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Imaging Mars during the 2018 apparition

Initial spatial analysis of the dust storm with ArcGIS

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Abstract

We have imaged Mars during the 2018 apparition using a Celestron C8 SCT (E.S.) and a C14 (J.S.), respectively. Since the altitude of Mars was the highest on Curaçao and this Caribbean island has often excellent seeing conditions the most detailed information was collected on Curaçao. Starting at the end of May a big dust storm developed, which at the end of June 2018 covered almost the entire Martian surface. In September 2018 the storm had vanished again.

Using ArcGIS software we have analyzed the development of dust clouds at three different positions, viz. at Syrtis Major, Solis Lacus and Valles Marineris, respectively. In particular the clouds in the Valles Marineris region were interesting. Using the USGS MOLA Elevation map of Mars we have looked whether there is a preference of dust accumulation in valleys. Close to Valles Marineris, we found a region in Sinai Planum where several short-lived storms seemed to originate. The MOLA Elevation Map shows that this location is positioned on an inclination with a flat slope at the transition f two geological structures. Further studies are required to understand the meaning of this phenomenon.

We also investigated the storm in relation to elevation patterns in Solis Lacus and Terra Sirenum where distinct dust clouds have been were detected.

The application of ArcGIS in combination with the elevation and structural maps obtained with the Mars Global Surveyor is probably also for amateurs a useful tool to understand certain planetary phenomena

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The Role of Amateur Observations in Characterizing the Current Equatorial Zone Disturbance in Jupiter

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Abstract

Observations from both the amateur and professional communities report the emergence of a disturbance in Jupiter's Equatorial Zone, which is being observed for the first time with a wide range of wavelengths. The continuous monitoring of the event by the amateur community is an invaluable resource for documenting the behavior of this phenomenon.

1. Introduction

Jupiter's Equatorial Zone (EZ) is normally bright and white colored at visible wavelengths, but it is subject to periods of remarkable darkening and coloration in records that date back to 1890. Recent work by Antuñano et al. [1] has shown that these episodes of EZ darkening are accompanied by brighter thermal emission at a wavelength of 5 µm, which is sensitive to thermal emission attenuated by absorption by clouds. Images and spectra at this wavelength are therefore very useful to diagnose the depth of clouds. The brightest, therefore deepest, regions detected at 5 µm are generally associated with the darkest visible features, with the most extreme brightness associated with the visibly darkest blue-gray regions, such as those located at the southern edge of the North Equatorial Belt (NEB), known as 5-µm "hot spots".

2. Historical behavior

During an EZ disturbance event, much of the EZ becomes generally a darker and usually redder color, sometimes evolving from yellow to browner shades and followed by an overall dark gray hue [2]. Meanwhile, there is often an intensification of the filaments of dark blue-gray material extending southward from the NEB hot spots far into the EZ. High 5-µm radiances continue to be associated with the darkest features during these events and, at their peak, a large portion of the EZ has become bright at 5 µm, quite the opposite of its normally dark/cold appearance that is consistent with high cloud tops reaching into the upper, colder parts of Jupiter's troposphere. One of the conclusions reached by Antuñano et al. [1] is that these events are quasi-periodic: the visible darkening seems to take place every 6-7 (Earth) years, although in some cycles, the bright 5-µm appearance of the EZ is much less than in other cycles (or even absent, which was the case in the mid-1980s and in 2012-2013). When a 5-µm-bright appearance takes place, it is generally limited to a lifetime on the order of 1-1.5 years.

3. The current event

Antuñano et al. [1] predicted a repeat of this EZ disturbance in 2019. A first harbinger of this event was the progressive visual darkening of the EZ in mid 2018, starting with a light orange-brown color, as documented by a suite of amateur astronomers (Figure 1). True to the progression of previous EZ disturbances, strips of bright 5-µm emission began appearing in 2018 August in the mid/southern part of the EZ. In 2019 January, 5-µm brightening was increased in longitudinal strips and also detected in some oblique streaks, but it retreated soon afterward (see the abstract by Orton et al. in session OPS4).

4. What's next?

It is difficult to forecast weather, particularly on a planet with no routine multispectral monitoring and only primitive versions of global climate models (CGMs). What we are left with are simple analogies to previous observations, with only the last two events (1999-2000 and 2006-2007) having routine 5-µm monitoring involving several observations taken throughout the course of a year. The lifetimes of the EZ disturbances at 5 µm have been on the order of 1-1.5 years, much shorter than historical coloration events, which can be 3 years or longer [2]. However, this comparison is provisional because only the most recent events in 1999-2000 and 2006-07 were well documented at 5 µm, and they had little visible color; 5-µm observations were sparse for the prolonged coloration events in previous decades, which were more similar to the present event. Observations by the amateur community have and will continue to help document the evolution of this disturbance, including the relationship between the darker blue-gray regions and the regions of enhanced 5-μm brightness over the next few months.

We will report on what will clearly be a definitive set of observations relating the evolution of this disturbance between the writing of this abstract and its presentation some 5 months from now. The need for continued support from the amateur community has seldom been more important, with the potential involvement of the Juno mission – particularly including the potential for observations by Juno's Microwave Radiometer of the ammonia distribution deep in the EZ during this period. It is also important because these disturbances are sometimes associated with other planetary-scale phenomena, such as South Equatorial Belt "fade and revival" sequences in what have been called "global upheavals" [2].

5. Summary and Conclusions

It has been and will continue to be important for the involvement of the amateur community to determine the evolution of EZ disturbances, particularly short time scales, as might be involved in the appearance of regions that are detected as bright at 5 μm. This will impact the evaluation of the forces responsible for the evolution of the phenomenon, e.g. whether this is a disturbance propagating upwards from below or downwards from above [1], and the interpretation of professional observations, including those from the Juno mission.

Acknowledgements

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References

[1] Antuñano, A. et al.: Infrared characterization of Jupiter's equatorial disturbance cycle, Geophys. Res. Lett. Vol. 45, pp. 10987-10995, 2018.

[2] Rogers, J. H.: The giant planet Jupiter, Cambridge University Press, 1995.

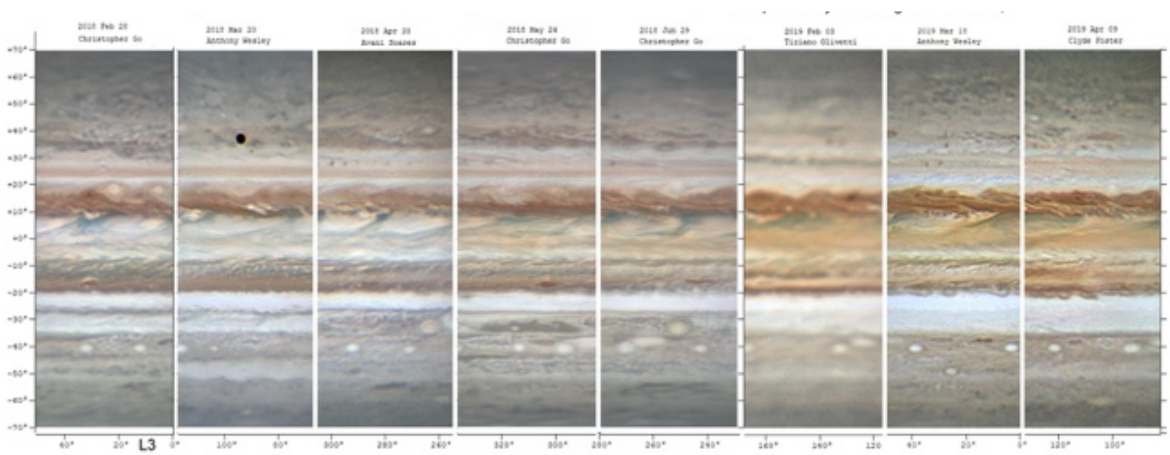

Figure 1: Series of Jupiter's belts and zones from 2018 February through 2019 April, from maps created by Marco Vedovato (JUPOS team). North is up.

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Summary of the Season 2018 - 2019 Exoplanet Observations in Taurus Hill Observatory

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Abstract

Taurus Hill Observatory (THO) [1], observatory code A95, is an amateur observatory located in Varkaus, Finland. The observatory is maintained by the local astronomical association Warkauden Kassiopeia. THO research team has observed and measured various stellar objects and phenomena. Observatory has mainly focused on exoplanet light curve measurements, observing the gamma rays burst, supernova discoveries and monitoring [2]. We also do long term monitoring projects [3].

The results and publications that pro-am based observatories, like THO, have contributed, clearly demonstrates that pro-amateurs are a significant resource for the professional astronomers now and even more in the future.

1. High Quality Measurements

The quality of the telescopes and CCD-cameras has significantly developed in 20 years. Today it is possible for pro-am's to make high quality measurements with the precision that is scientifically valid. In THO we can measure exoplanet transits < 10 millimagnitude precision when the limiting magnitude of the observed object is 15 magnitudes. At very good conditions it is possible to detect as low as 1 to 2 millimagnitude variations in the light curve.

2. Winter 2018/2019 Exoplanet Transit Observations in THO

THO research team has made 13 years transit and light curve measurements about the exoplanets. To this date the team has measured over 70 different exoplanet light curves, some of them several times. Most of the transit measurements have been stored in the EDT (Exoplanet Transit Database) maintained by Variable Star and Exoplanet of Czech Astronomical Society.

Here are some examples of the exoplanet measurements from THO. In Figure 1 below is the exoplanet measurement from HAT-P-32b, discovered November 2011, and so far it has been observed three times in THO. First time in September 2013 and most recently in October 2018.

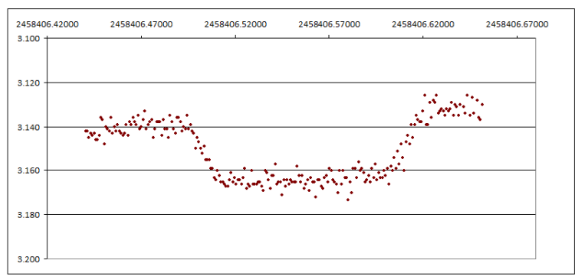

Figure 1: HAT-P-32b light curve 14./15.10.2018; C-14, Paramount MEII, SBIG ST-8XME.

Second example concerns KELT-16b, a highly irradiated and ultra-short period hot Jupiter transiting the relatively bright star TYC 2688-1839-1/KELT-16. THO team observed this exoplanet transit on 10./11.10.2018 (Figure 2).

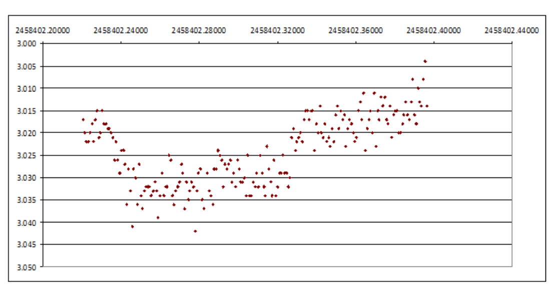

Figure 2: KELT-16b light curve 10./11.10.2018; C-14, Paramount MEII, SBIG ST-8XME.

3. TrES-5 b and possible existence of the exoplanet TrES-5 c

Some deviations in transits of known exoplanet has been discovered and by detecting these deviations as much as possible, it is possible to find out whether the deviation is caused by another planet in the system or not. This is the case with the TrES-5b exoplanet. It seems that there are disturbances caused likely by another planet (TrES-5c) with mass of 0.24x MJup. This and other candidates, and the findings of the TrES-5b and possible TrES-5c that are introduced in the article [4], have been observed between 2013 and 2016. Observations have, of course, continued until these days.

In addition to the TrES-5b, there are some dozens of other promising candidates on the Pulkovo Observatory list, and outside of it, that THO has observed. THO is also involved in an Italian group of enthusiastic astronomers (GPX) led by Paul Benni trying to find exoplanets from very small area of the sky. This group also includes researchers from the Pulkovo Observatory. Potential area is first investigated with the RASA telescope, and then promising candidate areas will be measured more accurately. Pro-am photographic observations are supported by the observations made by professional observatories on the spectrum of potential targets. Target list is updated regularly and there are new target candidates all the time and there are simultaneously 10 to 20 targets under investigation.

At the THO location (Eastern Finland), the target objects are always high on the northern sky, so they can be observed throughout the year in excellent weather conditions.

TrES-5b observation campaign [4] includes several participants from Russia, Belgium, Finland, USA, Canada, UK, France, North Cyprus, Greece, Spain and Ukraine, altogether 17 institutes or organizations.

4. Summary and Conclusions

Taurus Hill Observatory and other similar pro-amateur based observatories have a good record in field of astronomy and especially in the light curve measurements and photometric monitoring.

The research teams have the knowledge for making a good and high quality photometric light curve measurements. The publication records are one of the good examples from this knowledge. In the future the THO research team aims for more challenging astronomical research projects with professional astronomers and observatories.

As a conclusion it can be stated that it is possible to do high quality astronomical research with pro-amateur astronomy equipment if you just have the enthusiasm and knowledge to use your equipment in the right way.

Acknowledgements

The Taurus Hill Observatory will acknowledge the cooperation partners, Pulkova Observatory, Finnish Meteorological Institute and all financial supporters of the observatory.

References

[1] Taurus Hill Observatory website, http://www.taurushill.net

[2] A low-energy core-collapse supernova without a hydrogen envelope; S. Valenti, A. Pastorello, E. Cappellaro, S. Benetti, P. A. Mazzali, J. Manteca, S. Taubenberger, N. Elias-Rosa, R. Ferrando, A. Harutyunyan, V.-P. Hentunen, M. Nissinen, E. Pian, M. Turatto, L. Zampieri and S. J. Smartt; Nature 459, 674-677 (4 June 2009); Nature Publishing Group; 2009.

[3] A massive binary black-hole system in OJ 287 and a test of general relativity; M. J. Valtonen, H. J. Lehto, K. Nilsson, J. Heidt, L. O. Takalo, A. Sillanpää, C. Villforth, M. Kidger, G. Poyner, T. Pursimo, S. Zola, J.-H. Wu, X. Zhou, K. Sadakane, M. Drozdz, D. Koziel, D. Marchev, W. Ogloza, C. Porowski, M. Siwak, G. Stachowski, M. Winiarski, V.-P. Hentunen, M. Nissinen, A. Liakos & S. Dogru; Nature - Volume 452 Number 7189 pp781-912; Nature Publishing Group; 2008

[4] Transit timing analysis of the exoplanet TrES-5 b. Possible existence of the exoplanet TrES-5 c; Eugene N Sokov, Iraida A Sokova, Vladimir V Dyachenko, Denis A Rastegaev, Artem Burdanov, Sergey A Rusov, Paul Benni, Stan Shadick, Veli-Pekka Hentunen, Mark Salisbury, Nicolas Esseiva, Joe Garlitz, Marc Bretton, Yenal Ogmen, Yuri Karavaev,Anthony Ayiomamitis, Oleg Mazurenko, David Alonso, Sergey F Velichko; Monthly Notices of the Royal Astronomical Society, Volume 480, Issue 1, October 2018, Pages 291–301, https://doi.org/10.1093/mnras/sty1615

EPSC Abstracts
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Choosing the most effective imaging technique for planetary imaging in less than ideal conditions

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Abstract

The collaboration between amateur and professional astronomers is increasing rapidly and planetary astronomy is no exception. Not all amateur astronomers are living in areas with perfect conditions for planetary imaging so optimizing everything to get the maximum of data the conditions allow is of utmost importance. Using the imaging technique that allows to get the maximum of resolution in planetary colour images has a substantial influence on the end result. RGB and LRGB images processed from the same data captured at low altitude of the planet are compared. The comparison shows that there is one technique that consistently allows getting the maximum of detail from the raw data.

