Starscan

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A VERY SUCCESSFUL TRANSPACIFIC ASTEROID OCCULTATION MARCH 23, 2003

By Paul Maley

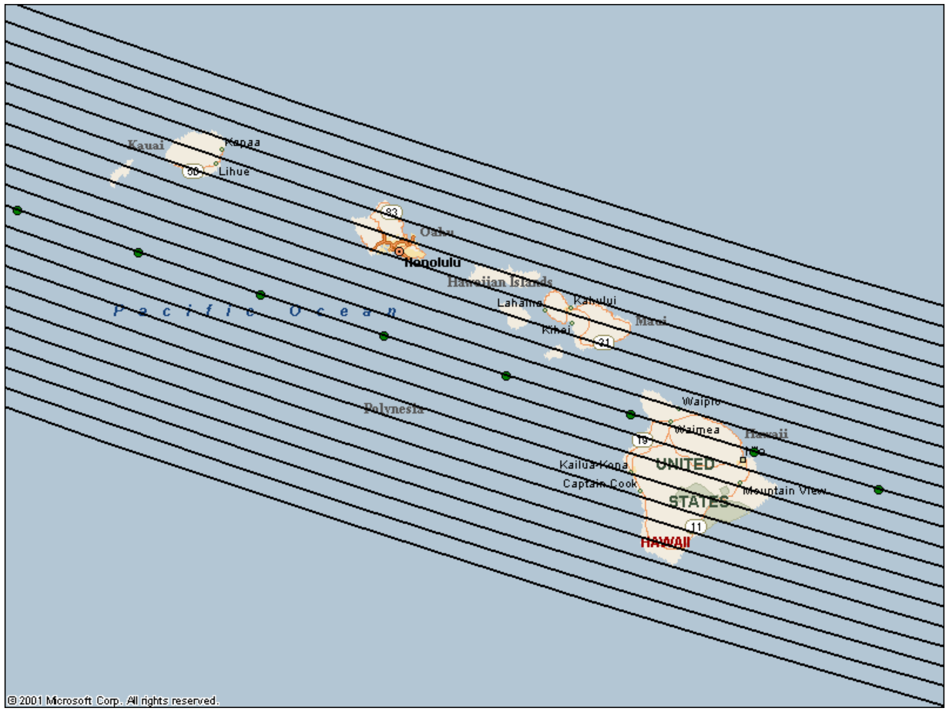
In January I found that the best minor planet occultation for U.S. observers in 2003 would take place in Hawaii, an 8-hour nonstop flight from Houston. This was the occultation of the 6.7 magnitude star HIP36189 by the asteroid (704) Interamnia. With plans in place over the next two months IOTA was able to mobilize a small group of amateur observers on the islands of Maui, Oahu and Hawaii. Instrumentation as small as 35mm aperture were used but also included some larger telescope facilities: the 0.6m University of Hawaii telescope on the peak of Mauna Kea, the 3.6m and 1.2m Air Force telescopes at Haleakala on Maui, and the 3.0 m NASA IRTF telescope also situated high up on Mauna Kea.

A view of some of the domes on Mauna Kea as seen from Kona just after sunrise March 23, 2003 (Photo by Lynn Palmer)

The circumstances were unusually favorable with a rank of "100" given to the prediction by Steve Preston. A 100 ranking is the best you can have and generally guarantees you will see the event almost anywhere in the predicted path assuming skies are clear. This time we had a 316km wide shadow path, which passed over Japan and the Hawaiian Island chain. While it would take 8 hours to fly one way from Tokyo to Hawaii and cost about $750, the asteroid shadow crossed this distance in a mere 21 minutes and did it free of charge. Dr. Bill Merline of Southwest Research Institute in Boulder, CO (famous for the optical discovery of a number of natural satellites in orbit around asteroids) and I met a couple of weeks before the occultation in Houston in order to talk about the event. In a representative effort showing cooperation between amateur and professional astronomers, he eagerly established some contacts in Hawaii and I was able to enlist some of them to participate. All the Hawaiian observers had never before attempted (or successfully observed) an asteroid occultation. One of the observers was Wayne Fukunaga whose business is showing the wonders of the night sky to island tourists using his suite of Celestron 11s and Celestron 8s in addition to other telescopes. Wayne turned out to be a huge asset supplying not only telescopic equipment for me but testing out other equipment with several other potential observers. The Hilo Astronomical Society also decided to participate, as did

