Uranus Campaign 2006

Dutch Working Group Moon and Planets

John S.Sussenbach

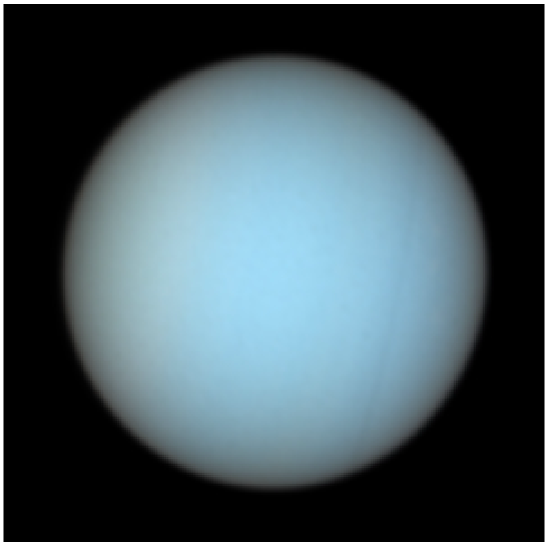


Fig. 1. Uranus in visible light (Hubble Space Telescope)

1. Introduction

The planet Uranus belongs to the remote giant planets and is in this category an exception due to its "fallen" state. The rule for the other planets is that the polar axis is oriented more or less perpendicular to the plane of orbit, but the polar axis of Uranus is oriented parallel to this planet (inclination 97º). Observed from the Earth the planet Uranus has a very small angular size and with his diameter of 3.7" it is a real challenge for amateur astronomers. Visually it is a rather dim, pale blue tiny disk without any detail. The only interesting thing is the constant dance of the larger Uranian satellites.

The members of the Dutch Working Group Moon and Planets has held a Uranus campaign in August and September 2006. The objective was to investigate what amateurs can detect and observe with the help of the latest digital cameras and other technical equipment.. It should be noted that the circumastances for observation of Uranus from The Netherlands were quite unfavourableduring this apparition. In 2006 the altitude of Uranus was not higher than 30º. As a consequence of this low altitude, several amateurs with permanent observatories have only small time windows of observation, due to neighbouring buildings and trees. Another consequence of the low altitude of Uranus is that the quality of the images is rather low. Nevertheless, a number of Dutch amateurs accepted the challenge.

1.1 At the limit of possibilities

Observations of Uranus by the Voyager spacecrafts, the Hubble Space Telescope and the big Keck telescopes have demonstrated that, in general, the planet shows only few details in visible light. (Fig.1). From time to time using infrared filters dark and bright clouds are observed. In addition, brightning of the South polar region has been detected. From the start of our campaign, it was obvious that detecting details on Uranus would be at the limits of the possiblities of amateurs. A major pitfall for amateurs is overprocessing van Uranus images creating all kinds of artefacts. In this campaign special attention was given to distinguishing artefacts from real details.

1.2 Artefacts of image processing

In particular, Willem Kivits has put a lot of effort in investigating the pitfalls of overprocessing and other problems associated with digital processing of Uranus images. A well known feature of overprocessing is the appearance of a bright rim around the disk (Fig. 2). This artefact is noticed quite easily, because in general, the planetary disks show rim darkening due to the globular shape of planets.

Willem Kivits has performed a number of tests to investigate the effects of overprocessing, strong contrast enhancement and extensive sharpening (Fig.3). He demonstrated that these procedures create an artifial pattern of dark and light spots is generated.