1. Introduction

Amateur planetary imaging has come a long way in the last 10-15 years, the images being produced today by amateur astronomers rivaling those obtained not long ago by professionals using a lot more expensive equipment. In contrast with the professionals, the amateurs are mostly imaging from sites with less than ideal conditions (high latitudes, unsteady atmosphere etc.) which have a big influence on the quality of the images. Using the right capture and processing technique is one of the aspects that help obtaining the best images possible given the conditions. This study focuses on identifying the best imaging technique to use in less than ideal conditions (low altitude of the planet and unsteady atmosphere).

2. Possible imaging techniques

There are two main possibilities for getting color images with a monochrome camera: using separate filters (usually R, G, and B) and then combining the channels to form the final image or using the same filters to capture color data and an additional one to capture the details (UV/IR-cut filter). More detail about RGB and LRGB imaging can be found in [1].

3. Raw data used

A series of RGBLBGR Jupiter capture sequences were obtained using a 245mm f/20 classical cassegrain telescope, an atmospheric dispersion corrector, an LRGB filter set and an ASI290MM monochrome camera. Jupiter was at 29° of altitude (maximum altitude for the observing site in 2018) in average seeing conditions.

4. Raw data processing

All the captured ser-files were first processed using the AS3! software to get raw stacks which were afterwards sharpened using the wavelet function in Registax 6. The sharpened images from each sequence were measured and then derotated in WinJupos to obtain the R, G, B and L final images. From each RGBLBGR sequence one RGB and one LRGB images were assembled in Photoshop CS2.

5. Comparison results

Comparing the RGB and LRGB images shows that for each sequence the LRGB image has finer detail.

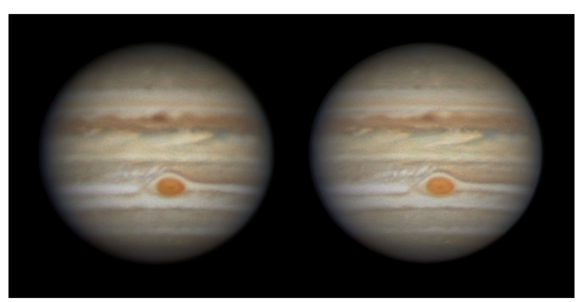

Figure 1: RGB (left) and LRGB (right) images.

This is explained on one hand by the fact that the L channel allows the capture of data at shorter exposure to better “freeze” the seeing without compromising the signal-to-noise ratio (SNR) and on the other hand by the fact that in conditions of variable seeing there is an SNR difference between the same channel images which cannot be completely compensated by WinJupos derotation.

6. Summary and Conclusions

To identify the most effective imaging technique to use, a series of RGBLBGR capture sequences were used to obtain RGB and LRGB images from each sequence. The RGB image from a sequence was afterwards compared with the LRGB image from the same sequence. For each sequence, the LRGB image had finer detail than the RGB one. This is also true in fluctuating seeing during the raw data capture.

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References

[1] Pellier, C., Delcroix, M., Monachino, G., Viladrich, C., Burgeot, F., Poupeau, J-J., Prost, J-P. : Astronomie planetaire, pp. 136-149, 2015.

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The cyclic expansions of Jupiter's North Equatorial Belt in 2015-2017

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Introduction & Summary

Jupiter's North Equatorial Belt (NEB) undergoes semi-periodic climatic cycles that involve broadening of the visibly dark belt to the north; hence we refer to them as NEB Expansion Events (NEEs) [1-3]. They affect phenomena across the whole width of the NEB. New convective outbreaks ('rifts') are commonly involved in the initiation of NEEs, and it was recently found that these rifts are more northerly and slow-moving than those seen at other times [2]. NEEs occurred every 3-5 years from 1988 to 2012.

The NEB underwent a new expansion event in 2015-16, but the expanded sector covered less than half the circumference; then it completely regressed. But northerly rifts reappeared in 2016 Oct. and led to a second NEE that developed rapidly and completely in early 2017. Here we describe these two NEEs as observed by amateur observers in visible light and in the methane absorption band, and we show how JunoCam images have recorded changing cloud patterns within the NEB during the NEE in 2016-17. Full details of these observations are given at: https://www.britastro.org/section_front/15.

1. The first NEE

A new outbreak of northerly rifts began in autumn 2014, and a sector of NEBn showed some disturbance from then on. However, it was not until solar conjunction in late 2015 that this same sector broadened fully. The expanded sector was ~95º long in 2015 Nov. and ~143º long in 2016 Jan-Feb.; however, this was its maximum extent. In Feb. it began to fade from both ends and by mid-June it had completely regressed, so the NEBn edge appeared disturbed but otherwise fairly normal.

2. The second NEE

During solar conjunction in 2016 Sep-Oct., a major upheaval began at 23°N on the NTBs jet, leading to turbulent revival of the North Temperate Belt (NTB) and massive disturbance of the N. Tropical Zone in the ensuing months. It is possible, though unproven, that this disturbance triggered the subsequent NEE.

In 2016 Oct., a new northerly rift appeared in the NEB, typical of rifts associated with NEEs. This and subsequent rifts appeared close to the locations of compact circulations, although always outside them. These rift systems progressed until by 2017 April they encompassed the whole circumference of the NEB, and in some sectors its whole width.

Between the highly disturbed NTropZ and NEB, the NEB expanded northwards to 20-21ºN around most of the belt from Feb. to April. By June it was clear that a rapid and complete NEE had occurred. Also, anticyclonic white ovals (AWOs) and cyclonic dark 'barges' were forming, as is typical after a NEE. NEB rift activity declined greatly after May.

3. Methane-dark waves

A notable feature of the 2015-2018 events was a wavelike pattern seen in methane absorption band images, both at 889 nm (amateurs) and 2.1—2.3 μm [3]. Such waves were also prominent during the NEE in 2000-01 [4]. They are diffuse methane-dark patches over the NEB with wavelength ~17°-22° longitude, representing clearings in high-altitude haze. They coincide with thermal waves above the main cloud deck, detected at mid-infrared wavelengths both in 2000-01 and in 2015-16 [3,4]: the haze is thinner where the atmosphere is warmer.

The methane-dark waves over some sectors persisted even after the first NEE, and were still prominent throughout 2017. In 2015-16, there was no obvious correspondence between the methane-dark waves and the underlying visible circulation patterns, but by summer 2017 there was a striking pattern of waves that were both methane-dark and visibly dark brown around most of the NEB. In visible light, the NEB returned towards normal width during mid-2018. In methane band, waves diminished during 2018.

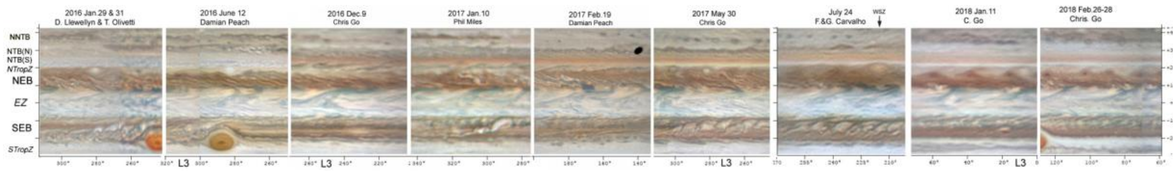

Figure 1. Excerpt from cylindrical maps showing the varying appearance of the NEB from 2016 to 2018. All maps made by M.V. (JUPOS team).

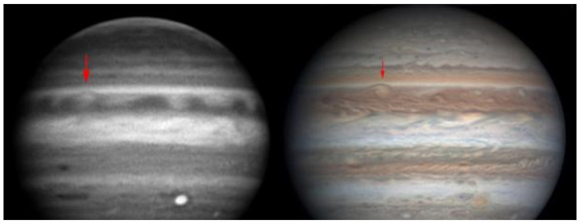

Figure 2. Image at 889 nm showing the high-amplitude methane-dark waves on the NEB, with a visible image (2017 June 14, by C. Go). Red arrow: a long-lived AWO.

These events are consistent with the following model [3,4]. The methane-dark waves coincide with thermal waves, which may be Rossby waves, above the cloud tops. These may be forced by meridional waves in the retrograding jet in the main cloud deck. The intensity amplitude of the methane-dark waves, and later of their visible brown counterparts, which increased from 2015 to 2017-18, perhaps reflected the amplitude of the waves in the jet.

4. Images from JunoCam

Juno's orbital mission coincided with the second NEE, so the camera (JunoCam) has obtained closeup views of the NEB at every perijove from PJ3 onwards. These reveal fine details such as multi-level haze streaks over expanding rifts, changing NEB cloud textures, and incipient circulations.

5. Conclusions

The NEE of 2015-16 only covered a limited longitude sector and then regressed. But then, the NEE of 2017 confirmed the typical features of such events: the initial association with slow-moving northerly rift(s); the broadening to 20-21°N; the subsequent appearance of AWOs and barges. The NEE of 2017 also had special characteristics that raise interesting dynamical questions:
--It occurred shortly after the adjacent NTBs outbreak started, and the two outbreaks together resembled the 'great northern upheaval' of 2012'; any mutual causality remains unclear.
--The methane-dark waves were very prominent, and persisted outside and between the two NEEs. This gave the opportunity to confirm their relationship to thermal waves and visible waves.
--As the second NEE occurred during the Juno mission, it was possible to obtain hi-res images of the changing cloud textures from JunoCam, and deep thermal scans from the Microwave Radiometer which could give unprecedented information on any changes that were occurring below the known clouds.

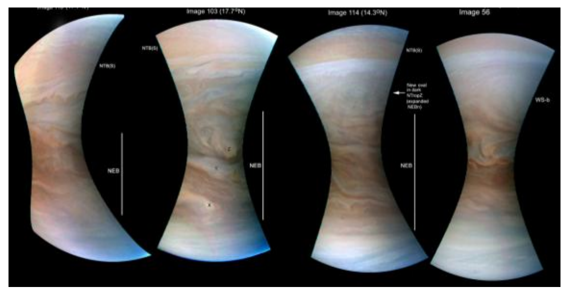

Figure 3. JunoCam images centred on the NEB from PJ3 to PJ6. The images were reprojected as if viewed from a point above the spacecraft's track, with north up.

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References

[1] Rogers JH. The Giant Planet Jupiter (Cambridge Univ. Press, 1995).
[2] Rogers JH. 'Jupiter's North Equatorial Belt and Jet: I. Cyclic expansions and planetary waves.' J. Brit. Astron. Assoc. 129, 13-26 (2019).
[3] Fletcher LN, Orton GS, Sinclair JA, Donnelly P, Melin H, Rogers JH, et al. 'Jupiter's NEB expansion and thermal wave activity ahead of Juno's arrival.' Geophys. Res. Lett. 44, 7140-7148 (2017).
[4] Rogers JH, Akutsu T, & Orton GS. 'Jupiter in 2000/2001: Part II: IR and UV wavelengths: A review of multispectral imaging of the jovian atmosphere.' J. Brit. Astron. Assoc. 114, 313-330 (2004).

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Experimental color analysis of Jupiter's clouds

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Abstract

Jupiter is a planet which is currently well followed by amateurs from the ground, with high resolution images taken in color, or in non-visible wavelengths such as UV, IR, CH4. Such images participate to the knowledge of the planet, along with professionnal data and space orbiters like the JUNO probe. Other technics of observation like spectroscopy and photometry, while being widely used among amateurs to study stars, remain largely ignored for planetary studies, and would deserve to be more investigated.

1. Introduction

Describing the variations of colors on planetary disks has always been a part of the following of planets. This topic is interesting because color changes are a manifestation of some meterological and chemical changes. On Jupiter, many short or long-term color changes can be identified. Some of them have been linked to a scientific explanation, like the recurrent episodes of strong coloration in the equatorial zone [1]. Some others remain, however, unexplained.

While the colors of the planet can be easily revealed by the modern high quality and high resolution images, evaluating them on those images remain partially a subjective work. In the professional world, it is possible to use high-resolution spectroscopy or absolute reflectivity on disk images [2]. But these technics can prove hard to use for amateurs.

Because this topic participates to the long-term knowledge of Jupiter, I will experiment some more basic methods, accessible to amateurs, for a more objective way to evaluate the colors of the jovian clouds.

2. Low resolution spectroscopy of belts and clouds

By using a simple grating of R=100, but modified in order to work with a slit, it is possible to extract low resolution spectra of the main belts and zones. By taking the spectrum of a nearby solar-like star, it will then be possible to produce reflectance spectra of those belts and zones.

3. Reflectance photometry of the jovian details

The concept of reflectance spectrum, which implies the simple division of planet's spectrum by a solar star spectrum, could be extrapolated for filter photometry. Images of Jupiter and the reference star will be taken with BVRI photometric filters and the first series divided by the second. While the resolution of such a reflectance "spectrum" will drop to only 150 nanometers (the mean transmission of a filter), it will be in return possible to extract reflectance photometry from details other than belts and zones, like the Great red spot (GRS).

4. Photometric color index of the jovian details

The final experimentation will be to calculate the photometric magnitudes of Jupiter, possibly in all UBVRI bands, or only some of them. This will be done by using the method of differential photometry, starting from nearby reference stars of different color index (B-V). Then, on photometrically calibrated jovian disks images, it will be possible to extract color index of the main details, either belts and zones, or smaller areas like the GRS.

5. References

[1] Arrate,A., Fletcher,L., Orton,G., Melin,H., Rogers,J., Harrington,J., Donnelly,P., Rowe-Gurney,N., . Blake,J. (2018), "Infrared Characterization of Jupiter's Equatorial Disturbance Cycle", Geophysical Research Letters, vol.45 Issue 20, 10987-10995.

[2] Mendikoa, I., Sanchez-Lavega,A., Pérez-Hoyos,S., Hueso,R., Rojas, J-F., Lopez-Santiago,J., "Temporal and spatial variations of the absolute reflectivity of Jupiter and Saturn from 0,38 to 1,7 µm with PlanetCam-UPV/EHU", Astronomy and Astrophysics, vol.607, november 2017.

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Recent contributions of amateur astronomers to the study of planetary atmospheres from Venus to Neptune

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Abstract

During the last two decades amateur contributions to professional publications in the field of planetary astronomy have increased exponentially [1-2]. Technical advancements in instrumentation and the collaboration of amateurs with professional astronomers have flourished making some amateur observers essential actors in planetary astronomy with regular scientific contributions and a capacity to perform unique discoveries [3-5]. The role of amateurs and citizen scientists is also acknowledged in missions such as the Juno mission [6] or in large projects like Europlanet 2020 RI, which has organized several activities aimed to increase the participation of amateur astronomers in planetary science. Here we review some of the current trends and recent collaborations in professional and amateur studies of planetary atmospheres.

1. Amateur astronomy and planetary atmospheres

The dynamic nature of the atmospheres of Jupiter, Saturn, Mars and Venus make frequent observations of them an essential need to understand their atmospheres. Over the last decade many amateur astronomers have mastered high-resolution observations of bright planets. Thanks to fast-acquisition cameras and image processing techniques, a large number of amateur observers now obtain images that can beat seeing effects and reach the diffraction limit of their telescopes. The amateur community provides regular observations that can discover the onset of storms in Jupiter [7] or Saturn [8-9], discover unusual events in Jupiter [3-4] or Mars [8], or that can be used to study the global dynamics of these planets [10-12] including also Venus [13-14]. Recent advancements allow amateurs to contribute to the study of exceptionally bright features in Uranus [15] and regularly to the study of Neptune [16-17].

