POSTERS

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Galileo's Medicean Moons: their impact on 400 years of discovery
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Observing mutual events of the trans-Neptunian object Haumea and Namaka from Brazil

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Abstract. By pure coincidence, for the next few years the orbit of the satellite Namaka around the dwarf planet Haumea (formerly 2003 EL61) is nearly edge-on to our line-of-sight. This type of configuration does not last for long, because as Haumea travels around the sun in its 283 year orbit, we continuously see the Haumean system from different angles. It is only edge-on at the angle we see right now, and at the angle it will again be in 141 years – half of a Haumean year from now. In addition to being an interesting coincidence, the fact that the orbit of Namaka is nearly edge-on provides the opportunity to obtain an enormous amount of information about the Haumean system. We present measurements of the timing of these events observed from Laboratrio Nacional de Astrofsica (LNA), partner in an international campaign to observe these events from the most suitable mid-sized telescopes.

Keywords. Kuiper Belt, planets and satellites: fundamental parameters, methods: data analysis

1. Introduction

In 1610, the most important observational breakthrough was made by Galileo Galilei. In that year he turned a telescope to the skies for the first time in the human history. His new tool led to important discoveries of planetary science such as the phases of Venus, the moons of Jupiter, mountains on the Moon, and the rings of Saturn. The legacy of these findings are in the current research about extra-solar systems, outer solar-system, your formation and, possibly, life in such systems.

Kuiper Belt Objects (KBO) are icy bodies in orbits beyond Neptune. That name is in honor of Gerard Kuiper, who predicted the existence of these distant population of small bodies similar to the asteroid belt. Since the first KBO was discovered in 1992, the number of known objects increased to more than a thousand. The study of the orbital dynamics of KBO bodies can improve our understanding of the formation of the inner and outer solar system, as well as its evolution.

Haumea (formerly 2003 EL61), the third brightest known Kuiper belt object, is perhaps the most interesting object in the outer solar system. Its extremely rapid rotation and subsequent elongation immediately leads to the hypothesis that Haumea suffered a giant impact which removed much of the water ice and left the body with rapid spin. The subsequent discovery of two satellites (Hi'iaka and Namaka) in orbit around the body and the confirmation that the largest one has the spectral signature expected from a collisional fragment, confirms that the giant impact which gave Haumea its fast spin also

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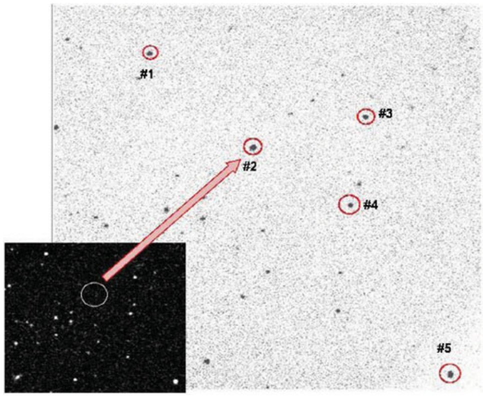

Figure 1. Finding charts for Haumea. In detail the chart showing the predicted position of Haumea at the precise time of the event. The large image was obtained at OPD during the event and shows Haumea and the comparison stars. The comparison star #1 was used to perform the differential photometry for the all the other objects.

shattered the icy mantle and ejected multiple fragments into orbit and beyond (Ragozzine & Brown (2009), Febrycky *et al.* (2008), Schaller & Brown (2008)).

For the next few years the orbit of the satellite Namaka around the dwarf planet Haumea is nearly edge-on to our line-of-sight. This type of configuration does not last for long, because as Haumea travels around the sun in its 283 year orbit, we continuously see the Haumean system from different angles. It is only edge-on at the angle we see right now, and at the angle it will again be in 141 years – half of a Haumean year from now. In addition to being an interesting coincidence, the fact that the orbit of Namaka is nearly edge-on provides the opportunity to obtain an enormous amount of information about the Haumean system. We present measurements of the timing of these events obtained from fast photometry conducted at Observatório Pico dos Dias (OPD), managed by Laboratório Nacional de Astrofísica (LNA), partner in an international campaign to observe these events from the most suitable mid-sized telescopes.