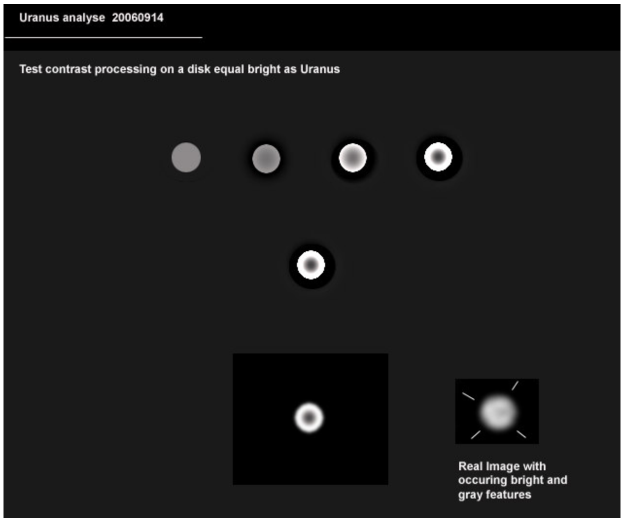


Fig. 2 Overprocessing causes the formation of a bright rim

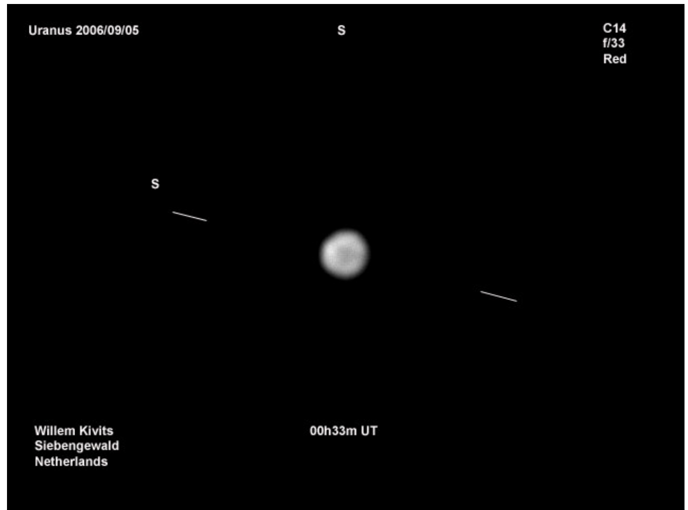


Fig. 3 Effect of extensive sharpening and contrast enhancement

A useful control was proposed by Martin van Ingen to test whether certain spots are real and not due to overprocessing. He suggested to image the planet twice, viz. the first time with the camera in the normal position and the second time with the camera rotated 90º. If a detail is genuine it will show rotation when the changing position of the camera. Another control to test the true existence of putative details is to image the planet with a time interval of a couple of hours. If a detail is real, it will rotate with the planet. Uranus rotates in about 17 hours 14 minutes, so in a few hours time the rotation of details must be detectable.

1.3 Importance of accurate collimation

During his other attempts to detect details on Uranus, Willem Kivits dicovered that the accurate collimation of the telescope is very important. A very small deviation is sufficient to cause a bright spot at one site of the planet, mimicking South Polar Brightening.. All astrophotographers are aware that high resolution images require precise collimation. Willem observed that collimation is even more critical with Uranus. His experiments demonstrated that even a hardly detectable deviation in collimation leads to a distinct artificial bright spot in the rim of the Uranus disk (Fig. 4 en 5). He proposed to test the Airy disks of Uranus and a star (out of focus images) during each observation session. In the case that during later processing bright spots are detected, one can exclude the possiblity that it is due to imperfect collimation.

Fig. 4 Influence of imperfect collimation

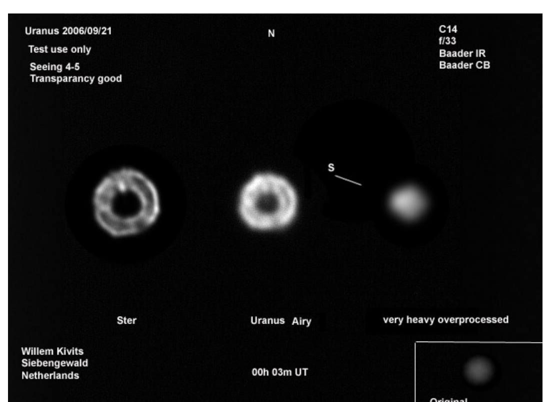


Fig. 5 Influence of the collimation status

1.4 Application of filters

To produce colour images most observers use sets of three colour filters, viz red, green and blue (so-called RGB set) of the brand Astronomik. It is known that a putative brightening of the Uranus South Pole is best observed with a red filter and even better with an infrared filter (e.g a Baader IR pass filter). In the atmosphere of Uranus methane is present and this causes a number of specific absorption bands in the spectrum of the planet at 619, 727 en 890 nm, respectively (Fig 6).