2. Sharing data

A key element for collaboration is sharing the data online. The two most important databases where amateurs post their data are ALPO Japan (http://alpo-j.asahikawa-med.ac.jp/) and PVOL http://pvol2.ehu.eus). The latter has a database structure, can be searched for specific data easily [18] and is integrated in the Virtual European Solar and Planetary Access (VESPA) query portal. Figure 1 shows a summary of the data available in PVOL. These observations are supplied by a few hundred observers distributed all around the globe.

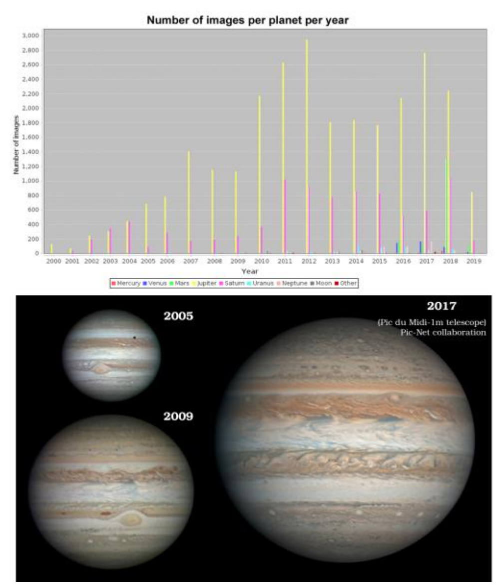

Figure 1: Number of observations per planet per year in the PVOL database and examples of the quality of some of the best data for the last 15 years. ALPO Japan contains an even larger number of observations.

3. Individual missions

A unique example of a broad collaboration between amateur and professional observations is currently the planning and interpretation of JunoCam observations with context images provided by amateur astronomers and processing of JunoCam images by citizen scientists [6]. See: https://www.missionjuno.swri.edu/ and the Jupiter section of the British Astronomical Association: https://www.britastro.org/section_front/15.

Coordination of spacecraft and ground-based amateur observations has also been planned for the Akatsuki Venus orbiter, but the collaboration of the Juno mission with amateur astronomers is unprecedented and articulates most of the current pro-am collaborations in Jupiter research. After the end of the Cassini mission much research can be done through a combination of past Cassini and current Saturn observations [9, 12].

4. Conclusions

Amateur observations of solar system planets are a very valuable resource to study open questions that range from the characterization of Venus atmospheric superrotation to Neptune's changing features including violent and rapidly evolving events in Jupiter, Saturn or Mars and unexpected phenomena like impacts in Jupiter. Amateurs respond rapidly to observational alerts, provide excellent data, are distributed around the globe and develop excellent software tools like the widely popular AutoStakkert and WinJupos. Amateur astronomers also obtain valuable spectroscopic data and their contribution to planetary science will undoubtedly continue to grow. With the end of the Europlanet-2020 RI, the Europlanet Consortium has solicited a new research infrastructure Europlanet-2024 RI that, if funded, will continue to foster amateur collaborations in planetary sciences.

Acknowledgements

We are very grateful to amateur astronomers that kindly provide their data to databases like PVOL and ALPO-Japan and actively collaborating in projects like the Juno mission. This work has been supported by Europlanet 2020 RI. Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208. This work has also been supported by the Spanish project AYA2015-65041-P (MINECO/FEDER) UE and Grupos Gobierno Vasco IT-765-13.

References

[1] Mousis et al.: Instrumental methods for professional and amateur collaborations in planetary astronomy, Exp. Astron., 38, 91, 2014.

[2] Kardasis et al.: The need for professional-amateur collaboration in studies of Jupiter and Saturn. JBAA 126, 29-39 (2016).

[3] Sánchez-Lavega et al.: The impact of a large object on Jupiter in 2009 July, ApJ, 715, L155-L159, 2010.

[4] Hueso et al.: First Earth-based detection of a Superbolide on Jupiter, The Astrophysical Journal Letters, Vol. 721, L129-L133, 2010.

[5] Sánchez-Lavega et al. An extremely high altitude plume seen at Mars morning terminator. Nature, 518, 525–528, 2015.

[6] Rogers JH, Jupiter and the Juno mission: the amateur's contribution. J.Brit.Astron.Assoc. 126, 197-200, 2016.

[7] Sánchez-Lavega et al., Depth of a strong jovian jet from a planetary-scale disturbance driven by storms, Nature, 451, 437-440, 2008.

[8] Sánchez-Lavega et al., Deep winds beneath Saturn's upper clouds from a seasonal long-lived planetary scale storm, Nature, 475, 71-74, 2011.

[9] Sánchez-Lavega et al., A complex storm system and a planetary-scale disturbance in Saturn's north polar atmosphere in 2018, Nat. Astr., submitted, 2019.

[10] Hueso et al., Jupiter cloud morphology and zonal winds from ground-based observations before and during Juno's first perijove, GRL, 44, 4669-4678, 2017.

[11] Fischer et al., Analysis of a long-lived, two-cell lightning storm on Saturn, A&A, 621, A113, 2019.

[12] Hueso et al., Saturn atmospheric dynamics one year after Cassini…, Icarus, submitted, 2019.

[13] Sánchez-Lavega et al., Venus cloud morphology and motions from ground-based images at the time of the Akatsuki orbit insertion, ApJ, 833, L7, 2016.

[14] Peralta et al., Morphology and Dynamics of Venus's Middle Clouds with Akatsuki/IR1, GRL, 46, 2019.

[15] Sromovsky et al.: Episodic bright and dark spots on Uranus. Icarus, 220, 6-22 (2012).

[16] Hueso et al., Neptune long-lived atmospheric features in 2013-2015 from small (28-cm) to large (10-m) telescopes, Icarus, 295, 89-109 (2017).

[17] Molter et al., Analysis of Neptune's 2017 bright equatorial storm, Icarus, 321, 324-345 (2019).

[18] Hueso et al.: The Planetary Virtual Observatory and Laboratory (PVOL) and …, PSS, 150, 22-35, 2017.

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Amateur mapping of Jupiter's southern high latitudes to support JunoCam between Perijoves 12-15

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Abstract

Jupiter’s polar regions are difficult to observe from Earth. Using amateur imagery, we were able to observe and map movements of folded filamentary regions (FFRs) and anticyclonic white ovals (AWOs) south of 60°S over the course of five months between March 30th and September 5th 2018, covering the time period of Juno’s Perijoves 12-15. Maps have been created from ground-based images every 4-10 days to create an animated timeseries showing the evolution of these features. JunoCam imagery helps to verify the observed features, while the image sequence allows us to identify changes in position and morphology of FFRs and AWOs in between perijoves, and trace longer-lasting FFR regions from one perijove to the next. These observations are in the context of longer sequences of data tracing AWO drift patterns in relation to wind profiles at high latitudes.

1. Introduction

A fortuitous combination of circumstances in 2018 allowed amateur observations to contribute to the understanding of the south polar region of Jupiter. A series of Juno spacecraft passes around Jupiter's May 6th opposition observed similar regions in each pass, while Jupiter's South Pole was especially favourably tilted towards Earth.

Observing the high latitudes of Jupiter is challenging from Earth as Jupiter’s poles tilt no more than 3.1° towards us. Juno’s polar orbit has facilitated detailed observations of the polar regions for the first time, including the circumpolar cyclones and high-latitude hazes (1,2). One of the goals of the JunoCam mission is to understand how features at high latitudes evolve; however the 53 day orbit limits the ability of the spacecraft to observe feature dynamics at shorter

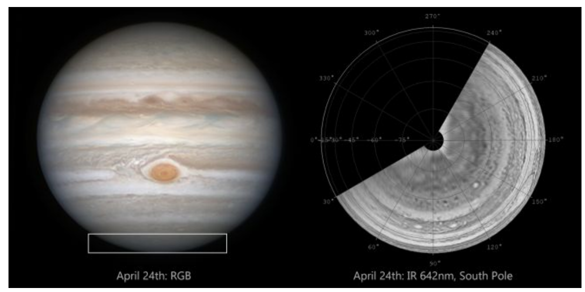

Figure 1: RGB and polar projected IR image of Jupiter, 24th April 2018. Region south of 60°S highlighted.

timescales. Amateur imaging can help fill in the gaps, and has reached the stage where useful contributions can be made.

There have been crucial improvements in imaging and image processing technology that now allow many amateurs to reliably capture fine details previously only achievable by a very small number of observers in perfect conditions. With enough observers using telescopes of 300mm and larger apertures, mapping and time-series of high latitudes are now feasible. Importantly, Jupiter's South Pole reached its most favourable tilt towards Earth of 3.1° in April 2018, presenting the southern high latitudes at their most favourable for over a decade.

2. Observations

This apparition represented the best opportunity since Juno's arrival to study the polar regions from Earth, and make direct comparisons to JunoCam imagery. The sharpest amateur images are taken in near infrared wavebands between 640-800nm, often showing more structural detail than RGB colour images.

We present time-series data collected for AWOs in 2018, part of longer-term AWO tracking by the

JUPOS Team and J.R., and a high-resolution sequence of images to capture FFRs between March and September 2018. South polar maps at intervals of 4-10 days between April and September 2018 capture the changes in FFR morphology between perijoves, tracing the continuous motion and evolution of these features. Animating the sequence clearly shows the motions of the FFR features between perijoves. These will be placed into context of earlier ground-based and spacecraft observations, showing how amateur contributions can help build our understanding of polar regions.

3. Discussion

JunoCam has observed a broad train of pale FFRs ringing the planet from 65-75°S, interspersed with longer-lived circular AWOs. Our sequences show that the larger-scale morphological changes in FFRs occur over timescales of a few days to a week, with the core regions of the disturbances south of ~70°S retrograding in System III longitude, and shearing/dissipation of some parts of FFRs north of ~67°S where they get close to the prograding S6 jetstream. AWO behaviour provides further insight into the flow region south of 70°S, which does not appear to have strong jetstreams or stable features away from the circumpolar cyclones.

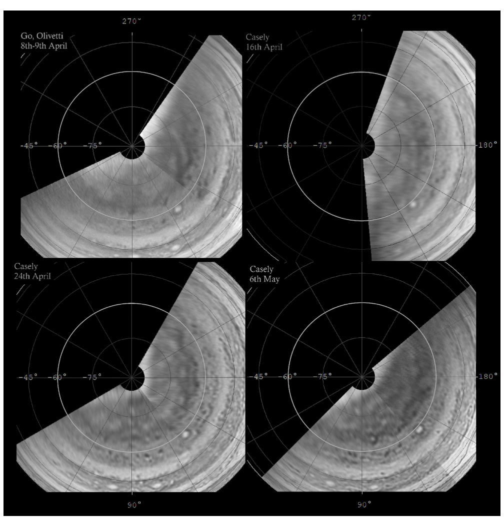

Figure 2: Four frames of the polar projection sequence showing changes to high latitude features (60°S highlighted) in April and May 2018. Images by A.C., Chris Go and Tiziano Olivetti.

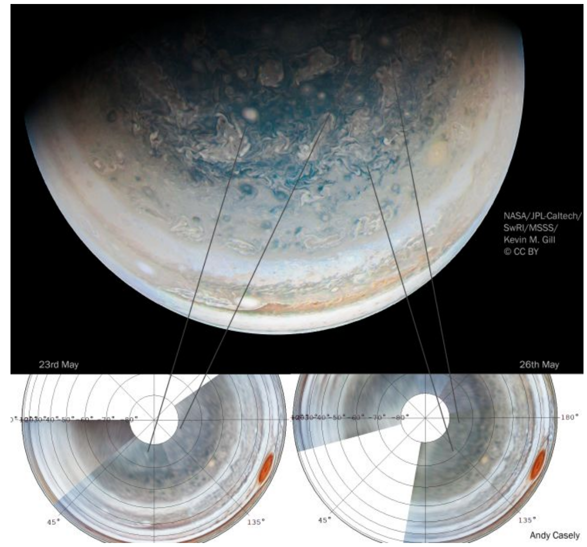

Figure 3: JunoCam PJ13 comparison to polar projected RGB images, 23rd-26th May 2018

4. Summary and Conclusions

Amateur planetary imaging and mapping is able to support professional science observations and contribute to our understanding of Jupiter's polar regions. We show observations that provide further understanding of the processes occurring in the high latitudes of Jupiter. Similar observations may be possible in 2019, but will be increasingly challenging from 2020 onwards as Jupiter's tilt becomes less favourable.

Acknowledgements

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References

[1] Orton GS, et al.(2017) 'The first close-up images of Jupiter's polar regions: Results from the Juno mission JunoCam instrument.' GRL 44, 4599–4606.

[2] Adriani A, Mura A, Orton G, Hansen C, Altieri F, Moriconi ML, Rogers J, Eichstädt G, et al.(2018) 'Clusters of Cyclones Encircling Jupiter's Poles.' Nature 555, 216-219

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The Great Red Spot in 2019 and its unusual interaction with retrograding vortices

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Abstract

Early in the 2019 jovian apparition, ring-like structures on the southern edge of the South Equatorial Belt (SEBs) were recorded by various amateur planetary imagers. Due to the retrograding jet at this latitude, the rings were progressively drawn towards, and into, the Great Red Spot Hollow (GRSH). This resulted in deformation and ultimate dispersal of the rings, with interaction taking place with the Great Red Spot (GRS) as well as the South Equatorial Belt (SEB) immediately following the GRS. These interactions were apparently repsonsible for the repeated detachment of red 'blades' from the GRS. Concurrently, an elaborate structure developed on the SEBs following the GRS, with dark material being drawn from this structure around the GRS, This paper presents the development of the SEBs rings and their subsequent interaction with the GRS and surrounding region, based largely on observations by the first author.

1. Introduction

Since 2014, the GRS has been smaller than at any time in the last two centuries, and has had a dark red colour that was hardly ever seen except when the SEB was whitened. For several years it has also been largely undisturbed by retrograding rings (vortices) travelling westward along the SEBs; these have been generally sparse in the last few years.

The first author has monitored the planet Jupiter from his location in Centurion, Gauteng, South Africa for the last 5 years. Primary equipment has consisted of a Celestron 14" Edge HD Schmidt-Cassegrain telescope combined with various planetary imaging cameras. Monochrome imaging using various filters has been the primary technique employed.

The state of the GRS and SEB over this period has been documented by J.H.R. in BAA Jupiter Section reports (https://www.britastro.org/node/17157), and by S.M. in compilations of maps on ALPO-Japan (http://alpo-j.asahikawa-med.ac.jp/Latest/j_Cylindrical_Maps/j_Cylindrical_Maps.htm). After solar conjunction in 2018, good-quality ground-based imaging began in 2019 Jan. Meanwhile, the Juno spacecraft camera obtained views of the GRS at perijoves 17 (Dec.21), 18 (Feb.12) and 19 (April 6), especially at PJ18 when Juno flew very close to the GRS.

