John Menke
22500 Old Hundred Rd
Barnesville, MD 20838
301-407-2224
john@menkescientific.com

Observations of Near Earth Asteroid 2010 AL30 on Jan. 13, 2010 (UTC)

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Introduction

On Jan. 11, 2010 the Linear Automated Sky Survey System identified AL30 as an incoming Near Earth Asteroid (NEO). Over the next 12-24 hours, various observers improved the orbit determination, and the Harvard Minor Planet Center (MPC) began putting out revised ephemeris and elements. Closest approach was estimated to take place on Jan. 13 at approximately 0.34 the distance to the moon when the speed relative to the stars was estimated to be 10a-s/sec at magnitude of about 14-15. The ephemeris showed that on the evening of Tues Jan 12 AL30 would be well placed in the Eastern sky for observers on the Atlantic coast in the U.S.

Upon reviewing the ephemeris, I decided that observing AL30 was likely feasible at my observatory in Barnesville, MD, about 35 miles NW of Washington, DC. Given the faintness (estimated mag 15), relatively high speed (2-4 a-m/min), and continued uncertainty as to he accuracy of the ephemeris, I decided against using video due to the small field of view (FOV), somewhat lower sensitivity as compared to a good CCD camera, and lack of exposure duration flexibility.

While I do not have software capable of tracking a fast moving NEO, I do have a reasonably good and flexible remote controlled observatory about 400 feet from my home office. In fact, all observations of AL30 were done using remote operations. I have not observed NEOs before this event; however, I do have substantial photometric experience.

I used an 18in Newtonian operating at f3.9 on an AP1200 Goto mount, normally controlled using TheSkyV5 software. The camera is an ST1603, USB download, with a chip of 1530x1020 9u pixels, giving almost exactly 1 a-s/pixel, and a FOV 18x25a-m. Given the speed and faintness of the object, the large number of images I would take, and the desire for fast downloads, I decided to operate almost all the imaging at bin 2x2 (in retrospect this was a good choice). Camera control and image data reduction was done using MaximDL.

Timing data was applied to the images by MaximDL (from the PC) as it controlled the images. Use of Internet timing provided an accuracy of substantially better than one second over the duration of the session.

Acquiring AL30

After calibrating the scope position, at about 7pm EST I began attempting to capture the object by searching around the ephemeris position using 20-30 sec exposures that should give an easily seen streak. At about 730 I downloaded a revised ephemeris from MPC, and began my search again. I noted that the ephemeris position matched TheSky5 to within about 10 a-m. I acquired AL30 at about 7:45 p.m. EST.

Exposure Regimen

AL30 would pass through my FOV in about 7-9 minutes (faster as the evening progressed and AL30 approached the earth), so once the asteroid was found, I decided to point the telescope then take continuous 60sec exposures until AL30 passed out of the FOV. I would then repoint using TheSky, and repeat the process. The 60 sec streak images would yield time resolution of order 2 sec; however, problems of analysis made this difficult to achieve.

I did vary this scheme later in the evening, and took three series of shorter exposures of 3 and 5 sec, where each series lasted about 7-9 minutes. In retrospect, I should have done the entire session in the 5 sec mode. The advantage of 5sec for this object was that the length of the asteroid track is about 3-6 pixels, and is still small enough (i.e., reasonably close to star-like) to analyze using standard photometric methods.

Results

As noted, I have roughly 100 one-minute images, each showing a streak of 20-40-pixel length. I also have three sets of 3 or 5 sec exposures, each set spanning about 7-9 minutes. The imaging was from about 8-11 pm (0100-0400 UTC on Jan 13).