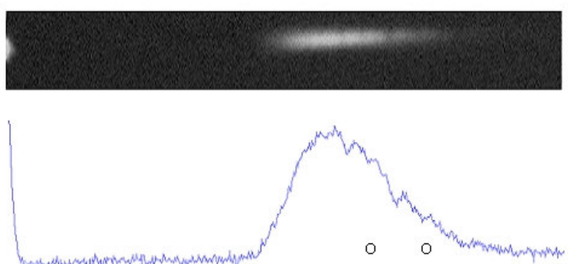


Fig. 6. Spectrum of Uranus (Ad Kalk)

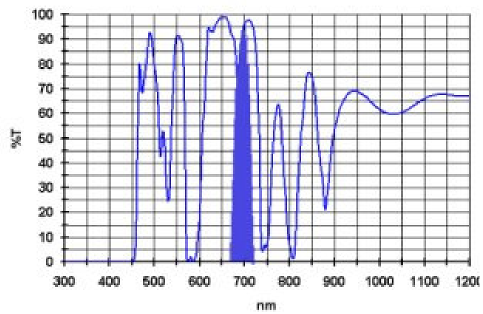


Fig. 7. Transmission spectrum of a combination of a Baader IR filter, a High Contrast Boost filter and an IR blocking filter

Professional observers use these and even longer IR wavelengths (1600 nm and higher) to detect details in the atmosphere of Uranus. In particular Willem Kivits again has investigated the potentials of methane filters to spot details on Uranus. In a first attempt to image Uranus in one of the methane bands he used a combination of a Baader IR filter, a High Contrast Boost filter and an IR Blocking filter. The resulting transmission of this combination is shown in Fig. 7. Later he used so-called Davin band pass filters of 620 nm (halve band width HW 10 nm, 729 nm (HW 30 nm) and a 905 nm (HW 45 nm) filter.

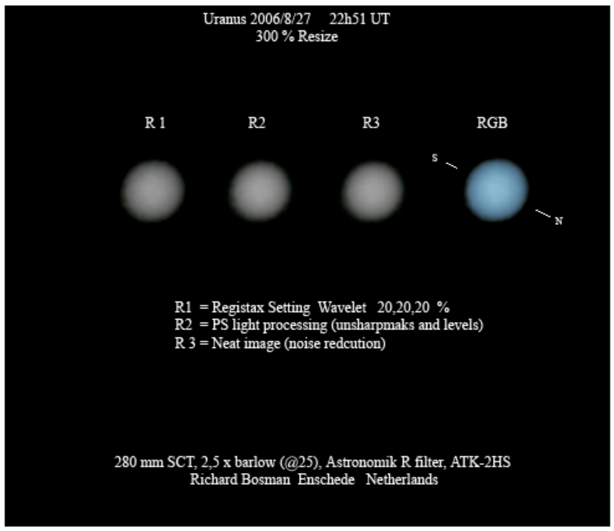
2. Results

2.1 Uranus images

To be able to compare the results of different observers a special Uranus protocol was developed (Addendum 1). The following members of the Dutch Working Group Moon and Planets participated in this campaign: Jan Adelaar (Arnhem), Richard Bosman (Enschede), Martin van Ingen (Geldermalsen), Willem Kivits (Siebengewald), Arnaud van Kranenburg (Vlaardingen), Conrad van Ruissen (Nijkerk), John Sussenbach (Houten) and Ralf Vandebergh (Wittem). . The opposition of Uranus took place on 5 September 2006 at 13 hours. Below the main results of the Group are presented. These images give a good impression of what experienced Dutch observers were able to detect of Uranus and its satellites in August and September 2006

2.1.1 Richard Bosman

Richard Bosman has used a Celestron C11 telescope equipped with an ATK-2HS camera. For his red channel images he used an Astronomik R or a Baader IR pass filter (670nm). For his RGB images he also used Astronomik filters. The quality of his images is in general very good, so that it was even possible for Richard Schmude (ALPO) to determine the polar flattening of Uranus. This flattening amounts to about 2%. The planetary disk clearly shows rim darkening, but no details or South Polar Brightening is detected. Richard used a well-balanced image processing technique as some of his images nicely demonstrate (Fig 8 and 9).