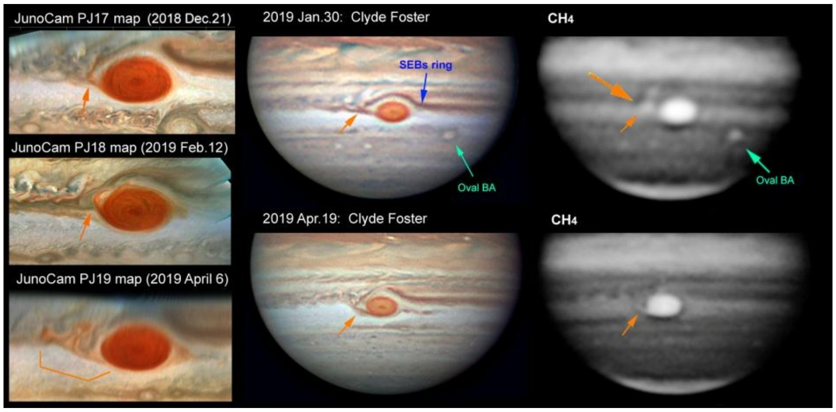
2. SEBs retrograding rings and their interaction with the GRS in 2019

Early in the 2019 apparition, amateur ground-based images started to capture an interesting structure along the SEBs edge. Oval or ring-like structures had formed and these were being carried in a retrograding direction due to the jet stream at this latitude. This renewal of the typical SEBs jet activity occurred across large sectors of longitude. It was maintained at least from February to May and appeared to be generated by the turbulent region following the GRS. Due to this retrograde motion, some of the rings were carried into the GRS Hollow, resulting in deformation of the rings, and interaction with both the GRS itself as well as the SEB immediately following the GRS.

During this period, various amateur imagers were able to capture red streaks or "blades" apparently sweeping off the west end of the GRS. They were also seen in JunoCam images at PJ17, 18 and 19 (see Figure). In view of their red colour and their brightness in methane-band images, they appeared to be material detaching from the GRS.

Maps of amateur images showed that each of three successive 'blades' was formed within a few days after a retrograding ring entered the GRSH, suggesting that these vortices were disrupting the periphery of the GRS. The red fragments last for more than a week, extending westward within the SEB(S). Their reddish colour is often difficult to distinguish from the brown of the belt but they can be identified as methane-bright.

Figure: *Left:* Cylindrical maps from JunoCam images of the GRS. (*Credit:* NASA/SwRI/MSSS/ Gerald Eichstädt / John Rogers.)
Right: Examples of images by C.F. All show red 'blades' (orange arrows).



In early April, another pair of retrograding rings was observed approaching the GRSH. Amateur images and map animations were able to monitor the distortion of the rings as well as their movement along the edge of the hollow, whilst interaction with the GRS itself was also observed. Indeed they triggered the emergence of a pair of red blades from the GRS (April 17-20). However, the interaction became more complex. A dark hook-like structure developed on the southern edge of the SEB immediately following the GRS. (This was reminiscent of the South Tropical Disturbance (STrD) that was passing the GRS in early 2018, although it did not have the circulation pattern of a true STrD.)

Some of the dark material in the hook-like structure was captured by the prograde jet that flows past the south edge of the GRS, forming a very dark grey ring around the GRS, and was distributed into the South Tropical zone preceding the GRS. This was a dynamic stream with multiple concentrations and extensions. Further observations of this stream, and comparison with the 2018 STrD, will be reported.

3. Discussion

Similar red 'blades' have occasionally been reported in the past, and may have been under-reported because they are only detectable with high resolution. Nevertheless, it is possible that this behaviour has only recently become common. In the Voyager 1 movie in 1979, SEBs retrograding rings were swinging round the GRS with vigorous interactions but not usually causing obvious disruption of the GRS itself as at present. In publicly posted maps from the Hubble Space Telescope, no such feature was recorded in 2014, 2015 or 2016; but the paired maps of 2017 Feb.2 showed a similar red 'blade', and showed its dynamics over 10 hours. The GRS periphery has also appeared 'ragged' in subsequent Hubble and JunoCam images, although the recent 'blades' appear more substantial. We suggest that the small size of the GRS has made it susceptible to disruption by incoming vortices in a way that did not commonly occur previously.

Acknowledgements

We are grateful to the other amateur observers whose images enabled continuous coverage of these events. We also acknowledge the NASA JunoCam team for the JunoCam imagery.

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Cometary CN cyanogen jet observations using small telescopes with narrowband UV filter

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Abstract

CN cyanogen radical rotating gas jets was first found and directly imaged in comet P1/Halley during 1986 perihelion [1]. Development and pricing of high quantum efficiency CCD-cameras, filter technologies and image processing software's has made it possible to amateur astronomers with relatively small telescopes to image cyanogen jets, spirals and other features in medium bright comets at ultraviolet wavelengths. This presentation describes CN jet observations and used equipment of comets 21P/Giacobini-Zinner, 46P/Wirtanen and C/2018 Y1 (Iwamoto).

1. Introduction

Three comets were observed with 12inch telescope, CCD camera and commercial 387nm narrowband CN filter to get possible CN cyanogen gas jets visible. Observations were also part of 4*P Coma Morphology Campaign organized by the Planetary Science Institute and images have been verified by the campaign professionals.

2. Observations

2.1 Comet 21P/Giacobini-Zinner

21P/Giacobini-Zinner was observed several nights at September 2018. Images taken with 12inch telescope and commercial CN filter show two gas jets onwards of comets optocenter. 4*P Coma Morphology Campaign professionals compared the images taken at same time with Lowell Observatory 42inch RC John S. Hall Telescope and HB CN filter, and verified that the observed CN jets were practically identical with minor dust signal contamination on dust tail direction, [Figure 1].

2.2 Comet 46P/Wirtanen

46P/Wirtanen was observed with the 12inch equipment several nights at December 2018 and January 2019. At night 11/12.1.2019 continuous observing time was 11 hours and totally 120 images each 5 minutes exposures through CN filter was taken. Processed images and animation show CN jet full rotation and pinwheel effect around 46P/Wirtanen optocenter during 11 hours of observation period, [Figure 2]. 46P/Wirtanen was a main target of 4*P Coma Morphology Campaign during 2018/2019.

2.3 Comet C/2018 Y1 (Iwamoto)

C/2018 Y1 (Iwamoto) was observed several nights at February 2019. Processed images show CN jet movement around comet optocenter during 3 hours of observing time, [Figure 3].

3. Equipment and software

3.1 Equipment

Telescope was 305mm aperture and 1200mm focal length F4 Newton. Combined coma corrector and focal length reducer was used so that the effective focal length was 905mm/F2.9. Mount was iOptron CEM60 and autoguider was configured to track comet during each exposure. Telescope was placed in Helsinki, Finland under area of severe light pollution.

Narrowband ultraviolet filter was commercially available Semrock FF01-387/11-27. Center wavelength of the filter is 387nm and measured bandwidth is 15nm.

CCD-camera was cooled QSI690wsg. CCD-chip in the camera is Sony ICX814 and at 387nm wavelength absolute quantum efficiency is ~60%. Typically 300s exposures were used through

Semrock 387nm filter with CCD binning 2x2, giving 1.68 arcsec/px resolution.

3.2 Software

Image processing software was PixInsight (PI) and images were registered and stacked with PI Comet Registration and PI Integration functions.

Image enhancing software was Cometary Coma Image Enhancement Facility [2]

4. Figures

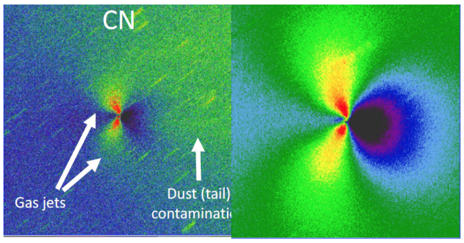

Figure 1: 21P/Giacobini-Zinner CN jets, left image 12inch/Ryske, right 42inch/Lowell. Processing by Knight. 21.9.2018.

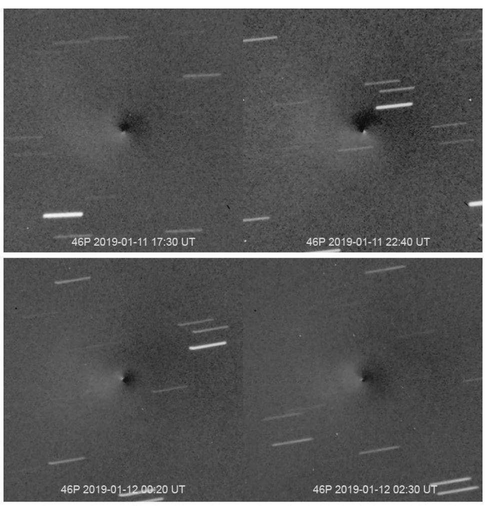

Figure 2: 46P/Wirtanen, CN jet rotation and pinwheel effect, 12inch. 11/12.1.2019.

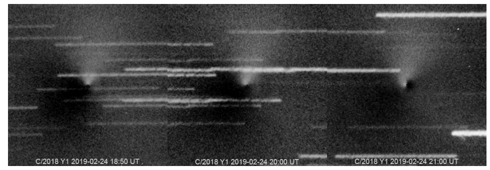

Figure 3: C/2018 Y1 (Iwamoto) CN jet movement, 12inch. 24.2.2019.

5. Summary and Conclusions

Comets narrowband UV imaging is possible with relatively small aperture amateur sized telescopes using modern CCD-camera technology. Fast changing and rotating CN cyanogen radical gas jets emitting at 3883Å can be resolved in comet coma morphology using commercially available narrowband filter giving useful research data by amateur astronomers.

Acknowledgements

Farnham, Tony, University of Maryland. Semrock 387nm CN filter analysis and tests.

Knight, Matthew, University of Maryland. Comets CN image verifications.

Samarasinha, Nalin, Planetary Science Institute. Comets CN morphology and image analysis.

References

[1] A'Hearn Michael F. et al.: Cyanogen jets in comet Halley, Nature vol. 324 18/25, pp 649-651, December 1986.

[2] Samarasinha, N. H., Martin, M. P., Larson, S. M. CometCIEF: A web-based image enhancement facility to digitally enhance images of cometary comae, Planetary and Space Science 118, July 2015.

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Citizen Science Astronomy with the Unistellar Network: From Planetary Defence to Exoplanet Transits

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Abstract

Thousands of Unistellar telescopes (light-amplifying, user-friendly devices made for the general public) will soon be sent to people around the world who are eager to observe the universe, from downtown or the countryside, in unprecedented clarity and detail. Every user will also be able to join a global network of observers conducting coordinated, worldwide viewing campaigns under the aegis of professional astronomers. We will describe the potential of the SETI/Unistellar network to do citizen science astronomy, coordinated campaigns conducted with the network, and our key scientific objectives in planetary defense, occultations, and exoplanet transits.

1. Introduction

Unistellar proposes to reinvent popular astronomy through the development of the Enhanced Vision Telescope (eVscope), a compact mass-market device. (Figure 1). The company's main goal is to make observational astronomy far more fun, exciting, and easy to do than it is today, while fostering a strong, growing interest in astronomical research and citizen science.

Figure 1: Five unique features of the eVscope.

1.1 Public Participation and Partnership

There is much to be gained from continuous observations of the night sky using telescopes spread around the globe, and by coordinating observations and sending alerts to users to study faint objects like asteroids or supernovae. Several groups of amateur and professional astronomers, including the International Occultation Timing Association (IOTA) and the American Association of Variable Star Observers (AAVSO), have for decades understood the value of those astronomy networks and the collaborative efforts they make possible.

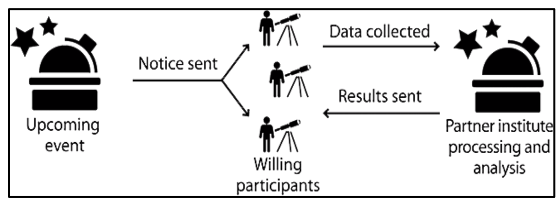

Figure 2: Alert system for citizen science.

In July 2017, the SETI Institute and Unistellar partnered to develop scientific applications for the eVscope network (Figure 2). Because of its sensitivity and ease of use, the eVscope can play a major role in a wide range of research topics linked to planetary defense, exoplanets, and the study of many transient astronomical events. This partnership was also a natural match because the SETI Institute has robust, world-class outreach and education programs.

2. Citizen Science Network

All eVscope owners will be able to receive notifications on their smartphones of transient events visible in the sky, such as occultations by asteroids, the flyby of a NEA, or transits by Jupiter-sized exoplanets (See Figure 3)

- If a campaign is predicted a few days or weeks ahead of time (a.k.a. an occultation or transit) and eVscope owners accept the request from the SETI Institute, they will get instructions on how to conduct observations (location, time, sky quality) along with regular updates from astronomers leading the event.

- If the event happens while they are observing (i.e., a small asteroid flyby), the telescope will interrupt the observation and automatically point to the correct field of view.

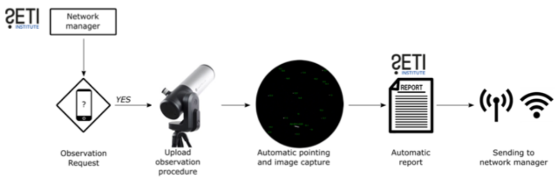

Figure 3: Campaign Mode schematic as designed by Unistellar. In this case, the flyby of the 650m NEA 2014 JO25 was observed in April 2017.

In both cases, the data will be collected while the citizen astronomer observes the event in the eyepiece. After the observations are complete, the data will be sent to the SETI/Unistellar database for processing, analysis, and publication.

3. First Results

3.1 Occultation Events

On January 27 2018, the International Occultation Timing Association (IOTA) predicted that asteroid (175) Andromache would occult TYC 1399-01064-1, a V=11.3 star. Centrality (i.e., the path of the shadow) was predicted to be a few-km-width line that passed near our headquarters in Marseille, France. We designed a fast-frame recording capability for the eVscope with an individual exposure time of 100 ms (which gives us ten images per second). At 18:37 UT, our team saw the disappearance of the star for about eight seconds, at very close to the predicted time.

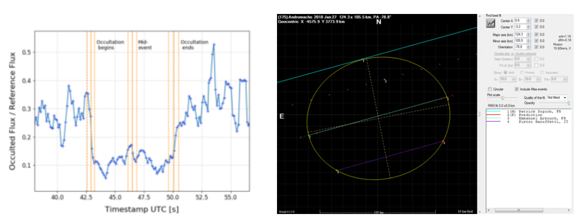

Figure 4: Occultation by the large asteroid (175) Andromache observed with the eVscope. Additional chords were recorded from other observers and the shape of Andromache can be approximated with an ellipse of 124 x 105 km.

The lightcurve clearly shows the occultation event (Figure 4). We measured the timing of the ingress and egress of the event and filled out a report for EURASTER.

Since then we have observed additional occultations involving main-belt asteroids and Pluto.

3.2 Exoplanet Transits

We have recently observed several transits of Jupiter-sized exoplanets, such as WASP-43 b, from Fuveau, France. The transit signature was detected using our pipeline for one telescope (see Figure 5). We propose to build coordinated campaigns of observations with the Unistellar network to support the NASA TESS mission and future ESA missions (KEOPS, PLATO).

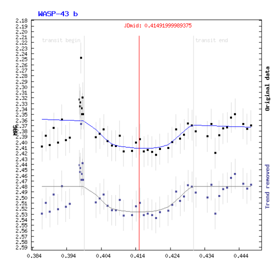

Figure 5: Transit of WASP-43b observed with one eVscope.