United Airlines mechanic Eric Cleintuar and Renaud Savalle, a software engineer for the Canada-France-Hawaii telescope on Mauna Kea, Bill Brevoort who lived at the north tip of Hawaii but had an observatory at the south tip, student amateurs John and Kealoha Swatek, and Mike Morrow who occupied the farthest south sites in Hawaii. Then there was Dr. David Tholen of the University of Hawaii who was the farthest north observer on Oahu.

The graphic below by Steve Preston shows the center line (green dots) and equally spaced lines at parallel intervals of 10 miles both north and south of the center. Hawaii itself had the most geographic overage of all the Hawaiian Islands. The path width is depicted by the boundaries of the extremities of the lines (path width about 195 mi = 316km).



The weather in the Hawaiian Islands was good overall. Lynn and I decided in advance to fly to the big island of Hawaii because it presented the largest expanse perpendicular to the ground track where we could arrange our sites. On March 23 just north of the Kona airport a brush fire had started earlier in the day. Smoke and fire was seen along the ridge just above my site at the Four Seasons Hotel some 9 miles north of the Kailua-Kona airport. Wayne had made arrangements with the security director to allow Lynn and me to set up a Celestron 8 with a Losmandy mount on the beach access road that was protected by a locked gate. It took about 1.5 hours before the video system was eventually set up and focused. Most of the delay was due to video focusing problems with the C8 and an unsuccessful attempt to attach an f/3.3 corrector lens. Finally I decided to discard the corrector and went with the prime focus and the Watec camera. Unfortunately, only the target star could be seen and this made comparison for atmospheric effects rather tricky. At least one observer had the misfortune to set up on the wrong star; the main penalty when one does not have enough time to locate the star.

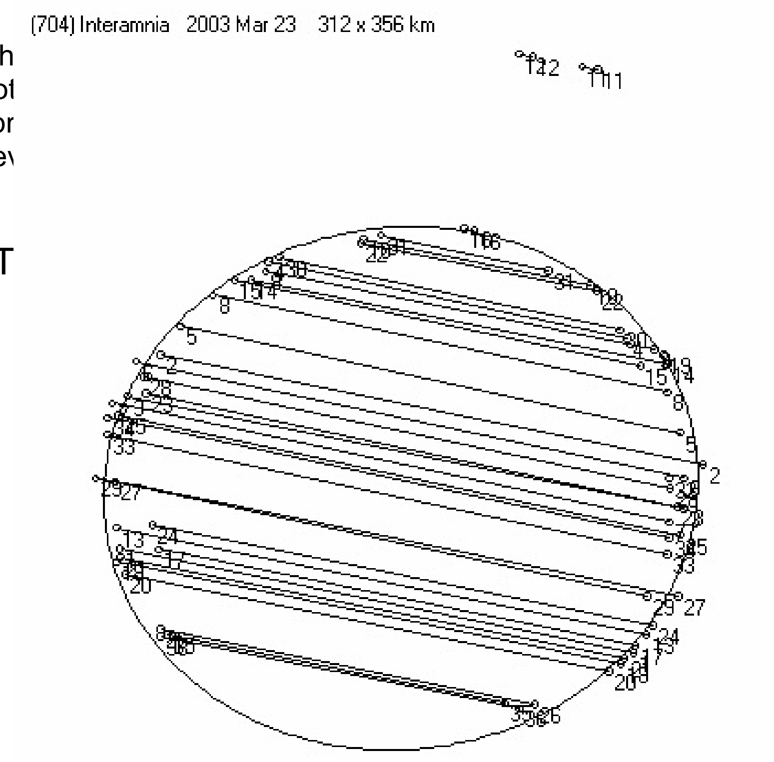
Our coastal site was in a good seeing location. Sites occupied by Bill Brevoort, Wayne Fukunaga and Verna Fukunaga experienced some turbulence as was evidenced from their videotapes. Other sites were higher up at 4,000 meters and had rather excellent conditions. The one problem we faced at Kona was a cloud that looked like "galactic dark matter." It was seemingly there and then not there.
At the start of the occultation, the disappearance of the target was instantaneous and clearly discernible. The slow apparent motion of Interamnia made this occultation one of the longest on record. At my site it was 67 seconds before the star reemerged. At the center line the longest event was over 70 seconds; this was about 10% longer than predicted.

