Starlight in the university lab: Astrolab

Project report (Phase 1)

(2-year project, started in 2013, to be completed in 2014)

1. Short summary of the completed project that we can place on the website (along with relevant web friendly photos/videos).

A research tutorial, Astrolab, is being developed and implemented in universities in need of astronomy infrastructure and curriculum, allowing undergraduate students in sciences to perform real-time observations on a remote telescope, and transforming those observations into a scientific result. This project is a pilot. The implementation is carried out in two partner universities, Anambra State University in Nigeria, and the Copperbelt University in Zambia.

The goal of this project is twofold :

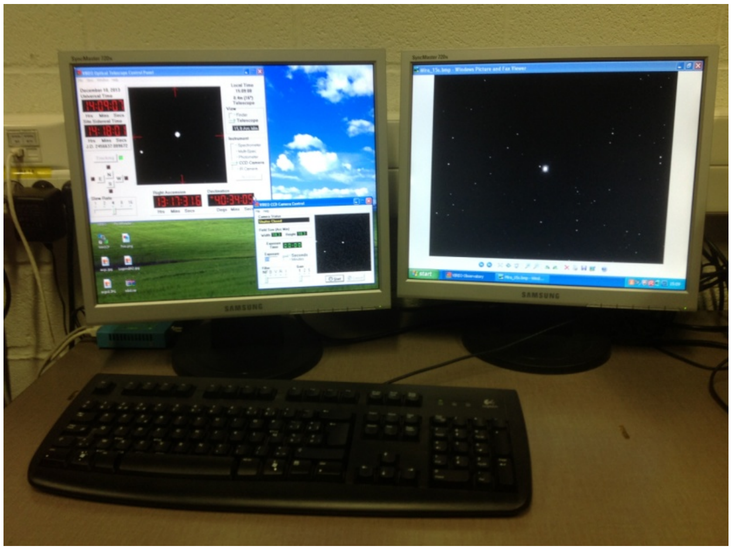
a) to introduce students to the scientific research method in general by working scientifically through project development and preparation, data acquisition and treatment, analysis and conclusions.

b) to enhance interest in science studies by making them more attractive and getting the students involved in the “learning”.

The level is that of science students at an introductory astronomy course (1st or 2nd BSc), but can be adapted downwards as well as upwards.

Astrolab is already implemented at the Vrije Universiteit Brussel since 5 years (see photos).

One of the 3 workstations in the Astrolab at the Vrije Universiteit Brussel in Belgium.



Telescope guidance simulator screen (left) and telescope view (right)

Image taken by Brussels students in Astrolab for the derivation of the Hubble law.

2. A section addressing how the objectives/deliverables that were originally proposed have been achieved

The project has two aspects : to implement the necessary PCs in the pilot universities and to develop a tutorial for the project management with the students in term of observations to be done, data to be collected, as well as the necessary astronomical/astrophysical background to analyze the obtained data. The tutorial will be developed with different modules in collaboration with the pilot universities. The modules are: an observational tutorial, a data reduction tutorial and a tutorial for the project to be developed by the students (eclipsing binaries, Cepheids, Huble law). A specific module in the domain of data analysis and/or astronomical/astrophysical could be added regarding the background of the students.

Status per 1 December 2013:

Manual:

a. Available information in Dutch was translated in English;
b. General content: ready
c. Tutor's manual: outline ready, details with screenshots from AstroArt will be implemented in December-January.
d. Student's manual: the manual for the Eclipsing Binary Project has been fully written using the situation at the Vrije Universiteit Brussel (see Annex). Adaptation to the two African universities is under way. The Cepheid and Galaxy projects largely use the same instructions as the Eclipsing Binary Project. Finalisation foreseen for the end of January.

Infrastructure:

Both universities have acknowledged that they will provide a dedicated room for Astrolab.

Equipment:

a. The computers with two screens have been provided:
b. Software AstroArt and The SkyX have been bought and were implemented in the computer software.
c. The computers are now being prepared for shipment to the African partners.

Telescope time:

A request for information on available observing time on remote telescopes have been sent to the members of TF1. Several possibilities were sent in. Requests for slots will be sent out mid-December. The final choice of the remote telescope will allow to modify the manual accordingly.

3. A description of any deviations from the original project implementation plan/timeline/duration/location/audience etc (if any).

   A change of university took place in Nigeria.
   There is a delay of a month due to an overload of university and ISYA work. The problem should be solved from January 2014 on.

