1. Measuring the light curve of Be X-ray binaries

Name of your Institution: HOU-España- Universidad de Valencia-Universidad Complutense de Madrid/Faulkes Telescopes-University of Glamorghan

Title of the educational scenario template: Inquiry-based teaching

Title of your educational scenario: Monitoring Be X-ray binary systems

Educational problem:

Very little about stellar dynamics is taught to high school students. In general the contents of astronomy and astrophysics are limited to the knowledge of the solar system and very little else. The large variety of time scales in stellar dynamics and evolution is in contrast with the apparently static night sky and the minimal activity perceived from the sun with the naked eye. The sense that everything is evolving and changing continuously, even in outer space, is not well transmitted to students within the normal educational framework.

This scenario aims to provide an insight into the richness of phenomenology present in the many astrophysical scenarios found in stellar systems. The target systems chosen, the Be X-ray binary systems (or BeX for short), provide both the opportunity the see stellar dynamics in action and to produce data and science which will help to solve some scientific issues for which we currently do not have a clear answer.

Educational scenario objectives:

During this scenario, students will:

1.Learn about the dynamics of stellar systems, and in particular the different time scales present in BeX systems (i.e. orbital motion, pulsations in compact objects, processes of formation and disruption of circumstellar discs)

2.Learn about the techniques and procedures to acquire astronomical data and measure stellar brightness (magnitudes)

3.Learn about the importance of standardised systems, in order to compare measurements obtained at different times or from different instruments.

Characteristics and needs of students:

Students have limited exposure to real scientific problems; they tend to work on well defined, ideal environments. Neither are they familiarized with the basic principles behind the modern technologies that underlie everyday activities

The exercise will also allow students to interact (e.g. by working in pairs) and develop social and collaboration skills, allowing them to understand science as a team work instead of a solitary activity. This change of perception may trigger an increased interest in science in many of them, and possibly in turn to science careers.

Rationale of the Educational approach and Parameters guaranteeing its implementation:

The activity is designed to increase the student's interest in science by participating actively in all aspects of the scientific method, and developing collaborations with students from different schools and even with scientists working in the research field.

A scientific problem is introduced to the students and they learn how to prepare the observations and use tools to gather data which will help to solve it. Students have the opportunity to work with real scientific instruments and use professional methods to analyse the data.

Learning activities:

1.Introducing the problem

Some documentation will be ready online about the Be X-Ray binary systems, in the form of PDF documents and/or powerpoint presentations. The main ideas to identify (or which students should able to identify, with teacher assistance) are:

•How binary systems are formed
•The richness of stellar dynamics
•Stellar winds and associated structures

These ideas can be introduced from an intuitive point of view, without the need for complicated physical formulae. As an example, assisted with a powerpoint presentation, the teacher can lead the discussion, pose questions to the students etc., about the proceses he is talking about.

A good starting point is the Sun itself. The observation of solar storms and aurorae, and the behaviour of comet tails, can lead students to guess what the stellar wind is. This fact can be used by the teacher to ask students what they think about stars, e.g. are they static or very active bodies? A brief explanation about stellar formation can follow, which can easily help students to deduce that binary systems will be quite common throughout the galaxy.

A brief explanation about the particular case of Be X-Ray binary systems (i.e. what kind of wind structure does a Be star have, why are they called “X-Ray binary systems” etc) will be included. Students will be measuring the wind structure around the Be star, but it can also be a good exercise to discuss the relationship between optical varibility and high energy (in this case X-ray) emission. A separate PDF document will be available about this issue.

b. Data Acquisition

This activity requires the use of the Faulkes Telescopes and/or the associated data archives. The Faulkes Telescopes web pages contain a simulator to learn how to use the real-time interface which controls the telescopes. This interface is very intuitive and easy to use, but some training through the simulator is recommended. The simulator can be accessed following this link:

http://lcogt.net/files/flash/rti-demo/index.html

The Faulkes Telescopes grants observing time in 30 minutes slots. These slots can typically be booked two weeks in advance. Therefore some planning is needed to perform the observations. On the one hand the visibility of the sources should be checked. A document with the seasonal visibility of the sources will be supplied, along with instructions on using planetarium software such as Stellarium. Also, it is necessary to check the proximity of the Moon to the source of interest. Tools like the online widget:

http://catserver.ing.iac.es/staralt

are very handy to prepare the observation. On the other hand 30 minutes is a very short time and the observation planning has to be very well defined before starting the observation. The teacher will have to help students to ask themselves questions such as: which source are we going to observe? Which filters will be used? How much time do we need to expose the detector for each filter?

A document with a guide to exposure times required per source, and indications on how long the system takes to process the data will also be available.

3. Getting the data and data analysis.

The tools available to perform these activities are simplified versions of the professional tools:

•SALSAJ: is the astronomical data analysis software developed by HOU, is freely available and all the tasks relative to astronomical image analysis are simplified and arranged in a very intuitive way.
•IRIS: Very limited in functionality compared to SALSAJ but also very simplified. It is used in a few training exercises available at the Faulkes Telesopes educational portal.

Both tools are well explained and documented at HOU web pages and Faulkes Telescopes educational portal.

A few questions should be raised when finishing the measurements:

•To what extent are these measurements comparable to previous ones, or to those performed by other schools? Are they very different? What might any observed differences mean?

•Which steps have we taken in order to ensure the “standarization” of the measurements?

•In view of the dynamics of these systems seen in the introductory lessons, what do the students think are the causes of any detected variations?

Analysing and getting conclusions from data is not a simple task, and many questions have to be answered before we decide our data is good and comparable to what other scientists have been measuring. At this point it is very interesting to stress the importance of collaboration and sharing data and knowledge.

4. Discussion and presentation

At the end of the course time, or when all observations and data analyis have been performed, a debate including these topics will be started:

–Are our data useful to address the problems associate to this particular BeX system (are we detecting variations, are they modulated etc.)?
–What difficulties have we found in the process? Could they be overcome?
–Was it easy to use the telescopes? And was it easy to perform the data analysis?

These discussions can be guided by the teacher with the participation of the whole class.

Alternatively, it is of great interest that the students prepare a presentation explaining to other students their work, how they have developed it and the measurements they have taken, what kind of dynamics can be deduced from these measurements, and how they can be used to collaborate with scientists in increasing overall knowledge of these systems.

Tools, services and resources:

1. Computers with Internet connection and Java
2. Wiki-HOU (Spanish) platform