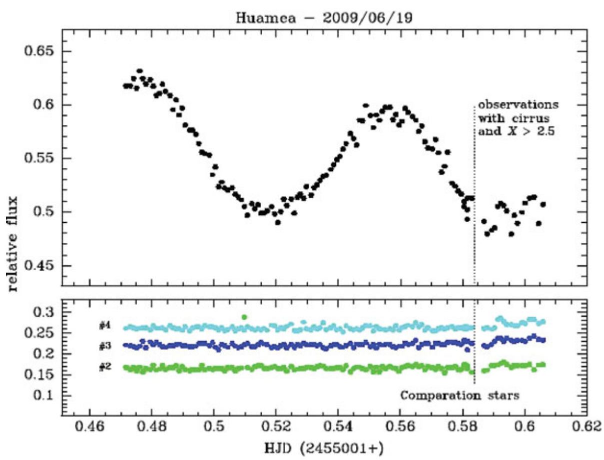

Figure 2. The upper panel shows the light-curve for Haumea obtained at OPD/LNA. A dotted line indicated the instant when clouds (cirrus) started to obscure the observations. These last images were also taken at high air-mass, $X > 2.5$, and not been used in the analysis. The lower panel shows the light-curves for the comparison stars, indicated in Figure 1.

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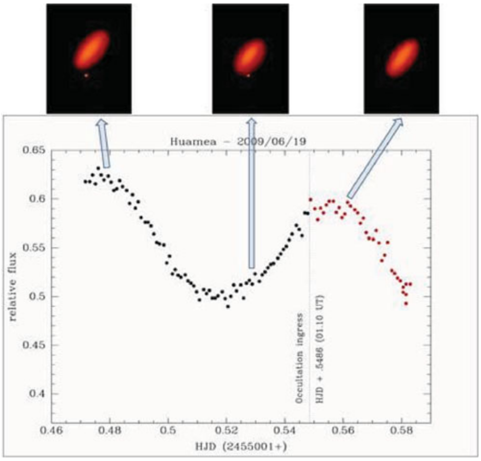

Figure 3. Light-curve analysis for Haumea. The modulation observed in the light curve is related with the geometry of the planet. The three upper panels illustrate the configuration for the system (Huamea + Namaka) in different instants. A dotted line is plotted to indicate the begin of the occultation of Namaka by Huamea.

2. Observation and Reduction

The data was secured in June 16, 2009 using the 1.6m Perkin-Elmer telescope at Pico dos Dias Observatory (OPD), the main optical observational facility in Brazil. OPD is operated and maintained by Laboratório Nacional de Astrofísica (LNA), an unit of Brazilian Ministry of Science (MCT). Figure 1 shows the chart with the predicted position of Haumea at the precise time of the event (marked as #2). The larger image was obtained at OPD during the event and shows Haumea and the comparison stars. The comparison star #1 was used to perform the differential photometry for the all the other objects.

In the Figure 2, the upper panel shows the light-curve for Haumea obtained at OPD/LNA. The lower panel shows the light-curves for the comparsion stars, indicated in the Fig 1. We can see that the modulation at the light curve of Haumea is intrinsical from object when compared with the light curve of the other objects. A dotted line indicated the instant when clouds (cirrus) started to obscure the observations. These last images were also taken at high air-mass, $X > 2.5$, and not been used in the analisys.

3. Data Analysis and Conclusions

The modulation observed in the light curve is related with the geometry of the planet. The three upper panels illustrate the configuration for the system (Haumea + Namaka) in different instants. A dotted line is plotted to indicate the begining of the occultation of Namaka by Haumea.

The relative deviation of the Haumea & Namaka's flux during the event as a fuction of time in HJD is showed in the Figure 4. The vertical dashed line indicates the beginning of the total occultation of Namaka. We split the relative deviations curve in 'before' and 'after' total occultation and we made linear fit to the both parts (showed like red dashed lines in the Figure 4). These adjustments indicate a decrement in light of the system, i.e. occultation of Namaka by Haumea. The typical value for the error bars is showed at the left side.

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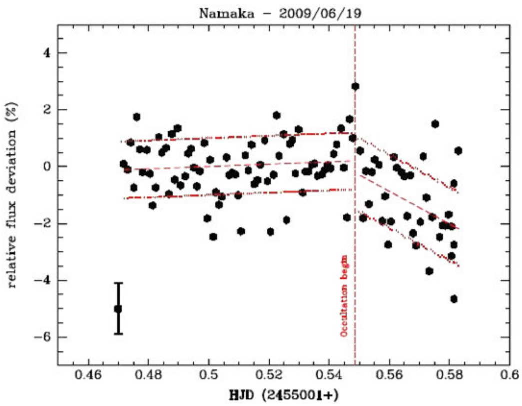

Figure 4. Relative deviation of the Haumea & Namaka's flux. A vertical dashed line indicates the beginning of the total occultation of Namaka. Dotted lines show the linear fit for the points. The adjustments indicate a decrement in light of the system, i.e. occultation of Namaka by Huamea. The typical value for the error bars is showed at the left side.

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