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The use of technology in capturing details on Jupiter's system with small telescopes

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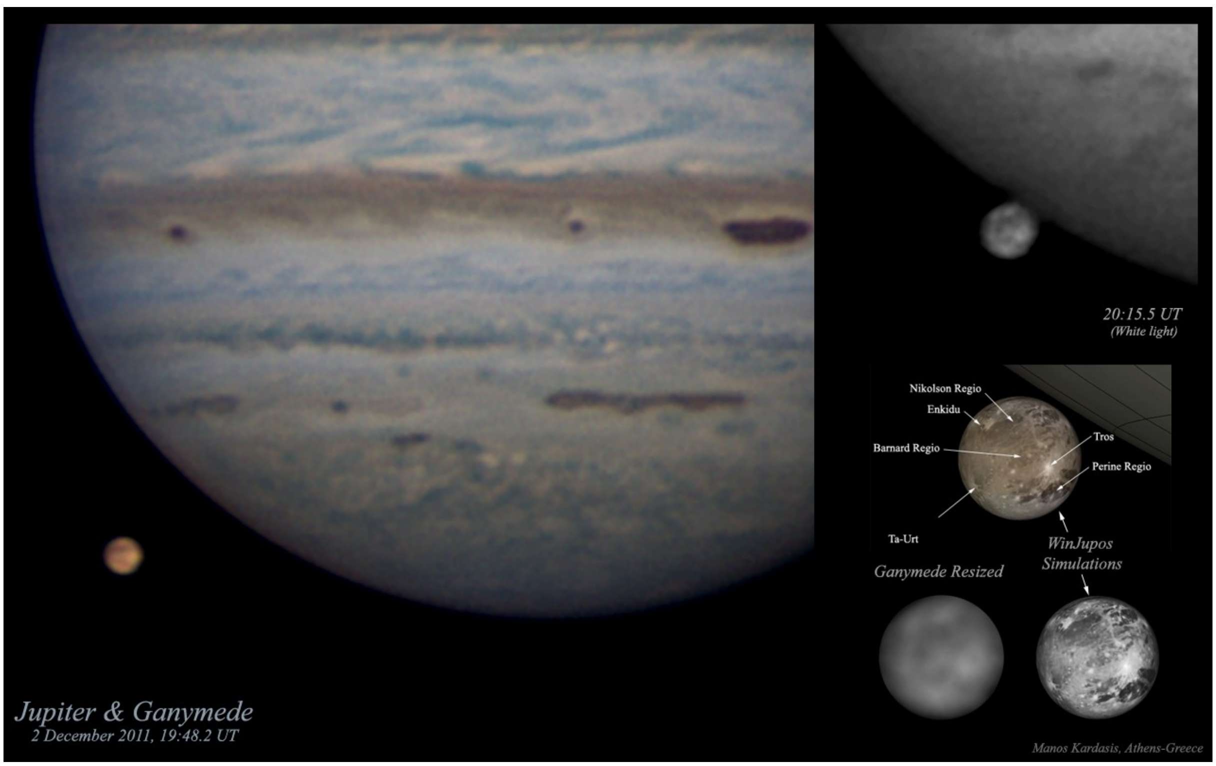

Figure 1. A synthesis of results derived from this work **a.** A detailed capture of Jupiter and Ganymede (left) **b.** Jupiter and Ganymede almost in "contact" (up-right) **c.** Ganymede and some recognized features compared with a WinJupos simulation (down-right).

Abstract

The use of modern technology has revolutionary helped the advance of the quality of planetary image-observations using small telescopes. In this work we present some extended effort on Jupiter's system and especially in the tiny disk of Ganymede. Observations were obtained with a small telescope (11inches, 0.28 m). We provide results and thoughts regarding the limits of Rayleigh criterion of the telescope used. All final images required the use of technology and excellent seeing conditions. The main result is a first amateur albedo map of Ganymede. Furthermore some other interesting observations are presented. This work may motivate more observers, ideally with larger telescopes, which may lead in useful systematic hi-resolution observations.

