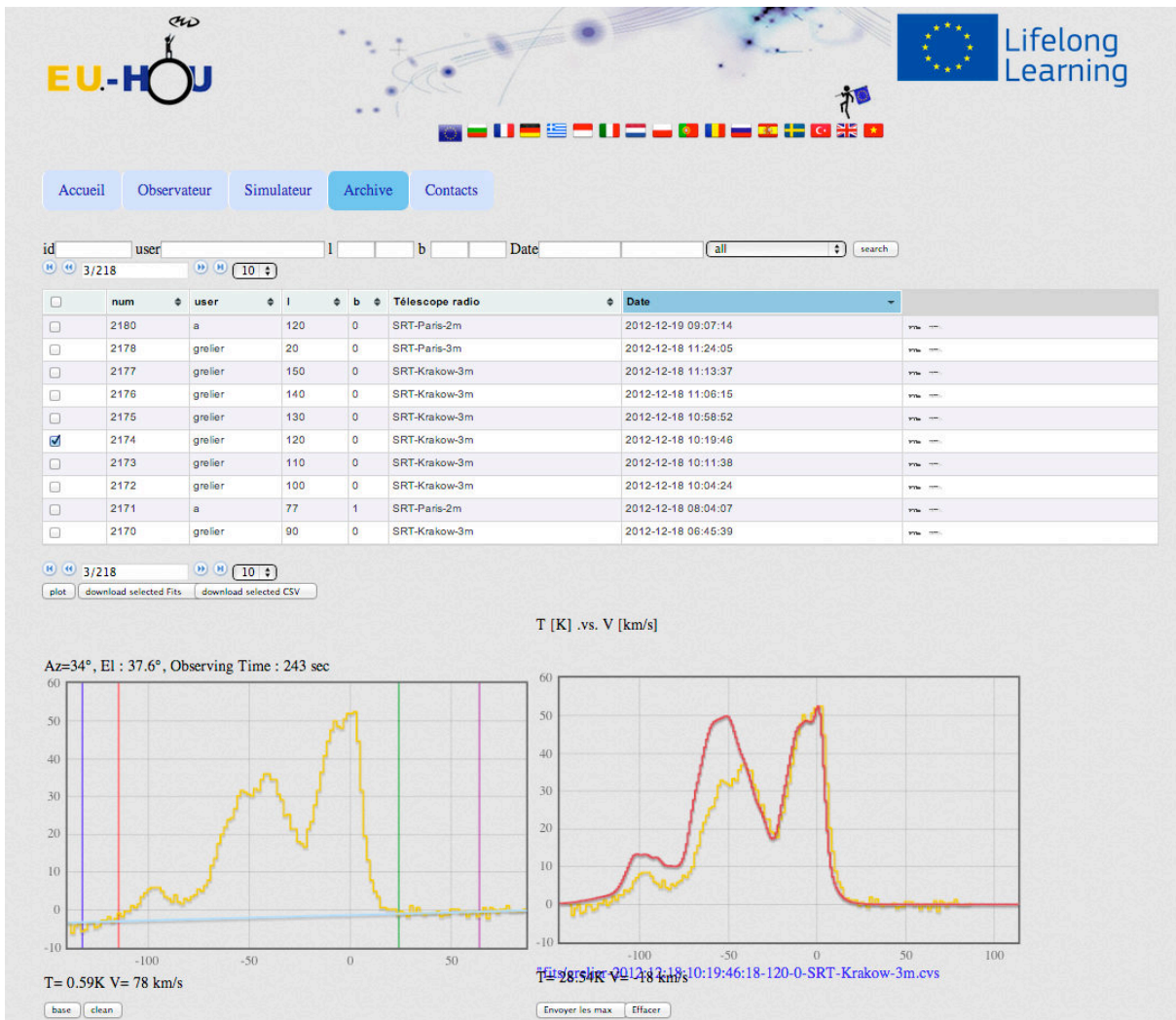
The simulator and the exercise to reconstruct the spiral arms of the Milky Way: the peaks marked in red and green account for gas clouds marked in the same colours onto the schematic view of the Milky Way. The orange points represent all the professional data (the display can be turned on and off), so that the user can compare and be critical about his observation.

3.5 Archive

The archives are organised as a database of all the observations made by the radio telescopes of the EUHOUMW network. This not only helps to rework its own data, but also recover other data from different users and different telescopes. This allows the comparison and the exchange of experiences between users, and possibly collaborations.