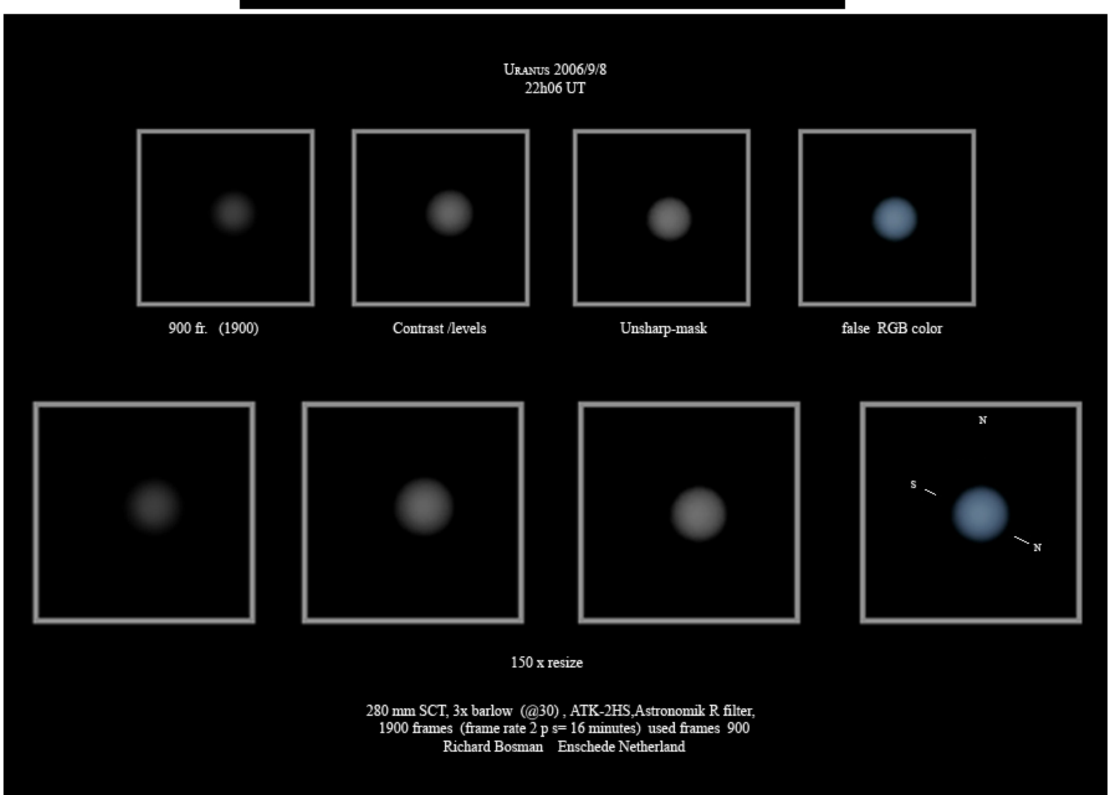


Fig. 8. Uranus images of Richard Bosman

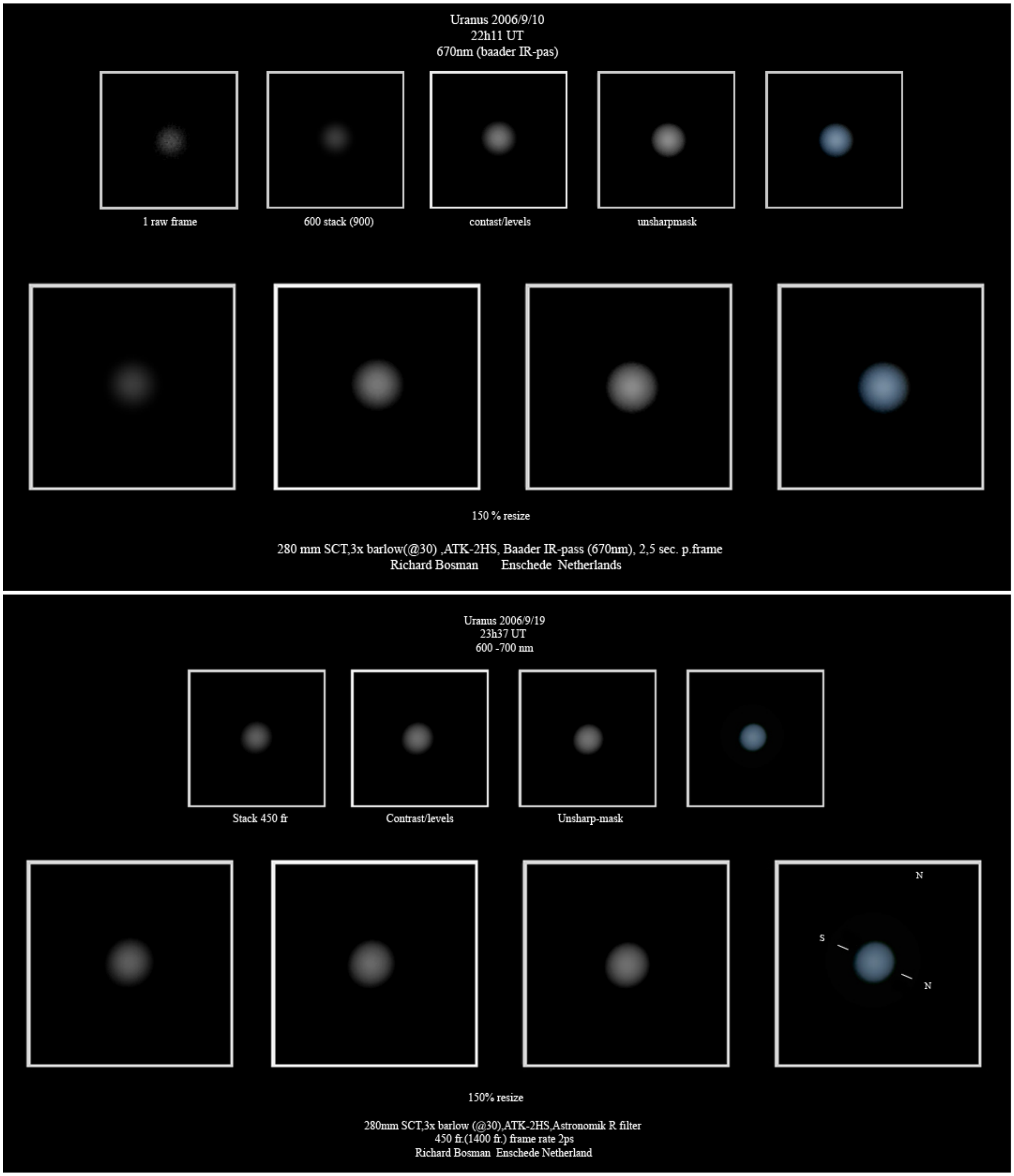


Fig. 9. Uranus from raw frame to final image

2.1.2 Willem Kivits

Willem Kivits uses a Celestron C14 telescope and a Meade 12LX200 telescope equipped with an ATK2HS camera. He further used a combination of filters such as a Baader IR pass and a Baader Contrast Booster filter (Fig. 10 en 11).He also used Davin band pass filters of 610, 729 en 905 nm, respectively (Fig. 12). Willem collected a large number of images and here only a selection is shown. His beautiful images reveal a pale blue planetary disk with rim darkening, but no other details. In some images the Southern hemisphere is somewhat brighter than the Northern hemisphere, but the author himself has his doubts whether this represents the classical South Polar Brightening. In the absence of further controls or comparative pictures of others it is very difficult to conclusively determine whether this is really the case