1. Introduction

In recent years amateurs around the world have managed to capture many interesting hi-resolution (hi-res) images of Jupiter and his satellites under ideal conditions. In some of them large scale characteristics of the satellites are obvious [1]. There is no dedicated amateur program on observing these targets as they considered demanding and theoretically beyond the limits of amateur scopes. In the following we will present some ideas in "extending" small telescope capabilities, though it requires at the same time excellent seeing conditions and skilled observers. We will provide in brief the methodology, the analysis and some first results of the experiments performed.

2. Methodology

The methodology presented is the standard procedure that all amateur planetary-imagers follow to obtain hi-res images. It is generally described in the following steps:

1. Planning observations when good local "seeing" and sky transparency are predicted [2].
2. Thermal equilibrium and alignment of the telescope.
3. Use of a planetary camera with sensitive CCD, working at high frame rates per second and combined with a fast PC. Capturing video data when planets are in optimum positions.
4. A software for alignment and stacking the video and applying wavelets on the final image (e.g. Registax)
5. Processing of the final image with some photography software.

In order to achieve captures of tiny details on planetary and satellite disks we focus on two critical additions in the above methodology. These are: imaging at extended focal lengths and the use of digital processing techniques to extract all hidden information. These two will be discussed in Section 3.

3. Observations and Analysis

All observations presented here were obtained with a small 0.28m telescope and a DMK21AS618 camera during the 2011-12 observational period of Jupiter. Table 1 describes the best observations ephemeris data:

Date	APmag	S-brt	Ang-diam	CM
2011/11/27	4.59	5.56	1.768	104
2011/12/02	4.63	5.57	1.745	360
2011/12/14	4.73	5.60	1.694	246

APmag = apparent visual magnitude, *S-brt* = surface brightness, *Ang-diam* = equatorial angular width (in arcsec), *CM* = Central meridian

Table 1: Ganymede's ephemeris obs. data [3,4]

All observations consisted of exposures in four wavelength bands: the white light (using a Luminance L Astronomik filter) and the Red, Green, Blue bands (RGB Astronomik filters). For the results presented we selected L & R filters because they provide better resolution, and surface contrast to search for features. Also the R filter suffers less from earth's atmospheric disturbance and L captures more light, so faster frames per second (fps) may be acquired. One minute videos at 30 fps were captured in order to produce the final images. It was absolutely necessary that the seeing had to be 1-2 in the Antoniadi scale [5].

At the epoch of observations Ganymede's geocentric distance was 4.1-4.3 AU and the illuminated fraction was greater than 99.4%. The angular diameter was near apparent maximum at 1.69-1.77 arcsec (so below we will suppose that 1.75 arcsec is the diameter for calculations). At the excessive focal length of 17m (f/60) Ganymede had a diameter of ~25 pixels on the CCD. Since the diameter of Ganymede is 5268 km, one pixel corresponded to a physical scale of about 210 km on the surface of the satellite.

According to Rayleigh limit, the maximum resolving power of the 0.28 m telescope is 0.41 arcsec. The use of Shannon sampling theorem applied on spatial resolution [6] requires at least 2 pixels (px) covering the maximum resolving power. So:

$$(1.75 \text{ arcsec}/0.41 \text{ arcsec}) * 2 \text{ px} \approx 8.5 \text{ px}$$

This means we need 8.5 pixels in the diameter of the satellite to capture maximum details with the current scope. When we have 25 pixels (at f/60) we "oversample" the image by a factor of ~3. This "oversampling" gives us the following advances:

- Ganymede has a significant size to process.
- Wavelets and digital processing do not saturate the result
- Processing techniques (like deconvolution of the Point Spread Function) allow resolution of even closer details (than the Rayleigh limit) especially when they have large light differences.

Better results can be achieved when the processing is made on an interpolated image (resized), after alignment and stacking (Figure 2).

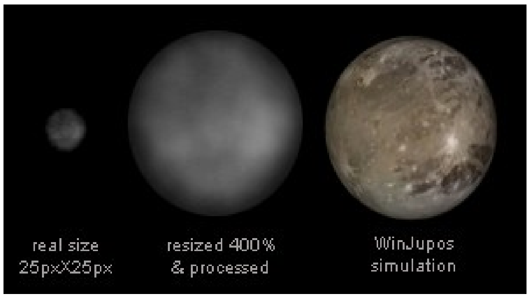

Figure 2. The real image scale of Ganymede according to the proposed methodology (after alignment/stacking/wavelets). The processed interpolated version of the real image and a comparison with a simulated image (2012/12/02, 19.56UT).

