User manual for the planetary transit experiment

1. Introduction

The computer system for driving the experiment is composed of four distinct elements, all of them running at the same time in a single computer. The details for accessing the computer can be found in section 2.

The first software element is the star simulation, whose operation is described in section 3.

The second proprietary utility is the payload simulator, which acquires the light curves. Its operation is described in section 4.

The third part of the software system is the analysis tool for the light curves, detailed in section 5.

The final part is a non-proprietary printing utility so that the PDF files generated for the visitors can be printing on paper. It operation is described in section 6.

Section 7 provides an end-to-end example of how to perform the demonstration of the experiment.

2. Access to the computer

The computer to operate the experiment is a Dell laptop labeled NB38-TA21. It should already be installed at the stand.

The credentials to access the laptop are as follows:

Username: vicouser
Password: didpfdvu.97

Please be aware that the laptop will not be connected to the internet, so any additional files that you might need (e.g. an image of the Sun) will have to be brought on a pen drive.

3. The target

The first element of the experiment is the simulated target, mainly a big white circle on a black background. This tool is programmed in Python and shall be invoke with a double click on the desktop icon labeled "**Star Generator**" (to access the desktop you can press Win+D). As usual, before launching a new instance of the program, please make sure that there is no other running in the background.

The window that pops us shall be dragged to the second monitor located on the other side of the pendulum to act as a target. Maximize the window by double-clicking on the top menu bar. The command line window that also pops-up can be minimized, but it has to stay open because, otherwise, the main display will close as well.

The simulated Sun can be adjusted for size and oblateness, in can have an adjustable sun spot and even pulsate with varying amplitude, just to demonstrate the kind of effects that can be seen in a light curve.

The controls for the star are as follows:

Arrow left: Make star wider

Arrow right:	Make star thinner
Arrow up:	Make star bigger
Arrow down:	Make star smaller
r:	Make star round
s:	Toggle the sun spot
Alt+Arrow left:	Make sun spot wider
Alt+Arrow right:	Make sun spot thinner
Alt+Arrow up:	Make sun spot bigger
Alt+Arrow down:	Make sun spot smaller
Alt+r:	Make sun spot round
Alt+h:	Move sun spot left
Alt+k:	Move sun spot right
Alt+u:	Move sun spot up
Alk+j:	Move sun spot down
p:	Toggle solar pulsation
A:	Increase the amplitude of the pulsation
a:	Decrease the amplitude of the pulsation
Esc:	End the simulation

Generally, the pendulum experiment shall be conducted on a static Sun so that the light curve is as clean as possible.

The target simulation can run continuously, so there is no need to start it and stop it repeatedly.

4. The payload

The second software element of the experiment is the simulated payload, which uses the webcam to measure to total brightness of the scene, generating the so-called light curves. This tool is programmed in Python and shall be invoke with a double click on the desktop icon labeled "**Transit Cam**" (to access the desktop you can press Win+D). As usual, before launching a new instance of the program, please make sure that there is no other running in the background.

The window that pops us shall be kept on one side of the laptop screen to allow the operator to follow the acquisition of the light curves. The command line window that also pops-up can be minimized, but it has to stay open because, otherwise, the main window will close as well.

The window displays the scene in front of the camera in real time. If necessary, you can adjust the tripod of the camera so that the simulated target is visible. The bottom part of the window also displays a continuous plot of the total intensity measured with the Region of Interest (ROI), which is indicated by a box within the video window. When the box is blue, the intensity of the ROI is measured but not recorded. During the actual acquisition, the box turns red. The ROI can be controlled with the following command:

Arrow left:	Move ROI to the left
Arrow right:	Move ROI to the right
Arrow up:	Move ROI up
Arrow down:	Move ROI down
Shift+Arrow left:	Move ROI fast to the left
Shift+Arrow right:	Move ROI fast to the right
Shift+Arrow up:	Move ROI fast up
Shift+Arrow down:	Move ROI fast down
Ctrl+Arrow left:	Decrease the width of the ROI
Ctrl+Arrow right:	Increase the width of the ROI

Ctrl+Arrow up:	Decrease the height of the ROI
Ctrl+Arrow down:	Increase the height of the ROI
l (lower case 'L'):	Toggle light curve acquisition
m:	Toggle monochrome mode
Space Bar:	Clear the bottom part of the screen
Esc:	End the simulation

The payload simulator shall be in non-acquisition mode (ROI is a blue box) when not in operation to avoid generating an enormous amount of useless data. Check section 7 for a detailed account of how to demonstrate the experiment.