My site was at the Four Seasons Hotel, Kona, Hawaii. Video from the Watec camera is fed into a Sony Digital camcorder while the flip out screen is used to focus and monitor the event. (Photo by Lynn Palmer) The reappearance was the most interesting part of the occultation phenomenon. We never know what to expect. Most of the time it is a simple quick D and R. But, Bill Brevoort's video shows the star reappeared at a low brightness level, remaining there a full second before it regained full brilliance. This same phenomenon was also seen by sharp-eyed Steve O'Meara who was able to watch the event with 7x50 binoculars from the flank of Mauna Loa volcano. Steve described the star as faintly visible and slowly swelling into view but dropping briefly before regaining full brilliance. Renaud Savalle described the reappearance "like the emergence of Io from the shadow of Jupiter" taking 1.5 +/-0.5 seconds to pop out. The perception of the reappearance differed at the south part of Hawaii where at three closely separated sites observers reported 0.1 to 0.2 seconds before the star completely came back, while Mike Morrow attests it took 10 seconds to return to normal light. My Watec camera recorded a 3 second period where the star was first reappearing at a low brightness and then jumped back to near normal brightness before briefly dropping down a bit. I think this latter part was due to intervening cloud. I was independently watching the star in 7x35 binoculars and could see the star disappear. But I could not make out the star reappear as all the stars were dimmed by thin cloud. But, the video record agrees quite well with the other observers.

One exciting discovery then is that we now suspect that the 6.7 magnitude target star HIP36189 is a likely close double star. I. Sato estimates that the magnitude of the companion is +9.0 with a separation of only 0.016 arc seconds. The second discovery is that the maximum occultation time is perhaps 15% larger than originally predicted (73 seconds vs. 63 seconds) indicating that the asteroid is a bit larger than previously thought. In addition a rather sizable south shift of nearly 70 km was identified from the prediction. Two separate short disappearances north of the primary path are as yet unexplained. The observation was made by H. Sugawara at Ichinoseki City with 7x50 binoculars.

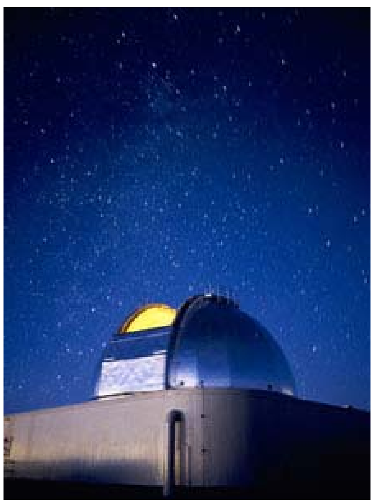
I have received 14.5 sightings in th
either the D or R were observed, not
below in order to bypass a plotting pr
shows the extensive coverage achie\

