High Precision Astrometry of Occulting Asteroids

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Abstract

In this project our objective was to update the positions of occulting asteroids. We accomplished this by selecting asteroids that would occult a star in the near future. We use software to create prediction plots of where these asteroids would be on the night of observation. From the predictions we only chose asteroids that fit certain criteria. The asteroids could not be too far south (Declination of -30 or greater), they need to have catalogued stars nearby, and could not be too close to the sun or moon.

After choosing the asteroids we wanted to observe we offset the plots by a few arc minutes in declination and seconds in right ascension in order to surround the asteroids by as many reference stars as possible while keeping it in the field of view. We did about 2-4 pictures per asteroid depending on how many stars were around the object.

For the observations went to the Table Mountain Facility and use the 0.6 telescope. We use the telescope's 4k or 2k Charge Coupled Device (CCD) camera to take the pictures we planned out for each asteroid. The observations took place over three consecutive nights, taking as many pictures as we could.

Once the observations were completed we ran data reduction software. The software combines the entire pictures we took into one complete picture. It used the reference stars in the pictures to pin point the position of the asteroids. This created better predictions for the position of the occulting asteroids.

Introduction

In the solar system there are hundreds and thousands of asteroids are orbiting the sun. Occasionally some of the asteroids occult a star as seen from earth. What is there to learn by observing these asteroids? There are three very important things we can learn by observing these asteroids. First, by observing these asteroids we can learn a lot about their shape. If many people around the earth view the occultation of the asteroid the different viewing position can help us give a rough shape of the asteroid because in each of these places the occultation time will be different. This means that an asteroid is wider in some sections than in other parts. All these observations can be brought together to create a rough shape of an asteroid. In addition by observing the occulting asteroid we can sometime discover that some of these asteroids are binary, in other words two asteroids orbiting each other. Lastly we can keep track of its orbit, these asteroids in general pose no threat to Earth but it is always important to update the location of these objects.

Equipment

0.6 Meter Telescope, Computer "Murzin", 4K CCD camera, 2K CCD camera,

Procedure

The first step of our project was to select the occulting asteroids we wanted to observe to do this we went to our plan directory, which had all the files to create the predictions. We input the dates of observations using the Update script, which told the program for which night to predict the asteroids position. We input dates in Coordinated Universal Time (UTC) in order to get the right prediction. Once that was completed we ran the pred2k or pred4k script. This would create the predictions of were the asteroids would be on those nights. The predictions were then brought up using Ghost view (gv). In Ghost View it was possible to see the asteroid predictions visually. Next we reviewed the schocc Files, which told us when the asteroids were set to occult a star. If the asteroid had already occulted the star or would in the near future we eliminated it from observation. Then once we had created our starting point, we examined every individual prediction for each asteroid. We need to see that there are enough reference stars around in order to give us a reference. Our third criterion was that it should not be to south in the sky, more precisely in not have a Declamation of -30 or less. Our last criterion was that the asteroid no be to close to the sun in the sky, this meant it had to have a BT of 90 or greater.

For the asteroids that met our criteria, we printed out the predictions. To more accurately update the path of an asteroid, we need to take exposures of the asteroid passing against as many reference stars as possible. To accomplish this we offset the prediction plots by a few arc minutes in declination and a few seconds in Right ascension. All these exposures are combined using our data reduction script in one super exposure. We calculated the coordinates of the exposures we wanted for each of the asteroids and them wrote them down.

The next phase of our project was the observation. To do this we went to the table mountain facility were the 0.6-meter telescope was located. There were many steps before could actually take an exposure. The first step was opening up all the control clients; the Paddle client, which allowed us to manually move the telescope. There was also the focus client, which control the distance of the secondary mirror and control the focus. There was the position client which allowed us to input coordinates into the telescope. The dome client controlled the position of the dome and controlled the doors. The last client was the TCP client, which told us were the telescope was pointing.

Before each run we had to prepare the telescope for observing. The first step was to open the dome with the dome client. Next we open the cover of the telescope. In this project we used both a 2k FLI and 4k FLI camera. Each one had different steps for preparation; however, we mostly worked mostly with the 2k camera. We opened the 2k filter and then set the filter to R. Next we open the 2k camera trigger client and 2k camera image client. In order for the camera function to work correctly the camera had be focused. To focus the camera we selected a star near the zenith using the Astrometric cataloged in the position client. We took exposures of the star in order to focus the telescope and to center the camera. We took exposures until we saw that the star in the exposure we not so blurry.

Once the telescope was focused and centered we create a temp file, which records the temperature, pressure and humidity for each asteroid exposure. In addition, we create a point file were we recorded the RA and DEC of each picture. Next we commence taking exposures we had planned for each asteroid. We record for each exposure the RA, DEC, H.A, and air masses (SEC) on our observers log. We do this continuously through out the night, and make sure to keep the air masses with in reasonable range 1.000 to 2.900. This meant that if we reached a point were the object was to far away we would wait in order to reduce the air masses.

Once the observations were completed, we transferred the temp, point, and pictures files back to our computer at JPL. There we began our last step of our project, the data reduction. To begin the data reduction we run the do it script that reformats the pictures into a format we can use. Next the do it scripts it goes through each picture finding all the objects and cataloging them. The last step of the reduction is also done by the do it script which goes through all the objects that it found and identifies the reference stars and the asteroids from known catalogs. From the known location of the reference star the script calculates a new updated position for the asteroids.

Results

After the data reduction, a summary file is created with the new updated position of the objects. However not all the objects are correctly identified. We use the findbad script to find the objects with bad residuals. These objects were either to dim, not in the field of view, or where to close to a bright star or the moon. When we identify the object we manually delete the object. Then we ran the software again without the bad objects. There are more steps to the data reduction however we were no exposed to these steps so will not comment on them. Lastly when the errors in the data are removed the updated positions of the asteroids are sent to the Minor Planet Center.

Discussions

When the project began we had the objective of updating the position of occulting asteroids. However, during the third week of our ten-week internship our Telescope was damaged and was unavailable for four weeks this was a big setback that did not allow us to complete our work. But at the end we were able to successfully update the positions of about 60 asteroids.

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