4. Any significant challenges faced during the project (if any)
5. Recommendations for improving the quality/implementation/impact of the project based on the lessons learned (self evaluation)

6. Suggestions/Recommendations to the OAD for expanding the project both locally and to other parts of the world (if applicable)

   Will be formulated in 2014, based on the experience with the present implementation.

7. Full financial report detailing the expenses and explaining any deviation to the proposed budget (this can be in the form of a single table with explanatory notes)

Accounts Project OAD-IAU 'Starlight in the university lab'

(all amounts are in Euro)

		2013		**2014**	
In		1155		3760	
			Balance (2)		
Out	AstroArt 2x	307,2	847,8		
	SkyX 2x	72,04	775,76		98 USD
	AstroArt (1)	153,51	622,25		
	Total	532,75			

(1): one extra copy for M. Gerbaldi (in Paris) for practicing reasons.
(2): balance per 1.12.2013 destinated for shipping/transport costs

8. Copies of associated invoices/receipts to support the financial report.
(attached)

Annex.

Eclipsing binary observational project

Eclipsing binary systems have a variable flux depending on whether one of the stars is blocking light from the other. This typically appears as a deep, long periodic dip (called the primary eclipse) in the otherwise constant flux, followed by a short, shallow dip (called the secondary). The depth, duration, shape and relative size of the two dips depends on the sizes of the stars, their separation and their intrinsic uxes.

The goal of this observational project is to conclusively identify the primary eclipse of a binary system of your choice. The procedure is outlined below:

1 Planetarium software

On the desktop of the astrolab machines you will find a shortcut to a planetarium simulator called

theSkyX. You should familiarise yourself with this software. With it you can change your location and time and also click on a toolbar button to highlight all variable stars. To search for a particular binary star, say one called "AZ And" then you must search for "GCVS AZ And".

2 Choosing a binary

Go to *http://vizier.u-strasbg.fr/viz-bin/VizieR?-source=J/A+A/446/785* where you will find a

search engine to select from a catalogue of binary stars. You will have between 15 and 20 observations, so you must have a primary eclipse that is 10% of the total period to have a good chance to observe it. Furthermore, you require the Right Ascension (RA) and Declination (Dec) to be within a certain range to be visible for long periods (you can use the planetarium software to help). The period of the orbit must be short, such that all phases of the period are observable several times in a month. This rules out periods that are too close to whole numbers of days (or half days). Finally, the magnitude of the binary must be bright enough to be visible with our telescopes and not too bright to saturate the field.

Some general advice here is to choose a binary that is visible for a large fraction of the night (check

http://catserver.ing.iac.es/staralt/ from now until early December. There are secondary considerations like if the binary has a neighbouring star that is too close or there are many very bright stars in the field.

3 How to make observations

3.1 The telescopes

The telescopes are based in New Mexico, USA and can be accessed from the following website *go.itelescope.net.*

The time zone is UT-7. You can log in with your VUB username (which is also the password). The telescope can only view objects more than ~30σ from the horizon. You are requested only to use telescopes T4, T5 and T14. They are identical and may be used interchangeably, but an analysis should be made comparing the mean fluxes of the reference stars (see later).

3.2 Test observations

From *go.itelescope.net* click the drop down menu at the top called “Offline Plan Generator". Choose your telescope from the list (e.g. T4). Fill in the form as per Fig 1, putting in your star's RA and Dec and choosing a duration (in seconds) of between 5 and 30. Go to the bottom and click “create plan".

Note: For your first ever observation, you might want to try a number of exposure times to check which works best for your star field. For this, you can just add extra rows to your plan and change only the “Duration". This is (both time and money) efficient because it takes many individual exposures with a single pointing of the telescope.

Next click on “Make a reservation" and choose the date and time of your observation. Also put “5 mins" for the exposure time. For “reservation type" choose your plan as per Fig 2. This procedure