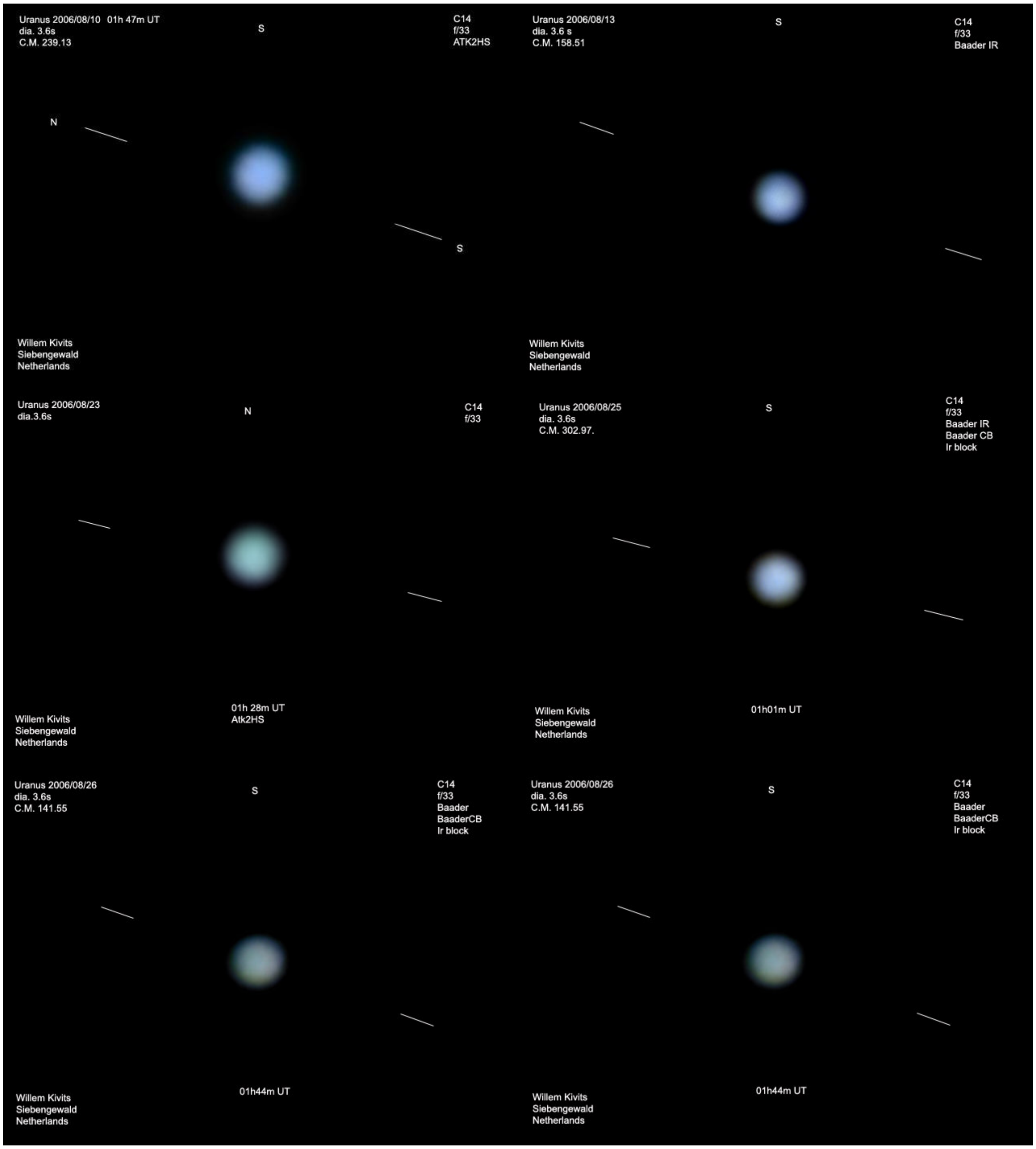


Fig. 10 Uranus imaged with a combination of a Baader IR filter and a High Contrast Boost filter

