A Novel Way to Measure the Distance to an Asteroid

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Global Rent a Scope

Abstract We have successfully measured the distance between Earth and a main belt asteroid, 298 Baptistina. We used remotely operated telescopes in New Mexico and Spain to take simultaneous images of the asteroid. The position of the asteroid with respect to the background stars was slightly different in the two images, and application of the method of parallax to the images enabled an accurate determination of the distance to the asteroid.

The Concept

A central question in the study of any astronomical object is that of distance. The oldest method for determining such distances is that of parallax using images obtained at opposite ends of the Earth's orbit.

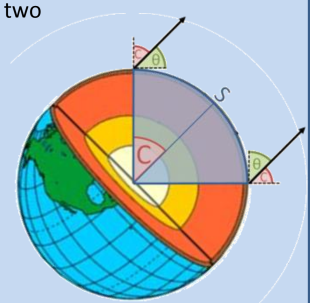
It is desirable to impress upon students the importance of the method of parallax, and the best way to do that would be by using it to measure the distance to some object. Unfortunately the feasible experiments of that nature are mostly trivial, and often involve closing first one eye and then the other. Potentially interesting experiments verge on the impossible with commonly available equipment. Here we describe the results of an experiment which fits nicely into the gap between the trivial and the impossible.

The advent of the Internet has permitted astronomers to control telescopes thousands of miles away from their office desks. In recent years this experience has become available to anyone for a modest fee. Probably the most technologically advanced and astronomically sophisticated of several web-based observatories is Global Rent-A-Scope (GRAS), the brainchild of Arnie Rosner. GRAS currently offers 12 telescopes at three locations (New Mexico, Spain, and Australia) around the world.

An impressive demonstration of the power of the parallax method would be to determine the distance to an asteroid using images obtained simultaneously from two widely–separated locations on Earth.

Is It Possible?

In order for an object to be imaged simultaneously from two locations it must be sufficiently high in the sky for both. The crucial question may then be posed as: given two locations on Earth, what is the highest elevation that any celestial object can have when viewed simultaneously from the two locations? We imagine standing at the center of a transparent Earth and looking out at two telescopes instead of stars with celestial coordinates replaced by longitude and latitude. Simple spherical trigonometry gives us the angular separation of the two telescopes: 2C in the diagram. The maximum elevation we seek will then be 90°-C. To our great joy we find that for the observatories in New Mexico and Spain the maximum elevation is 50.3 degrees. The other two pairs give unsatisfactory results.



The Plan

Once the asteroid was selected and a rough time for the image established, simple astronomical calculations allowed us to determine that the optimum time on February 5, 2011 (chosen for clear weather) would be at 3:27 UT when the asteroid would have an elevation of 44.8 degrees from New Mexico and 47.1 degrees from Spain. Of the available telescopes we selected G1 (12" Cassegrain) in New Mexico and G7 (17" Cassegrain) in Spain because they offered the best available image scale and thus the best potential for accurate position determination.

What Asteroid to Image?

Symmetry tells us that we should seek an object that would be directly overhead at the point midway between the two telescopes at a time when it is dark at both telescopes. By differencing the coordinates we find that midway location to be in the North Atlantic far from any land, but no matter. Winter in the northern hemisphere allows a window of about 6 hours between dusk in New Mexico and dawn in Spain. The constraints are rigid, but fortunately there are lots and lots of asteroids. The positions of tens of thousands of those asteroids are available at the Solar System Dynamics website (http://ssd.jpl.nasa) maintained by the Jet Propulsion Laboratory. At that site one may input any place and time and ask what asteroids are visible. Dozens of possible asteroids were identified, all near the zenith at an opportune time. Two additional criteria were then employed. The asteroid should be bright enough to image with a short (20 second) exposure but not much brighter so as to produce an easily measured position. The asteroid should also be in the inner part of the asteroid belt in order to produce a relatively large parallax. Those considerations led to the selection of 298 Baptistina at a V magnitude of 13.2.

The Results

We succeed in obtaining the two images of the asteroid and nearby stars almost (off by twenty seconds) simultaneously. Below we show the superimposed images with the two images of the asteroid in the small box.

The images were analyzed with *Astrometrica* to determine the precise coordinates of 298 Baptistina in each image. A calculation using the two positions of the asteroid resulted in an angular separation of 9.65 arc sec. We then applied $s = r * \theta$ where s is the linear (through the Earth) separation of the two telescopes and θ is the angular separation just determined to find r, the distance to the asteroid. The result was 1.16 AU which differs from the JPL value of 1.08 AU by only 7%.