We have identified several scientific areas where the Unistellar/SETI network can make important contributions to scientific research:

- Repetitive and coordinated observations of short-period Jupiter-sized exoplanets to accurately measure their size and orbit shortly after their discovery.

- Coordinated observations of transits involving, for example, rare long-period Jupiter-sized exoplanets to confirm their existence, measure their TTV effect, and inspect the areas surrounding these exoplanets (disks, large moons).

4. Conclusion

Thanks to citizen science campaigns such as these, Unistellar users will contribute to astronomy and experience the thrill of astronomical discovery. This project will stimulate interest, curiosity, and dedication to astronomy and to science at large.

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Atmospheric Retreivals of Jupiter: Combining Professional and Amateur Data

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Abstract

Traditional atmospheric retrieval methods assume apriori assumptions of the atmosphere and require large amounts of clock time to run. I present non-traditional approaches via professional-amateur observer collaborations to understand the observed variations in Jupiter's atmospheres such as regular cylindrical and geospatial mapping of the planetary disk; statistical approach such as Principal Component Analysis (PCA) to study the interaction of discrete features on the planet; limb polarization, allowing the probing of hazes in the atmosphere; and visualization of these results. These approaches take advantage of emerging technologies and field such as virtual reality, astrostatistics and the involvement of a global network of amateur astronomers via the Facebook group PACA_Jupiter.

1. Introduction

Jupiter's atmosphere exhibits dramatic and dynamic changes at all levels. With the arrival of NASA/Juno spacecraft at Jupiter in 2016 and ground-based observations (current and legacy; professional and amateur) of Jupiter, we seek to characterize the variability of Jupiter's atmosphere at various latitudes as a function of time. The data used in our study includes a combination of professional and amateur observations in the spectral range of 0.5 – 24.0 microns, from 2015 –present (and legacy data from 1991 as needed). Spectral decomposition of the geometrically-registered data identified variations of several latent physical variables of the atmosphere, *e.g.*, variation of global cloudiness increased during the interaction; the albedo of discrete clouds at different altitudes vary and there appear to be either enhancement or depletion of ammonia vertically in the atmosphere, especially after the color change in Oval BA in 2005. Analyses of the post-color change interactions of GRS and Oval BA in 2006 and 2008 indicated changes in thermal and albedo fields.

2. The PACA Project and PACA Jupiter Team: Mapping

3. While collaborations with amateur observers has long been in place, the primary contributors were individuals, forming a repository on IPVOL and developing software to be able to correlate with the pro- data. Now with cohesive teams and focused science goals, the role of the amateur observers is important to the data they acquire to allow collaborations to grow into Citizen Science projects. The PACA Project expanded from global comet campaigns on social media to planetary observing campaigns in 2015 and created PACA_Jupiter Team. Although formed as a voluntary group of planetary observers prior to the arrival of NASA/Juno spacecraft at Jupiter, there is a large overlap with ground-based amateur support of Juno mission from 2016, especially citizen science that has been enabled with JunoCam on NASA/Juno spacecraft. These collaborations are presented here as variability studies of various features on the planet. We hope to maintain this level of Jupiter observing campaign well after the NASA/Juno mission, to continue the variability studies to determine seasonal, episodic and non-auroral features. An example of the mapping of amateur images; ground-based professional observations of Jupiter's south hot spot and its equivalent from NASA/Juno spacecraft are shown in Figure 1.

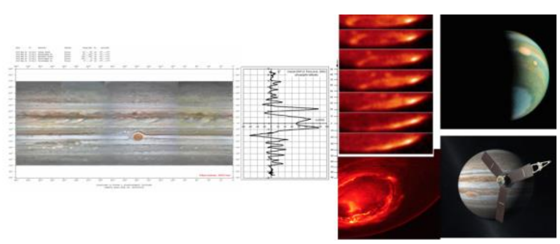
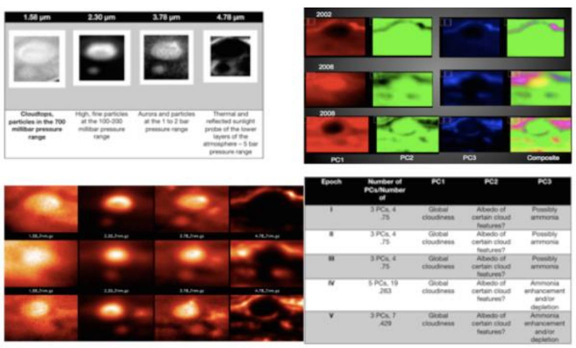


Figure 1: Examples of ground-based amateur, professional and NASA/Juno observations of Jupiter.

3. Principal Component Analysis (PCA): Interaction of Large Vortices on Jupiter

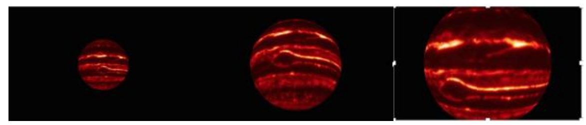
Spectral decomposition of the geometrically-registered data identified variations of several latent physical variables of the atmosphere, *e.g.*, variation of global cloudiness increased during the interaction; the albedo of discrete clouds at different altitudes vary and there appear to be either enhancement or depletion of ammonia vertically in the atmosphere, especially after the color change in Oval BA in 2005. Analyses of the post-color change interactions of GRS and Oval BA in 2006 and 2008 indicated changes in thermal and albedo fields, with enhancement of ammonia in the perturbed region. While this method works well for correlated features, we need to determine confidence levels for non–auroral featureless areas of the planetary disk.



Epoch	Number of PCs/Number of	PC1	PC2	PC3
I	3 PCs, 4 .75	Global cloudiness	Albedo of certain cloud features?	Possibly ammonia
II	3 PCs, 4 .75	Global cloudiness	Albedo of certain cloud features?	Possibly ammonia
III	3 PCs, 4 .75	Global cloudiness	Albedo of certain cloud features?	Possibly ammonia
IV	5 PCs, 19 .263	Global cloudiness	Albedo of certain cloud features?	Ammonia enhancement and/or depletion
V	3 PCs, 7 .429	Global cloudiness	Albedo of certain cloud features?	Ammonia enhancement and/or depletion

4. Geospatial Mapping ArcGIS

Geographic Information Systems (GIS) are very capable for storing, managing, exploring and analyzing geographic data. The spatial analyses are very often used for finding trends or patterns in data in time. ArcGIS, a commercially available desktop and cloud mapping software, has been employed to perform cartography and mapping for many applications based on earth data, but its application to planetary science is limited. Since most of the data of Jupiter, from either spacecraft or ground-based observers, is spatial data, ArcGIS is a suitable mapping platform. A Geographic Information System, like ArcGIS, manages and analyzes spatial data. With spacecraft and ground-based multispectral data of Jupiter, we can produce “layers” or calibrated maps for each wavelength, with time as an additional dimension and so analyze correlations by comparing spatial and temporal data of the planets. The spatial is re-projected, with planetary globes created and animations made. ArcGIS is capable of storing and re-projecting geographic data. As a pilot study of the potential of this method, working with Coll. E. Sussenbach, we recently ran a cylindrical map produced by amateur observations, from 19 January 2018, in support of NASA/Juno mission. By using ArcGIS on this map, we can re-project the 2D data map into various projections. The model runs in any supported browser on a PC. We illustrate this method on a 5-micron Jupiter map from 19 Jan 2017 rendered into a globe in ArcGis and can be explored by manipulating the globe. The images are part of the animation sequence generated from one 5.1-micron image from NASA/IRTF, a test program.



5. Going Forward

Going forward and after the completion of NASA/Juno mission, PACA_Jupiter will continue pro-am collaborations with amateurs and include legacy data to compare if there is reproducibility in the variability data. Other approaches that will continue and be updated are: multiple approaches in parallel: image planet, apply GIS analysis, visualization to explore variability; compare with traditional methods to determine latent variables of the atmosphere that influence changes in the atmosphere; and incorporate other observations such as thermal data, spectra and polarization.

Acknowledgements

I acknowledge the contributions and discussions with all the PACA_Jupiter Team members; G. S. Orton and E. Sussenbach for their discussions on the data and ArcGIS software.

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Jupiter and Saturn impact detection project

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Abstract

A long-term project for detecting impact of small bodies in Jupiter's atmosphere has been running since 2012. We here present the latest developments of the software used for it, and the latest impact frequency estimations resulting from the project.

1. Introduction

Since 2011, professionals made softwares (dtc and JID) available for amateurs to be used on their Jupiter acquisition videos with the aim to detect potential flashes resulting from small bodies impacts in Jupiter atmosphere (see [1]).
In 2012, an amateur made an evolution of one of this software in order to not only focus on flashes detection, but also on collecting all negative analysis in order to refine the impact frequency estimations, launching the DeTeCt project (see [2]).
Since then, several evolutions piloted by professional and amateur resources improved the project (see [3], [4], [5]) and more than 90 000 acquisitions have been analysed.

2. Principles

The principle of the project is to have each amateur use DeTeCt software on his own acquisition and check and send the results of the analysis, based on two different algorithms.
The first one aims at identifying burst of brightness in a short area of the atmosphere on the planet, while the second generates detection images for the user to check, showing the maximum value of each pixel of the acquisition over time minus its mean value (see figure 1).
Then the detection logs generated by DeTeCt are sent to the project coordinator, who runs an analysis on all logs collected to identify simultaneous observations to be ruled out and calculate from an impact frequency estimation from the duration of the acquisitions analysed.

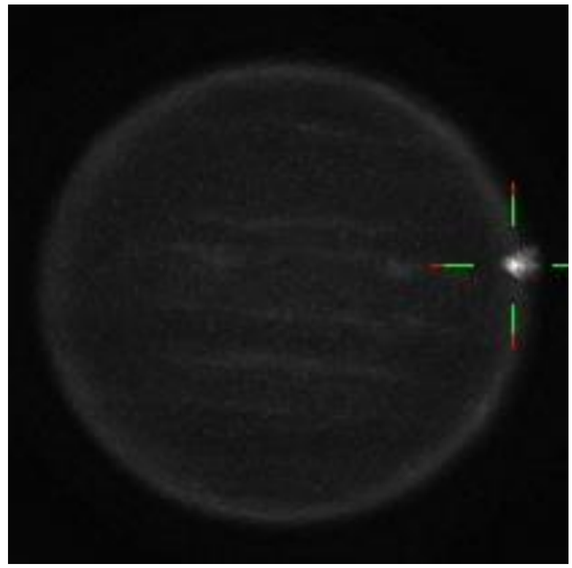

Figure 1: DeTeCt detection image from John Mc Keon's March 17th,2016 acquisition video showing the 4th impact flash discovered.

3. Latest evolutions

The latest developments of DeTect are in 3 different directions.
In order to increase the amount of data processed, usage of DeTeCt was simplified by offering an easy to use Graphical User Interface (see figure 2).

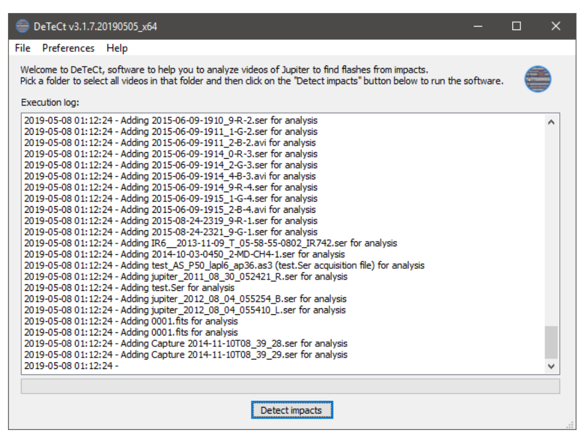

Figure 2: DeTeCt software

For the same aim, seamless integration into amateurs processing pipeline is studied, for enabling Autostakkert, the staking and alignment standard software used by the community, to launch automatically DeTeCt after having processed an acquisition.
The latest direction studied is to reduce as much as possible the number of false positives and non-detected positives impacts, by analysing the detection image automatically.

3. Project results

Project results are continuously updated on a dedicated webpage (see figure 3).
As of beginning of May 2019, 82 observers ran DeTeCt on 90 000 Jupiter acquisitions from 2004 to 2019, representing 103 days' worth of observations. (not including simultaneous observations counting for more than 5 days, around 5%).
This leads to an estimation of 3.5 impacts on Jupiter per year (absolute number, not "observable" number).

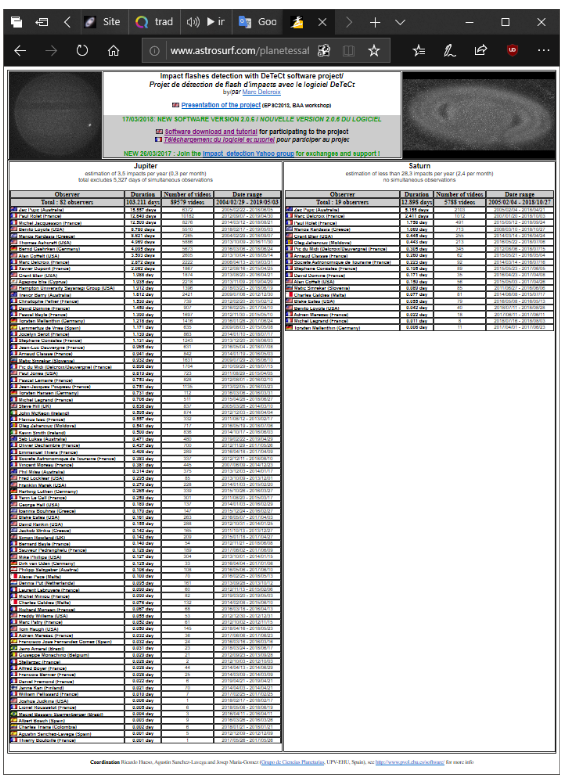

Figure 3: DeTeCt project webpage (http://www.astrosurf.com/planetessaf/doc/project_detect.php)

4. Future works and conclusion

Further automation could be implemented in DeTeCt (emailing, uploading data on a central repository, automatic updates, etc.).
Unfortunately, Saturn's data is not representative yet (only 13 days of acquisitions analysed). As the impact frequency on this planet is estimated to be one order of magnitude less as on Jupiter, motivating a large number of users to use DeTeCt on their Saturn's observations.
The results of this pro-am software and project proves useful for studying the impacts on Jupiter (see [6]). This showcases the added value of pro-am collaborations on planetary science studies (see [7]).

Acknowledgements

We would like to thank the planetary amateur participants to the DeTeCt project for their dedicated time for observing and analysing their Jupiter and Saturn observations.
We are grateful to Emil Kraaikamp for discussions of impact detection and detection algorithms. Part of this work has been developed in the framework of the Europlanet 2020-RI. Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208.

References

[1] Hueso R. et al., « The flux of impacts in Jupiter: From superbolides to large-scales collisions », A&A, September 2013

[2] Delcroix M. et al., « Jovian impact flashes detection with DeTeCt software project », EPSC 2013, London, September 2013

[3] Delcroix M. et al., « Impact flashes detection on Jupiter (and Saturn) », Juno Europlanet workshop, Nice, May 2016

[4] Delcroix M. et al., « DeTeCt planetary impact detection project - frequency estimations and big data set secondary results »,EPSC 2017, Riga, Latvia, September 2017

[5] Delcroix M. et al., « Jovian impact detection project update », Europlanet Juno workshop, London, UK, May 2018

[6] Hueso R., M. Delcroix et al., « Small impacts on the Giant planet Jupiter », A&A 617, A68 pp1-13 2018

[7] Hueso R. et al.,« Detectability of possible weather effects on Mars upper atmosphere and meteor impacts in Jupiter and Saturn with small telescopes », Journal of Space Weather and Space Climate vol.8 November 2018

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CORA (Collaborative Occultation Reports Archive) – An improved database of star occultation observations and reports

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Abstract

The Collaborative Occultation Reports Archive (CORA) [1] stores and serves reports (observations) of star occultations by Solar System objects. The purpose is to operate as a web based tool for collecting, validating, storing and providing reports of star occultation observations, and to enable the astronomical community to access and to process these data in a comfortable way.