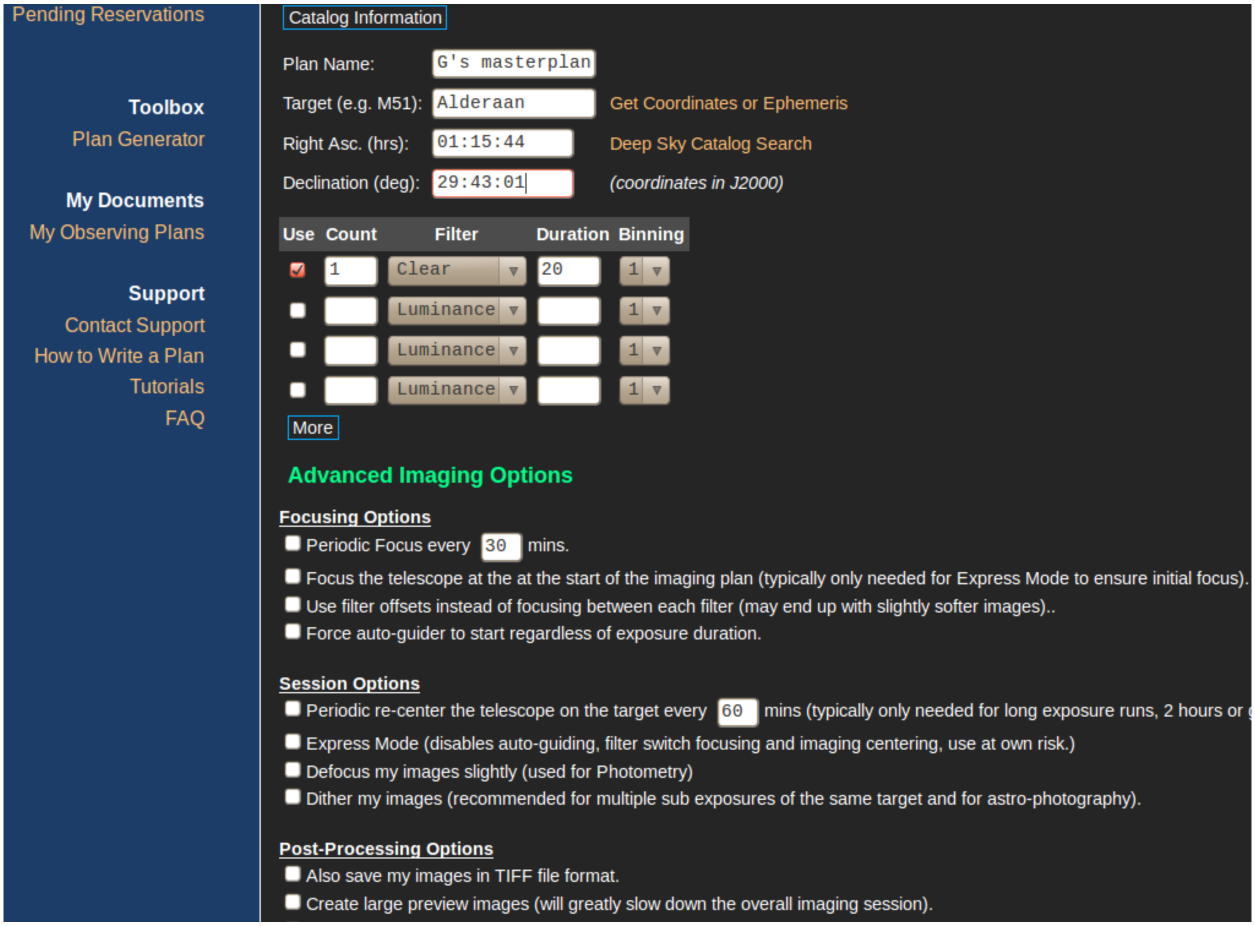


Figure 1: How to generate a plan for your observations.

generates a script which operates the telescope. A certain amount of time is required to slew the telescope to position, focus the telescope and then acquire a guide star to track with (to offset the drifting of the stars with the revolution of the Earth.

Earlier in the night, the telescope will also have made **dark frames** which are images taken with the mirror cover still on. This checks the thermal (white) noise in the CCD. The presence of thermal noise is why CCDs are cooled with liquid nitrogen. Other calibration involves taking fl**at fields** which is typically the observation of a screen that is uniformly illuminated by white light. This checks the pixel-to-pixel variation in the response of the CCD. These variations can be due to imperfections in the semi-conductor, or scratches/damage to it, and possibly imperfections in the mirror/optics.

The post-processing of your observations with the calibration images is done by the telescope operator.