PRELIMINARY REDUCT



I generated the profile above using the software program OCCULT (developed by David Herald and used as an IOTA tool for a number of years) that fits all the observations. OCCULT shows the best fit of the shape of Interamnia to be an elliptical body about 312 x 356km. With the exception of the South Pole, a very good fit is achieved in this complete mapping of the asteroid. Other profiles have been generated independently by the Japanese based solely on their observations (see following reference). The disappearance point is that on the right side which is connected by a line to the reappearance point on the left side for each observer. Individual differences can be noted. For example, observer 24's disappearance was likely "early". The principal discordance source between individual observers is related to inaccuracy in the event times reported. This is exacerbated for visual observers by uncertain human reaction time and, in at least one case, lack of the proper time source reference. Even a fraction of a second can be magnified in this reduction method.

The chords across the face of the asteroid are keyed to the following observers. Over the course of the next two weeks we hope to update the profile with any newly reported chords. The chord numbers change when a new plot is developed. A profound thanks is given to all participants in the Interamnia occultation campaign. It is hoped that a paper will be generated in the future that will summarize the comprehensive results.



The NASA IRTF telescope

* 1=A.Nakanishi
* 2=A.Tsuchikawa
* 3=A.Yaeza
* 4=J.Bedient, S.V.Erickson, W.Rujopakarn, C.Kakiuchi
* 5=B.Brevoort
* 6=S.J.Bus, W. Golisch, A. Quillen
* 7=E.Cleintuar
* 8=D.Dunham

1.2m Telescope

* 9=H.Hamanowa, K.Hosoi, H.Hamanowa
* 10=H.Sato
* 11=H.Sugawara (1st disappearance)
* 12=H.Sugawara (2nd disappearance)
* 13=H.Takashima, F.Ohba
* 14=A.Watanabe
* 15=Haleakala USAF
* 16=I.Ootsuki

* 17=K.Kaneko
* 18=K.Kitazaki
* 19=K.Usuki
* 20=M.Ida
* 21=M.Ishida
* 22=M.Sato
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* 25=S.O'Meara
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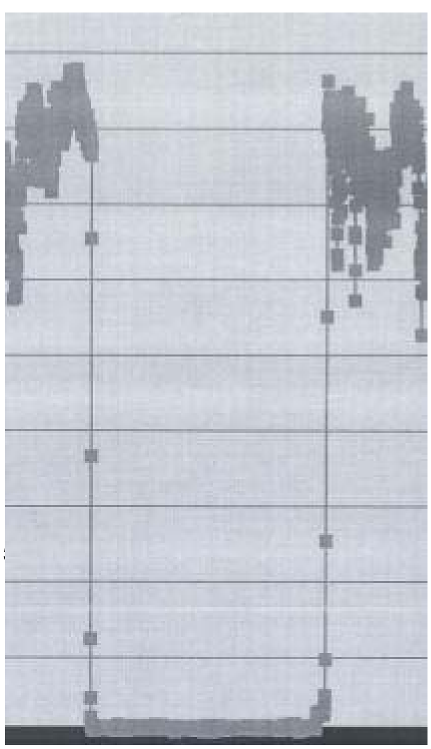
* 27=S.Uehara
* 28=R.Savalle, K.Franck
* 29=J.Swatek, K.Swatek, L.Durante, M.Morrow
* 30=R.Sydney
* 31=D.Tholen
* 32=N.Purvis, R.Crowe, D.Terry, T.Chun
* 33=V.Fukunaga
* 34=W.Fukunaga Sr., W.Fukunaga Jr.
* 35=Y.Hirose
* 36=Y.Sugiyama

The 3.6m telescope

Another reduction of the Interamnia occultation consisting of observations from Japan and analyzed by Tsutomu Hayamizu can be found at the Japanese reduction site. <http://uchukan.sendai-net.jp/data/occult/0303intera.html> S.J.Bus with the 3.0m NASA IRTF telescope on Mauna Kea reports his team observed the occultation using a SpeX Guider, which operated in Guide movie mode integrating at .04 second with a J band pass filter.