The payload simulator can run continuously, so there is no need to start it and stop it repeatedly.

5. The light curve analysis

The third element of the experiment is an analysis tools that processes the recently acquired light curves and plots the results. Contrary to other elements, this part shall be invoked from the command line. In case there are no command-line windows available, you can create one by pressing Win+R (a small dialog pops up), typing "cmd" (without the quotes) and pressing Enter. To go to the right folder simply type "**cd \Users\vicouser\Documents\python\transit_cam**". This command window can stay open and used for every execution of the analysis tool.

To perform the analysis of the last light curve simply type "**python analyze_transit.py**" and press Enter. In all likelihood, you will be able to save the typing by pressing the arrow up to repeat the previous command. Upon execution, the application will first show the whole light curve as relative brightness over time. If the analysis tool manages to find the minima of the curve, they will be marked in red.

Close the first window by clicking on the 'X' at the top right corner and the application will display a two-plot graph of the folded light curve. The bottom plot represents the "classical" folding of the light curve, where the minima are superimposed, with the ingress on the left side and the egress on the right side. The top panel displays an "accordion" folding of the light curve, which is better suited for this experiment: in this case, the minima are superimposed alternating the direction of the transit, so that half the ingresses will be on the left and half on the right. In this way, all the West flanks will be on the left side (regardless of whether they are ingresses or egresses) and the East flanks on the right. It should be evident that the top plot is more congruent than the bottom one (or at least not worse).

The plots also show the transit period (T) in seconds, the depth of the transits (d) as percentage of relative obscuration and an estimate of the relative radii (r/R) of the transiting planet and the simulated Sun. These two plots are automatically saved into a timestamped PDF file (e.g. "Nacht des Wissens 2022 - 2022_07_07_18_54_08.pdf") that can be printed for the visitors to take home.

As explained above, the light curve analysis tool has to be launched manually after each acquisition, but the command-line window can stay open as long as needed.

6. The printing utilities

The final element of experiment is simply a standard PDF viewer that will allow us to print the result of the analysis for the visitors to take home. This tool should open automatically by double-clicking on the PDF file to be viewed. Once the plot is displayed, you can print it by pressing Ctrl+P and then Enter.

The viewer can be kept open as long as necessary and the new files will automatically be shown as they are opened.

7. Execution of the experiment

The step-by-step execution of the experiment goes as follows:

- Make sure that the Sun simulator is running and visible on the remote screen. Otherwise, make the pertinent adjustment as per Section 3.
- Make sure that the payload simulator is running on the laptop screen. Otherwise, take the necessary measures as per Section 4.
- Adjust the ROI in the payload simulator to include the whole simulated Sun but nothing outside the screen (in particular, not the white wall behind the monitor).
- Make sure that the payload is NOT in acquisition mode (the box is blue). If not, press the 'L' key to stop the previous acquisition.
- Press the Space Bar to clear the bottom part of the payload screen and confirm that it is measuring the total brightness (even if it is not recording it).
- At this point, someone (the operator or a visitor) can swing the pendulum. They should not push the planet (with unpredictable effects) but instead displace it roughly one meter to the side and let it go. In this fashion, we ensure that the weight will not fly further than 1 m from the equilibrium position.
- You shall start the recording of the light curve (i.e. press the 'L' key) when the planet is OUTSIDE the ROI. The experiment will probably work even if this is not the case, but the plots would not be as "clean".
- The oscillation (half-) period of the pendulum is around 1.5 seconds. You can count the transits together with the visitor and stop the acquisition after 8 to 10 transits. The analysis will also work with more transits, but the dissipation of energy will eventually reduce the speed of the pendulum, widening the transits and blurring the overlap of the folded light curve.
- Invoke the analysis tool by typing "python analyze_transit.py" in a suitable command-line window. You can then explain the plots to the visitor. The title of the plot can be personalized by typing instead "python analyze_transit.py –n 'my name'" (use quotes around the name if you use more than one word).
- Once the analysis application ends, you can double-click on the last PDF and print it for the visitor.