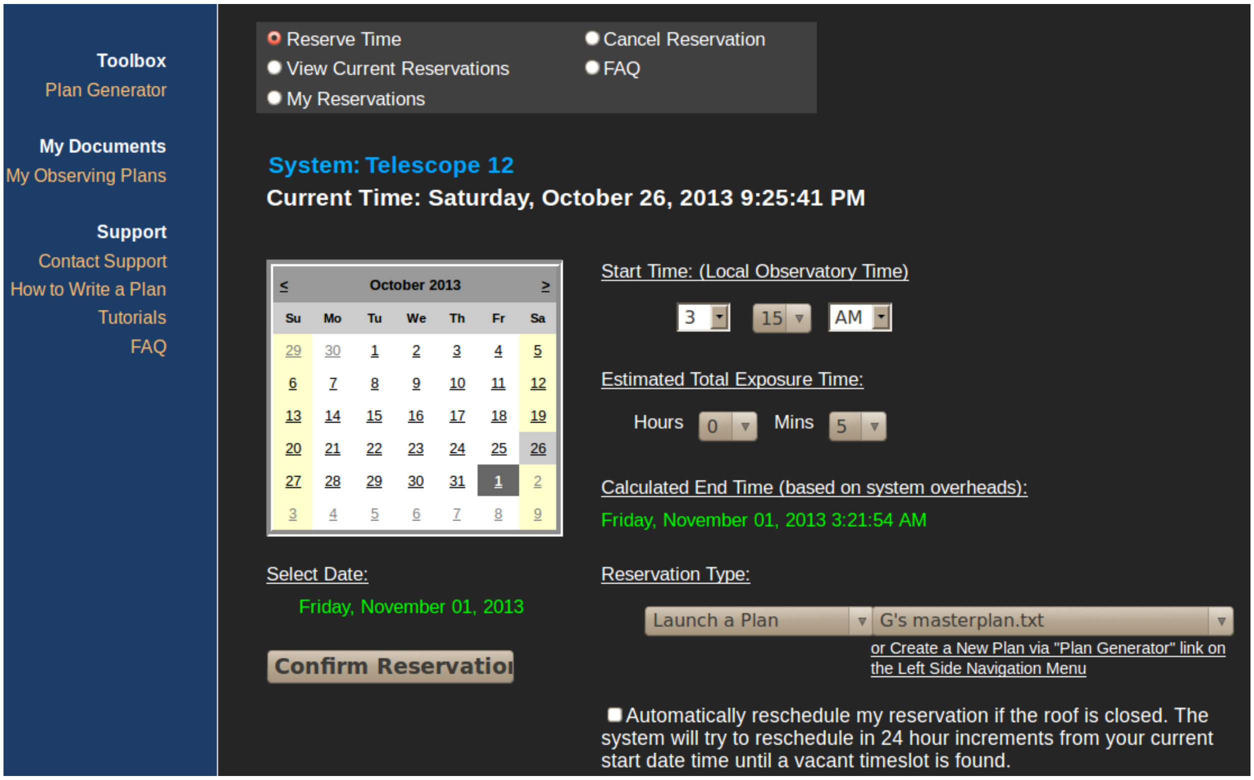


Figure 2: How to make a reservation on the telescope for your observations.

.

4 Planning an observing strategy

Your goal is to sample the phase of the period and locate the primary eclipse. To do this, there are many approaches. One I can suggest is to open an excel spreadsheet and format the cells to contain a date and time (i.e. 26/10/13 09:33) and then in the cell below add a new date which is the above date (26/10/13 09:33) plus one orbital period (say your star has a 2.87 day period then put in 29/10/13 06:26). Then extend this column to give every date until mid December. You find

no., yr, month, day, hour, min

1 13/10/26 09:33
2 13/10/29 06:26
3 13/11/01 03:19
4 13/11/04 00:12
5 13/11/06 21:05
6 13/11/09 17:58
7 13/11/12 14:51
8 13/11/15 11:44
9 13/11/18 08:37
10 13/11/21 05:30

11 13/11/24 02:23
12 13/11/26 23:16
13 13/11/29 20:09
14 13/12/02 17:02
15 13/12/05 13:55
16 13/12/08 10:48
17 13/12/11 07:41
18 13/12/14 04:34
19 13/12/17 01:27
20 13/12/19 22:20