The result is the graphic below. Note the bottom of the light curve on the left side (disappearance), which is unremarkable, while the reappearance side (right side) has a slight delay on it, which corresponds nicely to the slow reappearance observed by many stations.

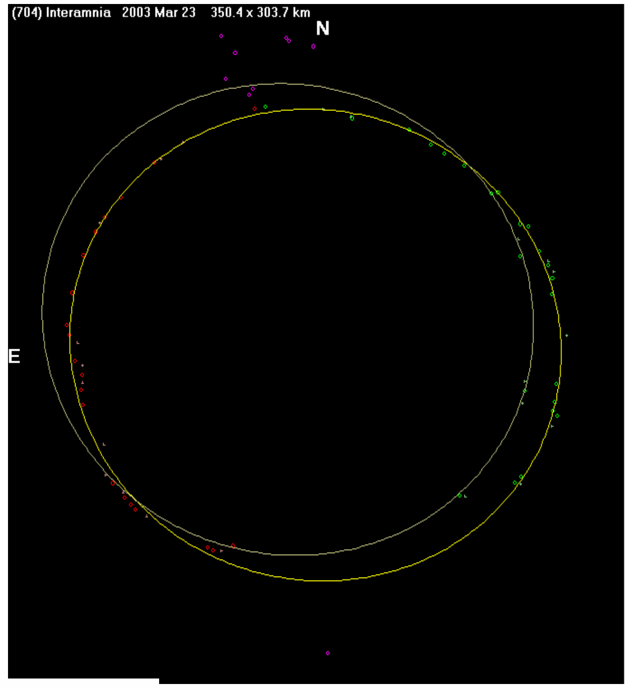


Data provided by S. J. Bus was graphed using Excel.

DAVID HERALD'S ANALYSIS

Further analysis by Australian David Herald has produced some very interesting images and a conclusion as to the nature of the slow reappearances that were seen. He has plotted approximately 52 "chords" which includes a number of "miss" chords from Japan where by far the most numerous observers were located.

In this graphic, red denotes the disappearance, green reappearance, purple shows the observer did not see the event (miss); circles denote either a video or photoelectric observation and a + sign shows visual events. The dark yellow ellipse is the fit to the primary star HIP36189, while the light yellow ellipse is a fit to the secondary star. Herald concludes from these analysis that the size of Interamnia is 350 by 304 km aligned along position angle 84 degrees; he computes that the secondary star is 13 milliarcseconds away in position angle 230 degrees.



In this graphic courtesy of David Herald, he has plotted all the chords from a different perspective in which it is possible to make out an indentation/irregularity in the asteroid shape on the east side which appears to be consistent with the adjacent times. Herald points out that it is fortunate that the spectral type K0 target star has a measured parallax, a characteristic that many stars do not have. Perhaps the most important conclusion developed by Herald is that he is able to develop an approximate size of the primary star based on the fade rates reported and the parallax (3.5 masec). He concludes that the diameter of HIP36189 is about 0.2AU = 18.6 million miles.

In summary this was the first asteroid occultation successfully observed from Hawaii. It also resulted in outstanding cooperation between professional and amateur astronomers. Approximately 52 observers attempted the event resulting at the moment in around 30 usable sets of data across the asteroid surface presented except for the South Pole. Though the

Hipparchos star catalog identifies a secondary star associated with HIP36189, there is no information on it. Observations primarily by amateurs yield fade rates that result in determination of the distance and relative orientation of the secondary to the primary star. In addition a proposed estimate of the principal star's diameter has been computed again from amateur derived data. An observed shift in the prediction of about 40 miles south was noted.