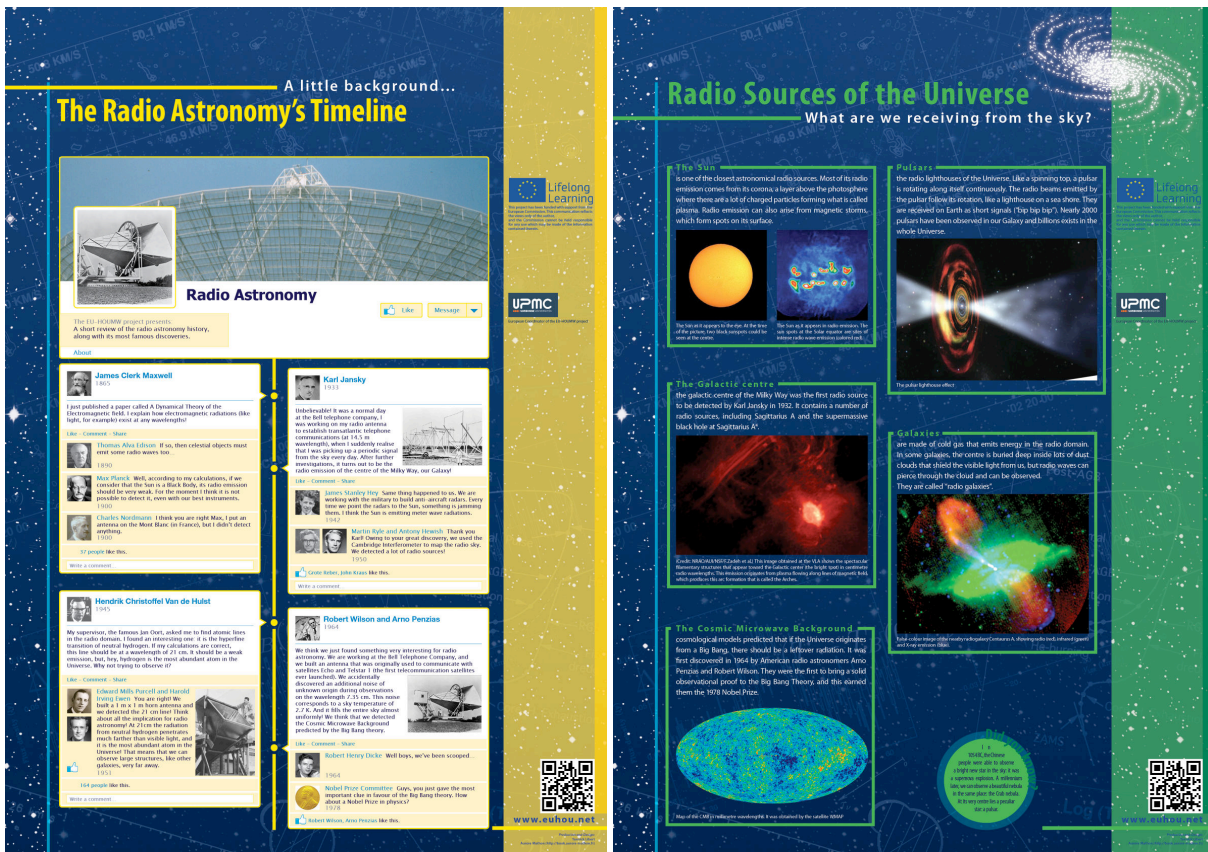
4. Exhibition

A radio exhibition containing 10 A0 panels was realised and translated in all the languages of the partners. This exhibition is designed for a large public, and was also intended to a pedagogical use in classrooms, as it contains a lot of interesting information about radio astronomy. In particular, the exhibition will be hosted at the Planetarium of Brussels (Belgian partner) and can thus be seen by the 45,000 annual visitors of the Planetarium, including a vast majority of school groups led by teachers. The content of this exhibition is translated into Dutch and presented as bilingual French/Dutch panels. The visit of this exhibition, free of charge, will be accompanied by the distribution of the CD-rom to the teachers, thus providing all the necessary information about the educational tools available on the site. When conditions allow it, a presentation of EUHOUMW is provided at the end of an astronomy lessons to school groups at secondary level: this introduction, projected on the hemispherical screen of the Planetarium, allows to directly inform the teachers and to provide them with some teaching tools available to them through the project. In addition, a specific



The archive tool allows retrieving any SRT observations. The red spectrum at the right was obtained with a telescope of 25m in diameter. Note how the spectrum of the archive taken with a 3m SRT match nicely the result of a professional telescope dedicated for modern research!

training session for geography and science Dutch teachers took place April 30, 2012 at the Planetarium. A small format (A4) radio exhibition was created during a previous EU-HOU project by the French team in coordination with the Ministry device "Sciences à l'Ecole". It was translated into English, and the file was posted on www.euhou.net. It can be accessed directly from <http://www.euhou.net/images/euhouradioexhibit.pdf>. It has been translated in the different languages of the EUHOU project.



Two of the panels of the radio exhibition in English. This exhibition was translated in 9 other languages

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