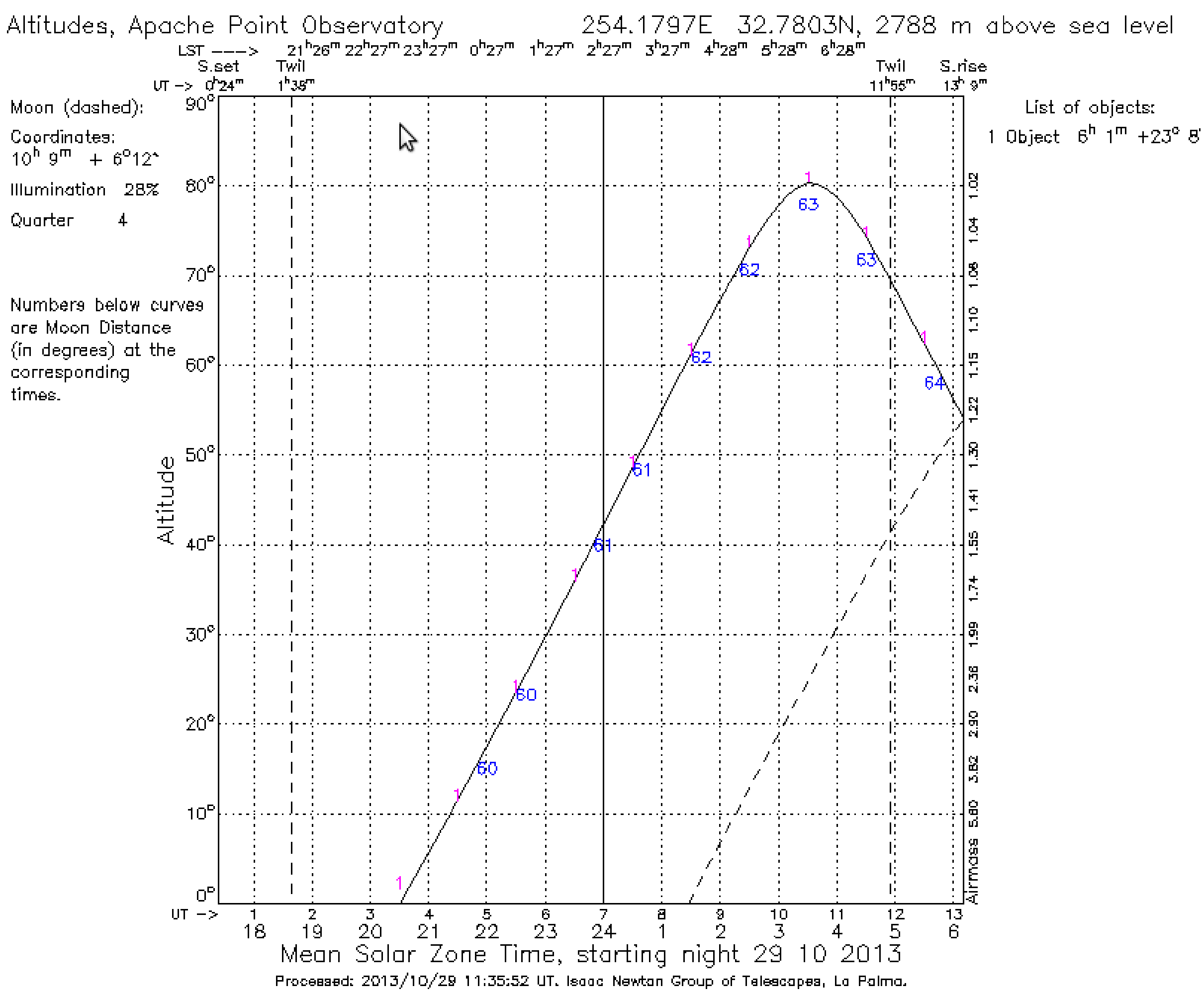


Figure 3: The altitude of your star (solid line) and the moon (dashed line) as a function of local observatory time (large numbers) and Universal time (UT; small numbers).

This is a list of each time and date this binary has this particular phase. From this you see that if

the sky is dark (and your object is about 30 degrees) from 2100 to 0700 then you can only use rows (i.e. dates) 2-5, 10-12, 18-20 and if the sky is dark from 2200 to 0600 then you can't use 2 and 5. So, you should make sure to observe the star on the 1st of Nov 2013 at 0319. You have to do the same scheduling for your other 15 or so well spread out observations of a different phase.
Go to *http://catserver.ing.iac.es/staralt/* to check whether your star is above the nominal 30 degrees altitude (the mount that supports the telescope, the electronics and the dome get in the way of lower altitudes) required to be accessible to the telescope. Insert your RA and DEC and change the location to New Mexico. You should get an output resembling Fig 3.

Things to bear in mind are that you must check that the Moon is not too close (or Full) at the time of your observation and also you must check that this time is not already scheduled for another astronomer. Book as early as possible. Finally, if you find the primary eclipse, you can go back and add more observations to the location of the primary eclipse and try to estimate the depth of the eclipse.