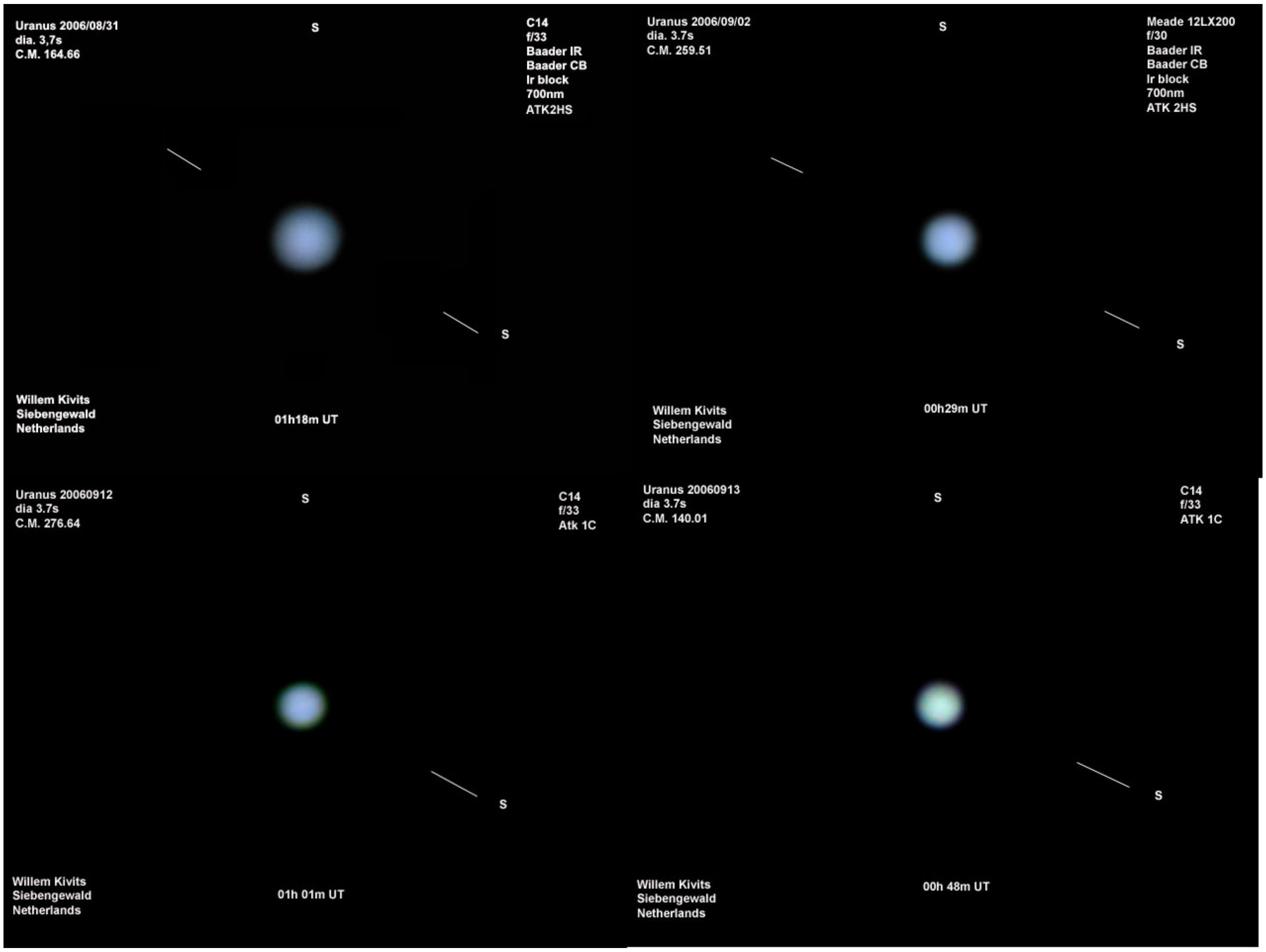


Fig. 11 Uranus imaged with a combination of a Baader IR filter and a High Contrast Boost filter (2)

Very interesting are the images Willem Kivits produced with the Davin band pass filters with transmission at 610, 729 en 905 nm, respectively. These filters exhibit transmission in the regions where methane bands at 620, 727 and 890 nm, respectively, are located (Fig. 6). Although these filters absorb a lot of light, the required exposure times for Uranus with the 620 and 727 nm filters are in the range of a single second. For the 905 nm filter an exposure time of 8-10 seconds is required. Thus, to obtain reasonable images with a 905 nm filter the seeing must be quite good (Fig. 12 and 13). However, also with these filters no details could be detected on the tiny Uranus disk. Still they are the best choice for amateurs to search for methane clouds in the Uranus atmosphere.