4. Results

Ganymede's surface is characterized by patches of dark and light terrain. There are many high contrast details like bright craters, bright young areas and old dark areas. High contrast features are easier to be captured, like the ones annotated in Fig.1c. In Fig.1b Jupiter and Ganymede are almost "in contact". In that image we can notice distortions in the contact area, possibly created from similar phenomena during Solar transits of Mercury and Venus [7, 8]. In Fig.1a there is a colour synthesis of Jupiter and Ganymede with many hi-res details on both disks visible. The final results with some observational details are presented in Fig.3. Large feature areas on the surface can be seen like Galileo regio, Nicholson region, Phrygia Sulcus and possibly many others. Comparing 3 different captures (Fig.1a,1b,3) with small time difference we recognize the same features. In Figure 4 a first albedo map of Ganymede from an amateur telescope was created. The map was made using WinJupos and observations of Fig.3. WinJupos does not create maps for satellites. Instead Jupiter option was selected by adding observations with the correct CM for Ganymede as it was CM1 for Jupiter. Due to the fact that the disks have different geometry the results have errors visible in the comparison image made with WinJupos simulations. Furthermore, at least 5 images would require producing an optimal result.

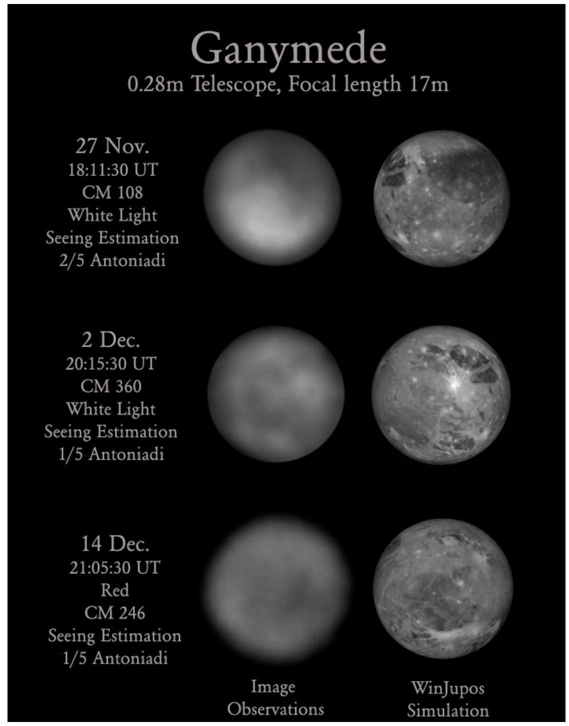

Figure 3. The best observations acquired, showing the three faces of Ganymede.

5. Summary and Conclusions

Modern capturing methodology and image processing techniques allow for more detailed resolution on planetary and satellite images. Some additions were proposed for tiny disks to the classic amateur methodology. Experiments were performed on Jupiter's system and especially on Ganymede. Although it is a small target for amateur telescopes we were able to create a first rough albedo map of Ganymede. This work may motivate observations with large instruments on more "active" tiny targets (e.g. Io, Titan, Uranus) which may become useful for detecting possible changes. However optimal atmospheric conditions are required.