1. Introduction

The prediction, observation and analysis of star occultations by Solar System objects is a typical domain of pro-am collaboration. The number of observations increased in the past years significantly due to a growing (mainly amateur) observing community, but also due to more and better predictions, instrumentation, software and web tools. On the other side we see new application cases for the usage of occultation observations like asteroid modeling from multi data sources or occultation astrometry on the level of some mas by using the Gaia star catalog.

The lack of a modern, over the web accessible, database of observations motivated the author in 2007 to develop such a tool [2]. It is now replaced by it's successor CORA [1], which is intended to provide all the necessary capabilities to satisfy the current and future demands of both observers and scientists.

2. Technology stack

CORA is a Python application running on the Django web framework, served by a nginx HTTP server. PostgreSQL is used as database (RDBMS). These software components are running on a Linux server.

3. Data and tools

The database contains more than 15000 occultation reports from 1997 to present[1]. Different queries can be performed on the web site in order to filter the displayed results, which can be exported for further scientific use. Reports can be submitted directly via a web front end. Data submitters have to be registered users (login + password). They can store their personal data (like observing site, instrumentation, observing technique etc.) in the system, enabling them to submit their observation very quick and easy. Submitted data can be checked / validated online via a dedicated web front end by data administrators before they are released. Reports and data records are cross linked to external data and services were possible, like Google Maps, DAMIT asteroid shape models and orbital information of the asteroid (JPL HORIZONS and MPC) as well as star catalog informations from CDS / VizieR.

4. Future improvements

New features will be added as necessary and on basis of feedback by the users / community. Currently the following improvements are planned: (1) import of additional data sources, (2) upload and storing of additional (meta) data like occultation light curves and images in general, (3) implementation of TAP (Table Access Protocol) and ADQL (Astronomical Data Query Language).

References

[1] CORA database. http://cora-db.de.

[2] Kretlow, M.: A web application / database solution for archiving, processing and publishing asteroidal occultation observations. European Symposium on Occultation Projects (ESOP), 2007.

[1] Currently the vast majority of the data covers occultations by asteroids, parsed from the euraster.net web site.

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Hungry Little Red Spot? The approach and probable merger of Jovian S4 storms AWO-2 and LRS-1 in 2018

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Abstract

A "Little Red Spot" (LRS-1) has been a long-lived feature in the far southern latitudes on Jupiter, residing at around 58°S in the 'S4' domain. A second large storm, known as AWO-2, approached LRS-1 during 2018, with a close approach during Juno's Perijove 15. We present calibrated tracking data covering the period of approach up to and following perijove, with detailed observations and commentary on changes in latitude and longitude of the storms.

Following PJ15, the two storms separated in subsequent weeks. During solar conjunction, they may have re-approached and merged, as LRS-1 has re-emerged in 2019 significantly enlarged, and there's no sign of AWO-2.

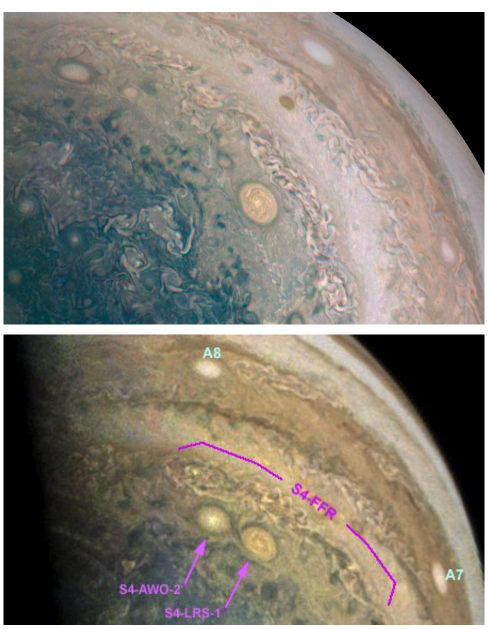

Figure 1: JunoCam images of AWO-2 (upper left) and LRS-1 (centre) at PJ14 and PJ15. NASA/SwRI/MSSS

1. Observations

During the 2018 apparition of Jupiter, two ovals were prominent in the S4 domain on Jupiter. The S4 domain is defined as lying between the S4 prograde jet (53°S) and S5 prograde jet (61°S). The anticyclonic white oval AWO-2 likely formed from the merger of ovals AWO-1 & AWO-2 in early 2018 (1). The red oval LRS-1 has been present for several years.

During the second half of 2018, LRS-1 remained relatively slow-moving to the south of the Great Red Spot, and AWO-2 was prograding rapidly towards it. Both storms were imaged clearly by JunoCam in July (PJ14), and subsequently our tracking observations showed that it was likely the two would approach each other very close to the 7th September Juno perijove (PJ15). At PJ15, the two storms were observed to be <10° apart, but not merged, with closest approach a few days before perijove. They separated in subsequent weeks, before Jupiter disappeared into solar conjunction.

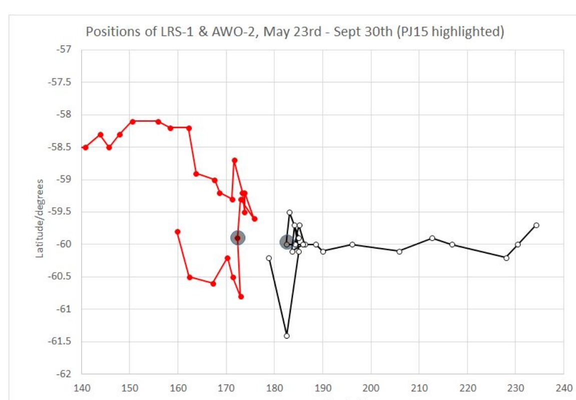

Figure 2: Track plot of LRS-1 & AWO-2 positions

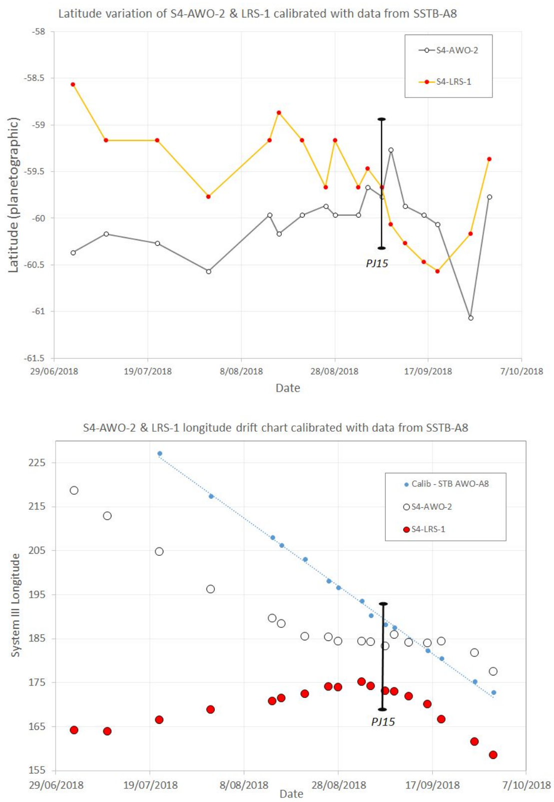

Figure 3: Calibrated time-series plots of latitude and longitude drift for LRS-1 & AWO-2.

Observations, particularly in August and September, were primarily collected by A.C & C.F, with Jupiter only favourably placed for southern hemisphere observers. Images were registered and map projected in WinJupos, and the oval positions measured. Observational errors due to the storms' far southern latitude and Jupiter's declining altitude were corrected by using a calibration with one of the SSTB white ovals, oval A8.

2. Discussion

The strongest motion of AWO-2 relative to LRS-1 occurred when the spot was AWO-2 was located 1-2°S of LRS-1, closer to the prograding jet S5. A slowing in speed occurred from the second half of August, coincidental with AWO-2 moving slightly north. Following PJ15, the two spots swapped latitudinal position, with LRS-1 a little further south, and separation increased, though separation appeared to have ceased by the end of September. It may be that the positioning of a large FFR region north of the storms prevented the two from swinging around each other and merging near PJ15. This may be another indicator of how FFR regions can influence the motion and speed of high-latitude AWOs [2].

A Merger?

With LRS-1 present in amateur and JunoCam imagery from PJ19 in 2019, but without any sign of AWO-2, it seems likely that the two merged at solar conjunction. LRS-1 remains red this year, but appears notably larger in extent in 2019 (Figure 4), perhaps as a result of absorbing the smaller storm.

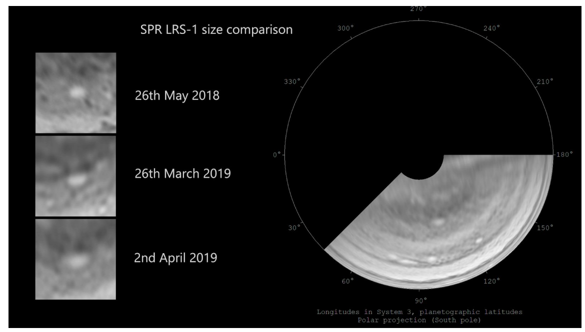

Figure 4: Size change of LRS-1 in IR685nm imagery (A.C.)

3. Summary and Conclusions

We were able to track the interactions of two high latitude storms on Jupiter, with amateur imagery supporting the detailed observations made with JunoCam. This provide context to infer processes controlling the motions and interactions of large storms on Jupiter.

Acknowledgements

Amateur imaging community, The PACA Project, PVOL, JunoCam.

References

[1] Rogers, J. Jupiter in 2018: Report No 6. British Astronomical Association Jupiter Section.
https://www.britastro.org/node/15381

[2] Rogers, J. Juno at Perijove-15 (2018 Sep.7): What the pictures show. British Astronomical Association Jupiter Section.
https://www.britastro.org/node/15673

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Fireballs in the Sky: Citizen Science with the Desert Fireball Network

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Abstract

Fireballs in the Sky is an innovative Australian citizen science program that connects the public with the research of the Desert Fireball Network (DFN). This research aims to understand the early workings of the solar system, and Fireballs in the Sky invites people around the world to learn about this science, contributing fireball sightings via a user-friendly augmented reality mobile app. Tens of thousands of people have downloaded the app world-wide and participated in the science of meteoritics. The Fireballs in the Sky app allows users to get involved with the Desert Fireball Network research, supplementing DFN observations and providing enhanced coverage by reporting their own meteor sightings to DFN scientists. Fireballs in the Sky reports are used to track the trajectories of meteors – from their orbit in space to where they might have landed on Earth. This presentation will provide an overview of the DFN and will focus on the Fireballs in the Sky citizen science component.

1. The Desert Fireball Network

The DFN uses automated observatories across Australia to triangulate trajectories of meteorites entering the atmosphere, determine pre-entry orbits, and pinpoint their fall positions. Meteorites with a known pre-atmospheric entry orbit can allow us to constrain the origin of the rock in the main asteroid belt, and possibly in some cases, even the specific asteroid parent body. The citizen science component provides expanded observations and data. Expansion of the network to international locations beyond Australia is now underway to build a Global Fireball Observatory (GFO). The expectation is that the Fireballs in the Sky initiative will be expanded to meet the needs of international partners. The DFN is a collaborative effort NASA SSERVI (Ames) and Curtin University in Western Australia. It is led by Phil Bland of Curtin University.

2. Observatory Design and Network

The observatories are fully autonomous intelligent imaging systems, capable of operating for 12 months in a harsh environment without maintenance, and storing all imagery collected over that period. Each observatory uses a 36MP consumer DSLR camera equipped with a fisheye lens providing spatial precision of approximately one arcminute. The DSLR is modified with a liquid crystal (LC) shutter. The LC shutter is used to break the fire-ball trail into dashes for velocity calculation, after triangulation. The LC shutter implementation allows the fireball's arrival time to be encoded by modulating the dash length according to a De Bruijn Sequence [1] synchronized with GPS time, yielding sub-millisecond timing precision. A video camera provides additional imagery of the fireballs - especially of fragmentation events. Observatory control and autonomy is implemented with an onboard low power consumption PC with a system drive, power supplies, GNSS module, microcontroller, and shutter driver.

The Australian network currently consists of 52 observatories covering more than 3 million km^2 of the Australian Outback. As a part of the event detection, the observatories communicate with the network's central server via an internet connection (where available) to corroborate potential fireball events with a preliminary approximate tri-angulation excluding single station false positives. Centralized tasks within the network include extraction of data points, decoding of timing, multi-station triangulation, trajectory analysis, mass estimation, atmospheric simulation, dark flight modeling, orbit calculation, and orbit back propagation.

Through a variety of partnerships including with NASA’s Solar System Exploration Virtual Institute, the DFN is expanding beyond the Australian Outback to international locations around the world. This includes establishing networks with international partners, as well as expanding the global user base of the Fireballs app. Institutions that are interested in joining the GFO initiative, as well as making observations and coordinating recovery efforts for fireballs in their areas, are invited to contact the authors for more information.

3. Results

The network has recovered four meteorites with orbits: Bunburra Rockhole, an anomalous basaltic meteorite [2] in 2008; Mason Gully, an H5 ordinary chondrite [3, 4] in 2010; Murrili, an H5/S1 ordinary chondrite in 2015; and Dingle Dell, a chondrite recovered near Morawa in 2016 [6]. The recent recovery of the Creston meteorite by the SETI GFO partner demonstrates how the GFO collaboration will work.

4. Citizen Science with Fireballs in the Sky

Fireballs in the Sky is an award-winning citizen science program that connects the public with the research of the DFN. Citizen Scientists using DFN's free Fireballs in the Sky app for Android and iOS can extend and enhance observations of the DFN by submitting their own observations. Through augmented reality, an intuitive interface and sensing technology of this smartphone app, anyone anywhere in the world can recreate their fireball sighting to contribute scientifically useful data. Users of the app can:

• Pinpoint the altitude and azimuth of the start and end of the fireball you saw

• Select different options for duration, shape, brightness, color and hue, and watch how an animated fireball changes to match what they've just seen. If it looked like it fragmented as it came through the atmosphere, users can select different options for number of fragments, and see the animation change accordingly.

• Add any other notes or details to their sighting report.

• Keep track of their sightings, and those of other users.

• Get updates on their sightings, and see levels of detail in feedback: Was it seen by other users? If it was, then how many other users saw it? Was there enough information to work out a trajectory? What was its orbit: where did it come from in the solar system?

• Find out when and where in the sky meteor showers are occurring, using the augmented reality heads-up display

• Get fireball news, and see updates on the DFN project, announcements and events

• Access the GFN's gallery of zoomable images – the fireballs the network seen and the meteorites that the project has found.

The Fireballs in the Sky Teacher Resource Book provides experiments and activity ideas to supplement classroom science and math teaching around the theme of 'Fireballs in the Sky'. Experiments can be used individually or as the whole unit to engage students in science and math.