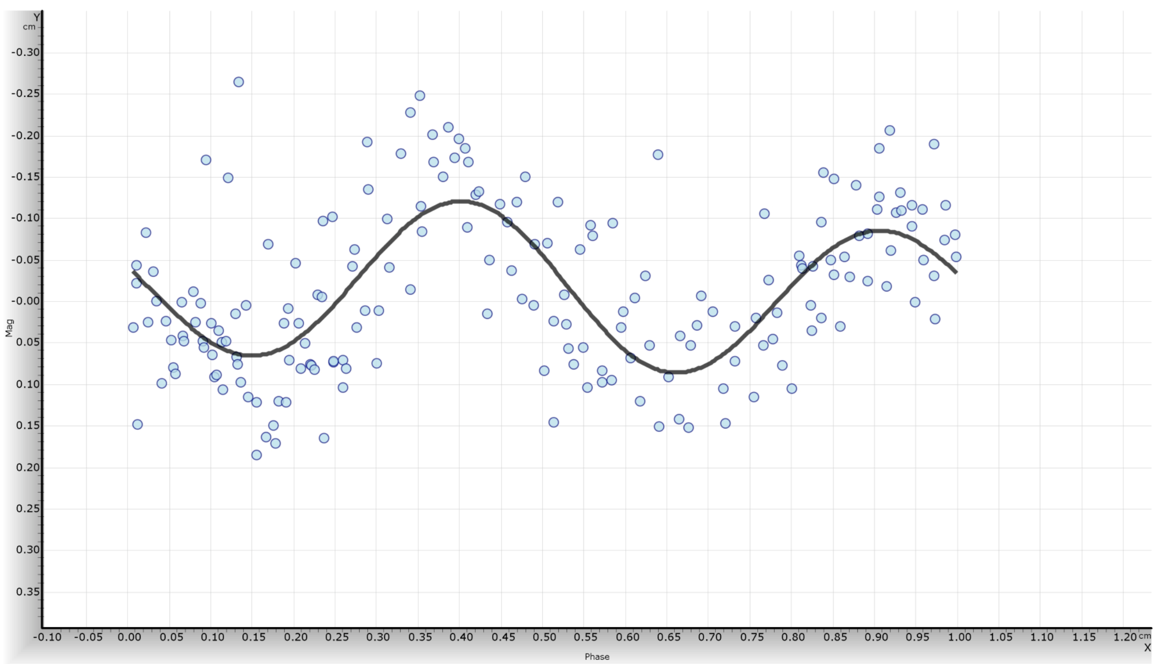
The analytic goal was to determine the photo curve of AL30 including average brightness, amplitude, and period.

I had intended to stack the one-minute image steaks end to end, but that was unealistic. The issues of streak registration and timing, intensity readout, and data management were very awkward. I was able to develop methods that allowed me to convert each image to usable data with about 3 minutes time invested per image. However, I found that the data were simply not worth analyzing. Part of the problem was a high level of noise during the trace (mostly scintillation), but the other part was the need to do frequent correction along the trace where a star interfered with the asteroid light. This was a major source of "noise" in the result, and was difficult to handle properly (I actually edited the pixels where I knew stars existed). As a result, only a portion of the 60 sec data has not been analyzed. I would note that I did search for obvious periodicities or glints in the data, but did not see any.

The 3 and 5 sec. images contain asteroid images that are small enough to be enclosed by photometric apertures, and small enough that MaximDL can interpret them as star images (i.e.. MaximDL could track the asteroid from image to image). Thus, I could easily stack 60-80 images and track the asteroid through the image set, measuring its brightness compared to field stars. I did analyze those three sets of data. Not surprisingly, there were a substantial number of data points affected by field stars; however, these were obvious and easy to drop from the data set.

I analyzed the three data sets (total 191 points) using a spreadsheet program to help identify features on the curves, to match the curves between the different fields, and to manually extract the period and amplitude. It was obvious that this was bimodal, i.e.. the curve has maxima of differing amplitudes. I then repeated the analysis using Peranso to determine the amplitudes and the period. Both analyses agreed. I also used the software package "FindGraph" to fit a two component Fourier series to the phased data. The resulting photo curve is shown in the figure along with the reference epoch. The amplitudes are 0.20 and 0.17 mag.

2010 AL30 Jan 12, 2010 Per=8.74 min T0=2455209.5586



Lessons for NEO Photometry

For those who are not expert in NEO observation, there are a few lessons that I would take from this experience. Of course, if the goal is astrometry (vs. photometry), then one might want to follow a different set of guidelines.
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- Use a wide FOV instrument capable of long exposures to make finding and tracking the object more reliable
- If you are doing photometry, consider using a CCD camera vs. a video to gain the exposure flexibility. If you lose the object, you want to be able to find it as easily

as possible. A camera with a series of filters would also allow at least some variety in bandpass.

- Consider long time series of relatively long exposures to improve s/n and to simplify data processing.
- There is a good case to be made for a succession of stationary fields so that you can do good comparison photometry. However, if suitable software were developed to track the object and a succession of comparison stars as the target moves through continuously changing starfields, that would be preferable. This would require software to control the scope (either continuously or repointing the scope after every image) and software to allow easy photometric analysis of the whole series of images.