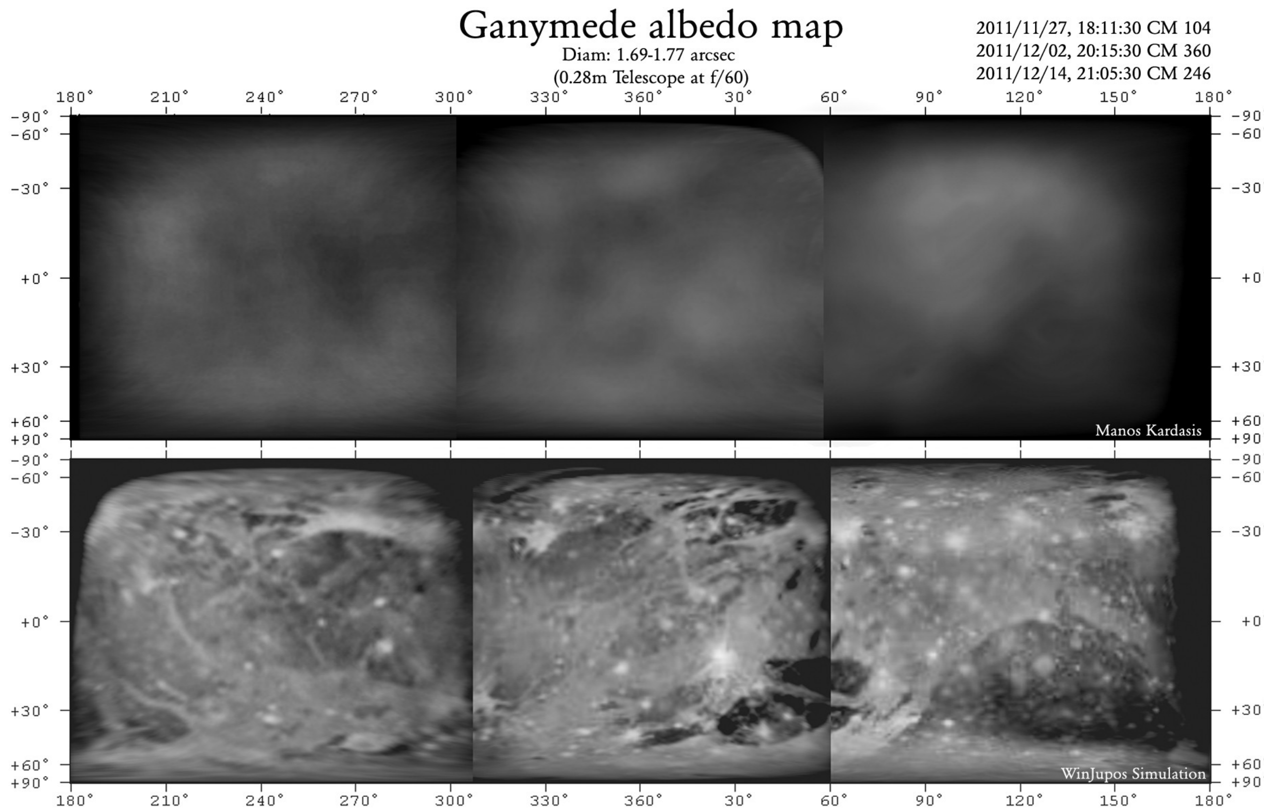

Figure 4. An albedo map of Ganymede made from observations of Figure 3. Simulated images map from WinJupos for comparison.

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References

[1] John Rogers, 2011. Images of Jupiter's Moons, 2011 apparition report No2 on Jupiter section of BAA, available at: http://www.britastro.org/jupiter/2011report02.htm

[2] Damian Peach, 2012. Predicting astronomical seeing in the UK, Journal of the British Astronomical Association, Vol. 116, No. 1, p.11.

[3] Grischa Hahn, 2012. WinJUPOS - Database for object positions on planets and the Sun, available at: http://www.grischa-hahn.homepage.t-online.de/astro/winjupos/index.htm

[4] HORIZONS Web-Interface. 2012, Generator of ephemerides for solar-system bodies, 2012, available at: http://ssd.jpl.nasa.gov/horizons.cgi

[5] Jeff Beish, 2010. Astronomical seeing, available at: http://www.alpo-astronomy.org/jbeish/Observing_Mars_8.html

[6] Franco Gori, 1993. Sampling in optics, Advanced topics in Shannon sampling and interpolation theorem – editor R.Marks, Springler-Verlag.

[7] Jay Pasachoff, Glenn Schneider and Leon Golub, 2001. Space Studies of the Black-Drop Effect at a Mercury Transit, American Astronomical Society's Division of Planetary Science meeting in 2001.

[8] Jay Pasachoff, Glenn Schneider and Leon Golub, 2004. The black-drop effect explained, Transits of Venus: New Views of the Solar System and Galaxy, Proc. IAU Colloq.#196,7-11 June,Preston, U.K..CUP, p.242-253