Renae Sayers, Planetary Science Outreach Officer at Curtin University, coordinates Fireballs in the Sky.

References

[1] De Bruijn N. G. and Erdos P. (1946) Koninklijke Nederlandse Akademie v. Wetenschappen 49:758–764.

[2] Bland P. A., Spurny P., Towner M. C., Bevan A. W., Singleton A. T., Bottke W. F., Greenwood R. C., Chesley S. R., Shrbeny L., Borovicka J., et al. (2009) Science 325, 1525.

[3] Towner M., Bland P., Spurny P., Benedix G., Dyl K., Greenwood R., Gibson J., Franchi I., Shrbeny L., Bevan A., et al. (2011) Meteoritics and Planetary Science Supplement 74, 5124.

[4] Dyl K. A., Benedix G. K., Bland P. A., Friedrich J. M., Spurny P., Towner M. C., O'Keefe M. C., Howard K., Greenwood R., Macke R. J., et al. (2016) Meteoritics & Planetary Science 51, 596.

[5] Macke R. J., Wiggins S., Britt D. T., Benedix G. K., Bland P. A., and the Desert Fireball Network team (2016) 79th Annual Meeting of the Meteoritical Society

[6] Devillepoix H. A. R., Bland P. A., Towner M. C., Sansom E. K., Howie R. M., Cupak M., Benedix G. K., Jansen-Sturgeon T., Hartig B. A. D., Cox M. A., Paxman J. P. (2017) 80th Annual Meeting of the Meteoritical Society

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GAVIP-GridComputing

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Abstract

GAVIP-GC is a project designed to take an advantage of using freely available CPU and memory resources provided by the volunteers of the BOINC platform in order to analyze the data from the Gaia archive on the GAVIP platform.

1 Gaia

Gaia is a very successful space mission of the European Space Agency, still in operation, which provides huge amount of information about the positions, velocities and other parameters of the stars of the Milky Way. The Gaia archive is planned to have eventually over 1 petabyte of data. It is becoming more and more crucial to provide tools able to analyze the archive in a complex way.

2 GAVIP

GAVIP is a computing platform, supported by ESA, designed for data analysis in a form of self-contained Docker images. GAVIP platform runs the containers close to the Gaia archive. This provides a unique and fast way to access the current Gaia Data Release 2 and the future ones.

3 BOINC

In turn, the BOINC platform is designed to run user codes in a distributed way across the globe on the hardware provided by the volunteers. An example of a project running on BOINC platform is the well known SETI@Home. In our project we use volunteer computers to analyze the data from Gaia archive, especially the ones which demand significant amount of CPU time for computations.

4 GAVIP-GC

GAVIP-GC will simplify the process of writing a code for the BOINC platform. This will allow scientists (or any other users) who have no access to large computing facilities, to perform complex data analysis using the Gaia archive. GAVIP-GC, through the GAVIP platform, will provide also some disk space for storing the data as well as Jupyter notebooks in order to analyze the results further with the python programming language.

5 Gaia@home

http://gaiaathome.eu

Acknowledgements

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A Fast Digital CCD Camera with Precise Time-Stamping for Use in Occultation Astronomy and Photometry

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Abstract

Dedicated camera systems for use in occultation astronomy and or photometry need a precise time-stamping facility. For both applications instruments with more than 8 bit intensity resolution are required. Only, if occultations by atmosphereless bodies are recorded, analogue recording can be the matter of choice. However, in may cases precise photometry of the signal is important. In this report the combination of an industrial camera with a special recording software for LINUX is described. A timing accuracy of +/- 6 msec using a GPS receiver with 1pps facility has been achieved. The camera system generates FITS images with the appropriate timestamp keywords. Such a camera system, lightweight and easy to mount on each telescope (small or big) is one of a prerequisite in many PRO-AM cooperations.

1. Introduction

The history of imaging cameras for use in occultation astronomy is very long. For a long time analogue video systems, have played an important role. The video signal is fed through an "time inserter", which directly integrates the timing information into the analogue video stream. The timing has to be corrected due to the complicated signal processing of the video camera itself, Dangl [1].

However, the linearity can not always been guaranteed (Gamma factor!) and video systems have only an intensity resolution of about 8 bit. This is well suited for occultations of atmosphereless bodies such as main belt asteroid occultations with reasonable bright stars. In these cases only an "on/off" decision is required. If the visibility is poor or the stellar signal is dimming gradually, 8 bits are not sufficient, specially if brighter reference stars are used.

Many commercial available cameras on the market fullfill these requirements, but if we look for their time stamp precision, it looks rather poor. Even systems with implemented GPS have their problems. Because of the non availability of OpenSource software in most cases, the performance can only be changed by the manufacturer. Because of the small number of systems sold to observers in the occultation astronomy business, their interest to do so is rather limited.

2. Main Definitions

The following prerequisites have to be accounted for:

Light weight of the camera for mounting it at even on small telescopes.
Minimum 12 Bit resolution
Better than 8 electrons readout noise
High quantum efficiency, peak better than 60%
Minimum 20 images per second in FITS format
Timing accuracy better than 0.03 sec
Availability of an SDK software kit for LINUX
Low price tag, presumably less than 500 Euro

3. The Camera and Software

Many manufactures had been screened. Finally a small industrial camera from FLIR© (formerly PointGrey ©), the Chameleon3 © has been selected. It has a very sensitive CCD chip (Sony ICX445©) with a maximum quantum efficiency of about 66%, a diagonal of about 6 mm with a pixel size of 3.75 µm x 3.75 µm. It has 12 bit resolution and allows a binning of 2x2. Further it has a readout noise of around 6 e^- and can be used on an USB3 port with 30 images per second. It can be used with an image size of 1280 x 960 px as well as with 640 x 480 px. The last format is used for developing the software.

The manufacturer provides an SDK [2] for LINUX as well as a lot of testing software. Using this SDK, an operating software for LINUX has been developed. The software allows full control of the camera, displays the image and records the images in standard FITS format. The GPS time (1pps output of a Garmin receiver) of the NTP controlled OpenSuse operating LINUX system is used to generate the time stamp.

During extensive testing the average accuracy of the time stamp has been found to be better than +/- 6 msec. Comparisons have been done successfully with an internet NTP time server, such as www.ptbtime1.de generated by the Physikalisch Technische Bundesanstalt, Braunschweig. The jitter has been found to result from the internal firmware of the camera itself.

A graphical user interface with the DISLIN package of the Max Planck Institute for Solar System Research has been used for writing the GUI [3].

4. Testing and Examples

The camera system has been used for about 40 occultations, either occultations by main belt asteroids, lunar occultations or TNO occultations. It has been used also for mutual events of the Jovian satellites. Intensive testing with artificial light sources and timing devices have been performed to guarantee the timing capabilities of the system. In long term tests more than $2*10^6$ images have been taken to check the timing jitter. The readout noise and other data of the camera have been monitored in accordance to Abbott [4]. Calculations with images were done using ESO-MIDAS [5].

As an example, an occultation of a 12m4 star by Triton observed with a small 11 inch telscope can be seen in figure 1.

Figure 2 shows an photometric example of a mutual event of the Jovian satellites with only a drop of 0.29mag. Recorded with a 270 mm telescope.

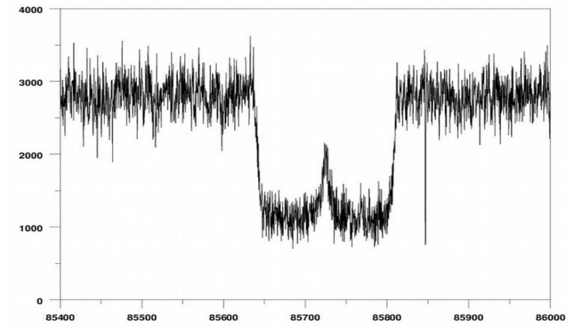

Figure 1: Occultation of a 12m4 star by Triton, recorded with an 11 inch telescope

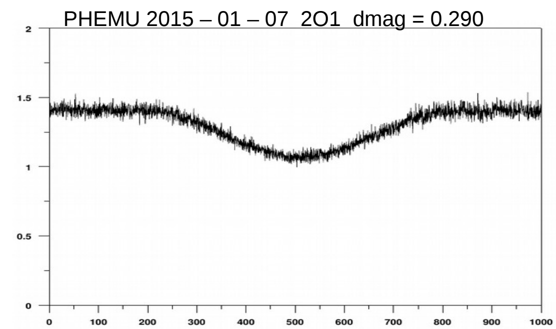

Figure 2: Mutual events of Jovian satellites, Europa occults Io, 07/01/2015, 11 inch telescope

5. Summary

On the basis of an industrial CCD camera with 12 bit resolution, a system has been developed for occultation astronomy and photometry with generated time stamps with an accuracy of about 6 msec. Maximum frame rate is 30 fps. It is well suited to be distributed in the PRO-AM community to replace analogue video recording systems still in use in many small observatories.

References

[1] http://www.dangl.at/menue_hh.htm

[2] https://www.flir.de

[3] https://www.mps.mpg.de/dislin

[4] Tim M. C. Abbott: In situ CCD testing. 24. Mai 1995 http://www.cfht.hawaii.edu/tmca/cookbook/top.html, no longer available

[5] https://www.eso.org/sci/software/esomidas/

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GAIA-Ground-based Observational Service for Asteroids

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Abstract

We present GAIA-Ground-based Observational Service for Asteroids (www.gaiagosa.eu). GaiaGOSA is a webservice created for amateur observes who want to support asteroid studies taking a photometric observations of asteroids or recording timing of stellar occultations.

1. Introduction

Gaia Ground-based Observational Service for Asteroids (GaiaGOSA) was created as a result of a cooperation between Astronomical Observatory Institute at Adam Mickiewicz University (AOI AMU) and the European Space Agency to facilitate collaboration between amateur observers and Gaia mission scientists (Santana-Ros et al., 2016). The service can be found at: www.gaiagosa.eu GaiaGOSA is a website dedicated to observers who can contribute to studies of the physical properties of asteroids by gathering photometric observations of selected targets at specific time. For many asteroids the whole lightcurve cannot be covered during one observing session, like for example those with period longer than 8-10 hours, or for asteroids with period resonant with the Earth's day. In such situation an ideal solution is to coordinate larger observing campaign and gather observations from many sites around the world with the help of amateur observers equipped with 20-cm or larger telescopes.

2. Results

Gaia-GOSA website started to work at the beginning of 2016. In total, after almost three years of webpage work, we have over 140 registered users who sent us the data from over 580 nights of observations. The most active observer spent more than 1200 hours observing asteroids and sent high quality data to GaiaGOSA database. The raw observations sent by observers are reduced and analysed by astronomers from Astronomical Observatory of Adam Mickiewicz University in Poznań, Poland and obtained lightcurves are shown on GaiaGOSA webpage. When we have the whole rotation period covered we make composite lightcurves and show them on GaiaGOSA website Forum. The Forum was created for observers who want to discuss the results, share their experience and coordinate planned observations. An example of a composite lightcurve from data gathered for 402 Chloe can be seen in Fig. 1. It is worth mentioning that the precision of the data is better than 0.01 mag.

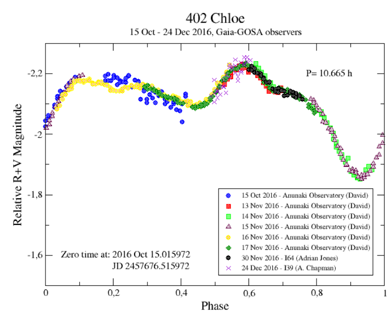

Figure 1: This is the example of an included figure.

So far the observations gathered on GaiaGOSA helped for asteroid modelling in the framework of the HORIZON 2020 Programme: "Small Bodies Near And Far", and in ESO Large Program on Very Large Telescope (Vernazza et al., 2018, Viikinkoski et al., 2018, Carry et al., 2019).

References

[1] Carry B., et al., 2019, “The homogeneous internal structure of CM-like asteroid (41) Daphne”, A&A accepted

[2] Santana-Ros T., Marciniak A., Bartczak P., 2016, “Gaia-GOSA: A Collaborative Service for Asteroid Observers”,MPBull, 43, 205

[3] Vernazza, P. et al., 2018, “The impact crater at the origin of the Julia family detected with VLT/SPHERE?”, A&A, 618, 154

[4] Viikinkoski M., et al., 2018, “(16) Psyche: A mesosiderite-like asteroid?”, A&A, 618, 3

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Photometric Observations of Fast Move and Fast Rotate Asteroids

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Abstract

I present the results from my short-exposure ($t_{exp} \leq 10$ s) photometric observations of faint asteroids, including fast-rotate and fast-move NEA. I introduce deep data analysis method to get quality outcome using small telescopes equipped with quick camera, widely available today even for amateurs. I show how I use statistical analysis of big amount of frames to compensate SNR deficiency. Light curves and determined period of 2018 UY1 (NEA super-fast rotator and fast-mover; P = 98.05±0.04 s) and (3040) Kozai (Mars Crosser; P = 4.5133±0.0002 h) are presented.

1. Introduction

Among asteroids NEO group has a significant importance for 2 reasons at least: a) they are considered to be hazardous and b) there is potential for future space mining projects. The study of spin rotation provides us with knowledge about interior structure of the object. It's admitted that fast-rotators should be coherent bodies to keep its consistence [1], hence its impact is more dangerous than if it was a rubble pile.

Despite of their importance there is still bias in NEO studies: only for 262 asteroids with H ≥ 24 period has been determined so far (as of May 6th, 2019) and for only 84 of which with LCDB quality code "3-" or better [2]. This is because of difficulties in observation of such objects: when they are close enough to be measured with proper SNR they are usually moving fast on the sky, rapidly changing geometry and observation window is relatively small (single nights).

2. Telescopes & setup

Observations have been done using 3 telescopes: 0.65m Roman Baranowski Telescope (RBT) located in Winer Observatory (Arizona) equipped with Andor iXon X3 888 EMCCD camera, 0.43m Corrected Dall-Kirkham Astrograph (CDK) located in Nerpio (Spain) with FLI ProLine 16803 CCD and 0.28m Rowe Ackremann Schmidt Astrograph (RASA) located in Lusowko (Poland) with ZWO ASI290-MM camera. FLI ProLine 16803 is a classic CCD camera while Andor iXon X3 888 represents scientific standard electron-multiplying CCD and ZWO ASI290-MM is a CMOS camera of amatour level. The last two have high quantum efficiency, low read noise and short readout time thus are apropriate for making fast photometry.

3. Observations

Table 1: Following observations has been done. For CDK sloan r' filter has been used. For RBT and RASA - luminance filter applied.

Asteroid H (mag)	Dates	V(mag) Speed("/s)	#Frames Exp. (s)	Telescope
2018 UY1 24.1	2018-10-29 2018-10-30 2018-10-31	17.6 - 17.1 0.17 - 0.28	6070 10,8,7,6,5	RBT
(3040) Kozai 13.8	2019-02-26 2019-02-27 2019-03-30 2019-03-31 2019-04-01 2019-04-05 2019-04-06	15.6 - 16.8 0.03 - 0.005	11909 10	RASA
	2019-03-28 2019-03-29 2019-04-03 2019-04-04	16.6 - 16.8 0.010 - 0.006	44 300	CDK

4. Data reduction

Because of high number of data collected for single object it was necessary to implement a tool to pipe all the reduction process. Huge number of frames together with quality alghoritm to uncertainty estimate lead to trustworthy results.