More Machines for Mars

Mars Express, the European Space Agency's mission to Mars, is due to launch from Baikonur in Kazakhstan in June 2003 (launch window is 1st to 23rd June). Today, scientists involved in both the orbiter and lander will meet together in London to finalize and co-ordinate scientific operations between these two elements of the mission - a community of European scientists linked by their mutual desire to reveal the secrets of the mysterious Red Planet. Professor Ian Halliday, Chief Executive of the Particle Physics and Astronomy Research Council (PPARC) said, "Mars has always fascinated us. The world has continually postulated on the Red Planet harboring life and this awesome mission, in which the UK has played such a significant role, will answer this age-old question. A positive result would be the vital first step in answering an even more fundamental question: are we alone in the universe?"

By mapping the Martian surface and sub surface, studying the planet's atmosphere and ionosphere from orbit and by conducting observations and experiments on the surface using the Beagle 2 lander, the spacecraft will attempt to answer this profound question whilst revealing a wealth of knowledge about the Red Planet. UK scientists, funded by PPARC, play key roles in the orbiter and lander. Of the seven instruments on the orbiter UK scientists are involved in three. The Mullard Space Science Laboratory and Rutherford Appleton Laboratory are involved with ASPERA, the energetic Neutral Atoms Analyzer, which will look at how the solar wind erodes the Martian atmosphere to identify the constituent atoms of water. University College, London and the Open University are involved with HRSC, the High Resolution Stereo Color Imager, which will image the entire planet in full color. University College London, Queen Mary University of London and University of Bristol are involved with MARSIS, the subsurface Sounding Radar/Altimeter, which will search for water beneath the surface crust of Mars.

The UK plays the lead role in the development of Beagle 2, the lander element. Consortium leader Professor Colin Pillinger of the Open University heads up the team, which also involves scientists from the University of Leicester and Mullard Space Science Laboratory. The Open University, with additional funding from the Wellcome Trust, is responsible for the key instrument, the gas analysis package including the mass spectrometer.

Mission Objectives

Recent space missions have revealed a wealth of knowledge about Mars but have also raised many questions about the creation and evolution of the Martian landscape. Mars Express will help to answer these questions by mapping the Martian sub-surface, surface, atmosphere and ionosphere from orbit and by conducting observations and experiments on the surface.

The Orbiter will:

- Image the entire surface at high resolution and selected areas at super resolution
- Produce a map of the mineral composition of the surface at 100 m resolution
- Map the composition of the atmosphere and determine its global circulation
- Determine the structure of the sub-surface to a depth of a few kilometers
- Determine the effect of the atmosphere on the surface
- Determine the interaction of the atmosphere with the solar wind

The Beagle 2 lander will:

- Determine the geology and the mineral and chemical composition of the landing site
- Search for life signatures (exobiology)
- Study the weather and climate

Launch and flight

Mars Express will be launched by a Soyuz-Fregat launcher from the Baikonur Cosmodrome in Kazakhstan in June 2003. At this time the position of the two planets make for the shortest possible route, a condition that occurs once every twenty-six months. It will take the spacecraft six months to reach the Red Planet. Six days before arrival in December 2003 Mars Express will eject the Beagle 2 lander, which will make its way to the correct landing site on the surface. Mars Express will remain in orbit around Mars for one Martian year (687 Earth Days). During this time, the point of orbit closest to Mars will move around to give the scientific instruments coverage of the entire Martian surface at all kinds of viewing angles.

Beagle entry, descent and landing

Beagle 2 will descend to the surface, entering the atmosphere at more than Mach 31.5 (31.5 times the velocity of sound - just over 700 mph). When its speed has fallen to 1600 km/h, parachutes will deploy to slow it further. Finally large gas-filled bags will inflate to protect it as it bounces to a halt on the landing site. Once still its solar panels will open out and the cameras will start to take in the view. After a couple of days the detailed rock and soil analyses will begin carried out by the instruments mounted on the Position Adjustable Workbench (PAW) which will also deliver samples to the gas analysis package inside the lander for analyses to determine if there is evidence of remnants of life.

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