The main features of the pipeline process:

- each raw frame has been calibrated to 32-bit data FITS;

- each frame has been plate solved to get asteroid's position on the frame, even if it's not noticeable;

- no frame has been rejected because of low asteroid's SNR or image quality; instead uncertainty of each asteroid measurement has been determined;

- stars' brightness transformation function of airmass has been determined; for fast movers this still ensures reference brightness and known uncertainty;

- aperture photometry parameters (aperture, annulus) were determined using genetic algorithm for frame series; each frame serie covers 15 minutes timeframe. Parameters were optimized for sources of brightness similar to the asteroid (± 1 mag);

- for asteroids with P ≥ 600s, frames were stacked into 60s sets with sideral-, asteroidal- and half-asteroidal speed; stars' photometry has been taken from the first, asteroid photometry - from the second. However this was not applied for highly crowded fields; in this case half-asteroidal speed is usually used;

- period was determined using Fourier series approximation based on weighted points.

5. Results

Table 2: In table below I present results of the observations. The reduction is ongoing and more results will be presented during the Congress.

Asteroid	Date	Period	Amp. (mag)
2018 UY1	2018-10-29	98.05 s ±0.04	0.28
2018 UY1	2018-10-30	98.01 s ±0.02	0.22
2018 UY1	2018-10-31	98.08 s ±0.04	0.42
(3040) Kozai	2019-02-26 - 2019-02-27	4.516 h ±0.002	0.27
(3040) Kozai	2019-03-28 - 2019-04-06	4.5133 h ±0.0002	0.32

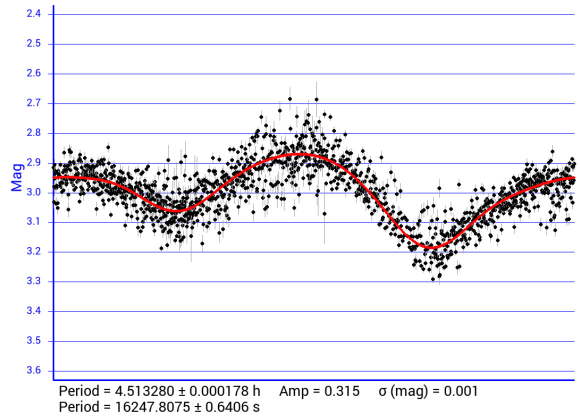

Figure 1: Lightcurve of (3040) Kozai. Data collected between 2019-03-28 and 2019-04-06. It's worth to notice that determined period is fully consistent with the ones given by Pravec and Stephens and cited in LCDB [2].

6. Conclusions

Fast photometry combined with statistical analysis can be strong technique for obtaining quality photometric data. For faint asteroids including fast rotators and fast movers it's possible to determine high quality rotation data even if SNR of single observation is very low. This enables small telescopes and amateur observatories to deliver valuable scientific input and overcome biases, especially in our knowledge of very small NEAs (D < 0.15 km).

Acknowledgements

I would like to thank the Staff of the Institute Astronomical Observatory of Adam Mickiewicz University in Poznan for making observations at remote RBT telescope in Arizona possible and for valuable input. I want to especially thank Prof. Tomasz Kwiatkowski for all the knowledge about asteroids he was willing to share, for his patience and openness.

References

[1] Pravec, P., Harris, A.W. and Michałowski, T. (2002b) Asteroid Rotatios. In Asteroid III (W.F.Bottke Jr. et al., eds.), Univ. of Arizona, Tucson.

[2] Warner, B.D., Harris, A.W., Pravec, P. (2009). Icarus 202, 134-146. http://www.MinorPlanet.info/lightcurvedatabase.html

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Pro-Am collaboration on ground-based exoplanet observations in support of the ARIEL space mission

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Abstract

ExoWorlds Spies (www.exoworldsspies.com) is a project that started in early 2018, aiming to monitor transiting exoplanets through long-term regular observations using small and medium scale telescopes. We are actively collaborating with the ARIEL consortium on obtaining follow-up observations of exoplanet-hosting systems in order to define their ephemerides as precisely as possible. In this effort, we are highly supported by amateur astronomers, the Holomon Astronomical Station and the private telescope network of Konika Minolta. We strongly believe that research is an effort that everyone can contribute and thus, in our project we have an active collaboration with amateur astronomers from different locations. To facilitate this, we have developed user-friendly data analysis tools and a dedicated website, in order to disseminate the material to as many people as possible. The website includes audiovisual material, information on the project, data analysis tools, instructions, observational data and graphics. All sources are online, free, and available for everyone both in English and Greek.

So far, we have collected approximately 60 transit observations of more than 25 different exoplanets, from both the North and the South hemisphere, including recently discovered planets with limited data available. These observations prove that multiple small observatories can collaborate in order to cross-calibrate their data and provide complementary, high-precision results. In this presentation, we will present the network of our observing partners, the importance of the synergy with ARIEL, the future observing plans, and the most exceptional cases of exoplanets observed until today as part of our project.

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HOPS: the photometric software of the HOlomon Astronomical Station

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Abstract

HOPS (HOlomon Photometric Software) is a python-based package which includes a user interface and it is compatible with Linux, OS X and Windows. It is open-source (github.com/HolomonAstronomicalStation/hops) and it is designed to analyse data from small and medium class telescopes. A significant factor of any citizen science (CS) project is the meticulous development of dedicated tools. In this direction, HOPS is a user-friendly photometric software for exoplanets, where graphical representations, statistics and models are brought together into a single package. HOPS can be used by amateur astronomers individually or as part of a CS project in analysing transiting exoplanets and producing light-curves. In this way, it could contribute to the scientific data analysis but it could be used also as an educational tool for learning and visualizing photometry analyses of transiting exoplanets, where the everyone can engage with exoplanetary research and data analysis.

The basic features included in HOPS, are: a) reduction, which includes the calculation of master bias/dark/flat frames and the correction of the scientific frames, b) frame selection, which provides interactive graphs for selecting the damaged images, c) alignment, an automatic detection of star patterns in the field of view, despite large shifts or meridian flips, d) photometry, which includes an interactive window for selecting the target and comparison stars and extracts the light-curves using both aperture and PSF photometry, e) transit fitting, which provides the fitting of the transit model on the relative light-curve using MCMC sampling. HOPS makes use of the python package PyLightcurve which is completely developed in Python and provides routines for: a) finding planetary parameters from the open exoplanet catalogue, b) calculating limb darkening coefficients, c) calculating the planetary orbit, d) calculating the transit light-curve model using numerical integration. The PyLightcurve package can be found on github: https://github.com/ucl-exoplanets/pylightcurve.

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Amateur collaboration within Europlanet 2020 and beyond

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Abstract

The Horizon 2020 advanced research infrastructure project Europlanet 2020 aimed to strengthen the collaboration in European planetary sciences. One of its goals was for the first time to foster the collaboration between professional planetary scientists and amateur astronomers in Europe. This presentation will thus give an i) overview on this collaboration within Europlanet 2020 (ending in August 2019), but also on ii) the future of amateur astronomy within the potentially upcoming follow-up project Europlanet 2024. If granted by the European Commission, Europlanet 2024 will provide exciting opportunities for amateur astronomers in Europe and beyond.

1. The present: Europlanet 2020

Europlanet 2020 (www.europlanet-2020-ri.eu) is an advanced research infrastructure project of the European Commission's funding scheme Horizon 2020, which provides access to planetary field sites and internationally renowned laboratories, hosts the biggest Virtual Observatory in European planetary sciences, engages in public outreach, and organizes a diverse set of different scientific workshops. In addition, one of its Work Packages – *WP12: Networking Activity 1 (NA1) "Innovation through Science Networking"* – supports the organization of amateur workshops and observation campaigns. As an example, the "Workshop on Juno Ground-Based Support from Amateurs: Science and Public Impact", which took place from May 12-13, 2017, in Nice, France, marked one of the most successful amateur oriented workshops of the whole project. Furthermore, the support of amateur astronomers can even be seen as one of the big success stories of the whole project. This presentation will thus briefly give an overview of the amateur collaboration within Europlanet 2020 and also discusses its outcomes, of which the following will be emphasized in particular.

2. The future: Europlanet 2024

The collaboration of amateurs within Europlanet 2020 culminated into the preparation of a separate Work Package on the Coordination of Ground-based Observations within the potentially upcoming follow-up project Europlanet 2024. The support of amateur astronomers is planned to be one of its cornerstones. If granted, the Work Package will provide 3 dedicated schemes to support amateur astronomy, i.e. i) the support of pro-am-workshops (as in Europlanet 2020), ii) the organization of dedicated regional amateur training workshops, and iii) the support of amateurs observing at professional observatories within Europe and beyond. The presentation will give a short overview on Europlanet 2024 with its focus on the potential support that will be available to amateur astronomers in case the project will finally be granted by the European Commission.

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Solar Windsocks: Estimating Solar Wind Speeds from Comet Ion Tail Images

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Abstract

As part of the Europlanet 2020 Research Infrastructure Planetary Space Weather Services (PSWS), University College London's Mullard Space Science Laboratory (MSSL) is making available software to estimate the speed of the solar wind at comets by measuring the orientation of their ion tails. As ion tails are cometary ions flowing downstream of the comet carried by the solar wind, images of the tails can provide a great deal of information about the solar wind speed at the comet. Software has been developed that allows the user to trace the ion tail, and, using information on the comet's position and velocity at the time the image was taken, allows estimates to be made of the solar wind speed at the comet's location in the inner heliosphere. These estimates can complement more accurate but limited measurements of the solar wind by spacecraft. We describe the software, its use, and limitations. The latter includes complications that arise when the solar wind flow is not purely radial, and difficulties in the use of the software when the Earth is crossing the plane of the target comet's orbit.

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INFRARED STUDIES OF JUPITER USING IMAGE SUBTRACTION

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1. Introduction

The aim of the poster paper is to demonstrate the effectiveness of image subtraction to enhance the visibility of fine Jovian atmospheric detail from 600 nm to 1000 nm.

2. The Equipment

The telescope is a 246mm f/10 apochromatic refractor. The instrument is mounted equatorially in a 3.3 metre fibreglass observatory situated in the authors backyard. All above mentioned items have been made by the author.

The camera is an ASI224MC camera made by the ZWO company. It has an IMX224 sensor with 1.2megapixels each 3.75 μm square.

A set of band pass filters made by Andover Corporation is used to image Jupiter. The set is comprised of six filters with a centre bandwidth of 600, 700, 800, 900, 950 and 1000 nm respectively. Each filter has a FWHM bandwidth of 40nm. In addition, a methane absorption filter centred on 889nm with a FWHM bandwidth of 8 nm is used.

3. Processing.

After a set of data is acquired using all filters up to 1000 nm, the images are processed in an identical manner using the software packages Autostakkert and RegiStax6. Subtle differences are difficult to highlight without a more direct means of comparison.

4. Enhancement

Two methods of enhancement are used.

4.1 Three images of descending wavelengths are assigned to red, green and blue and are used to create a false colour image of the planet. The resultant colour image emphasizes the brightness of an image at that wavelength. Figure 1 is an example of allocating images taken with the 800x40, 700x40 and 600x40 nm filters allocated to red, green and blue.

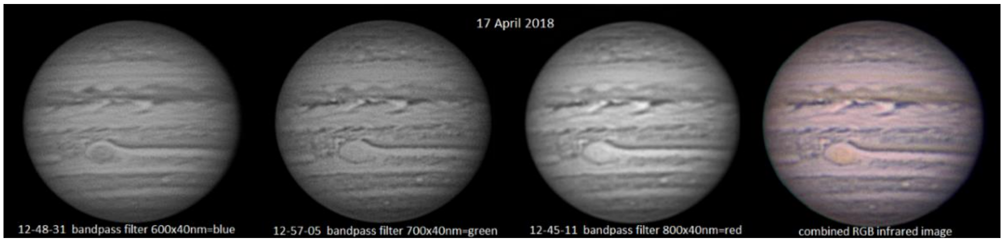

Figure 1

4.2 The second method uses image subtraction of two images taken with different bandpass filters to directly highlight the differences. The images to be subtracted must be taken at very close to the same time. To make this so one image must be de-rotated. For example, if an image taken with a 600x40 nm filter is to be subtracted from one taken with an 800x40 nm filter it is necessary to acquire a 600 nm image, an 800 nm image and a 600 nm image in that order. The two 600 nm images are then combined using the Winjupos software and time of the resultant image is very close to that of the 800 nm image. The combined 600 nm image is then subtracted from the 800 nm image using Matlab. Figure 2 shows the results of the procedure.

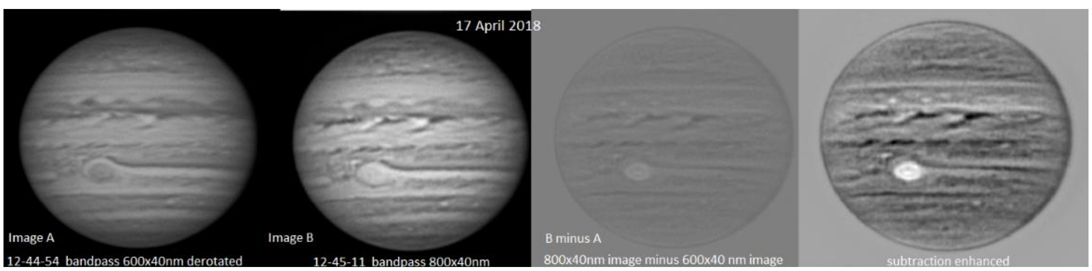

Figure 2

5.Results.

Enhanced images as a result of image subtraction show an increase in subtle detail not otherwise obvious. A sample is shown in figure 3 image.

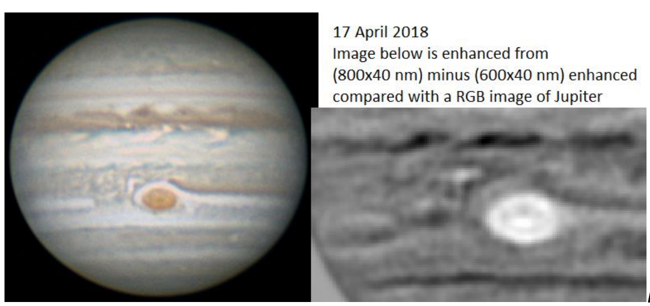

Figure 3

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Working With Schools to Observe Asteroids, Comets and Other Solar System Bodies Using the Faulkes Telescopes

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Abstract

We present examples of collaborative efforts between professional and amateur astronomers and educational groups and schools throughout Europe. These projects involve the use of the two 2-metre Faulkes Telescopes located in Hawai'i and Australia as well as those of the Las Cumbres Observatory network of 1-metre and 0.4-metre telescopes from multiple sites around the Earth.

One example is that of German student, Levin Belli, from Pascal High School in Muenster, Germany who discovered a new asteroid called 2018AM4 in 2018 using Faulkes Telescope North. This work won him first place in "Earth and Space Sciences" at the regional competition of "Schueler Experimentieren" in the House of Technology in Essen.

Other European students including those from the UK and Germany have recently imaged Comet 46P/Wirtanen using the Faulkes Telescope's real-time observing interface leading to an ESA press release[1].

As well as providing free telescope time to our educational users, we also provide resources based on the background science to these objects, curriculum links and the software required to analyse these objects.

1. http://www.esa.int/spaceinimages/Images/2018/12/Students_analysing_Comet_46P