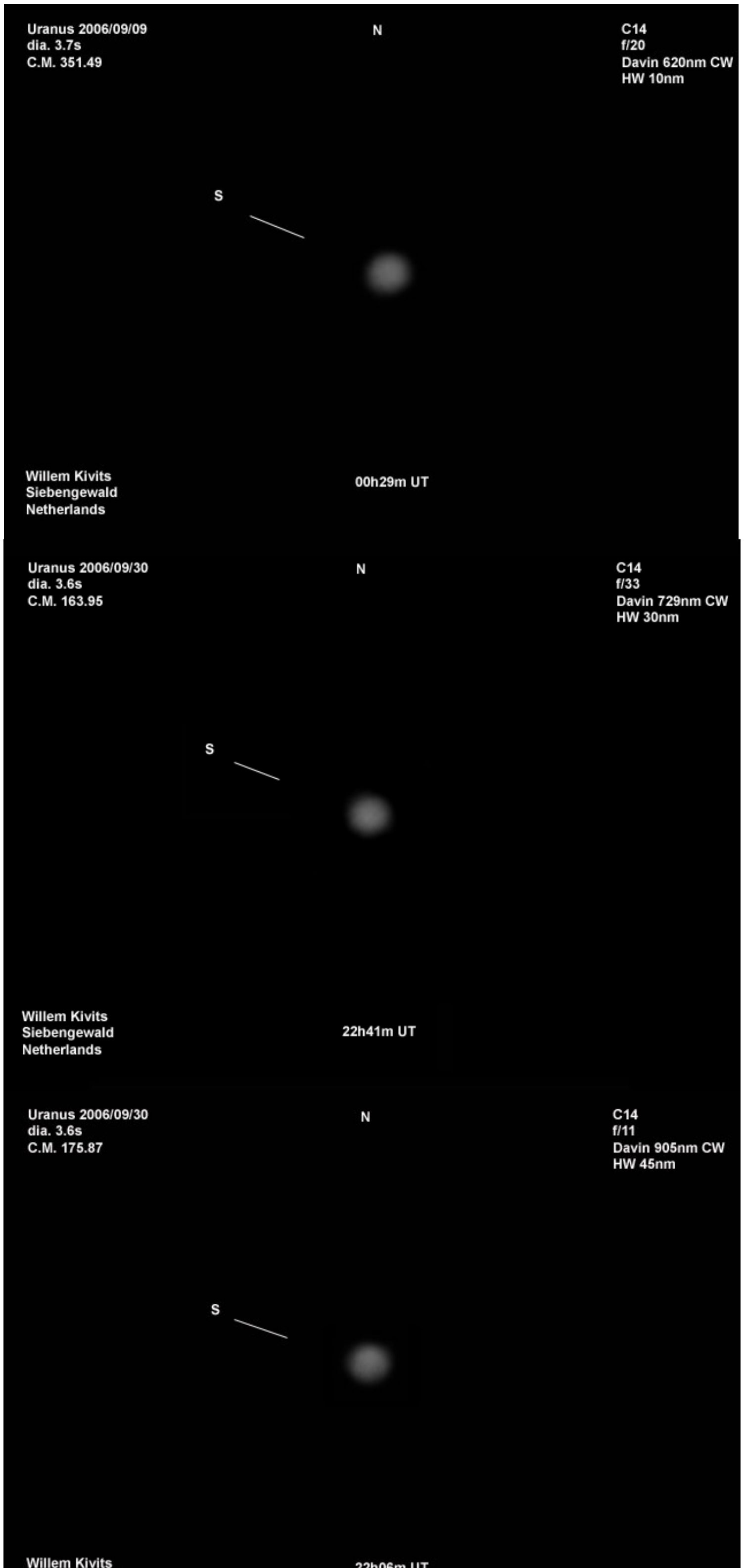


Fig. 12. Uranus imaged with Davin band pass filters of 620, 729 and 905 nm, respectively

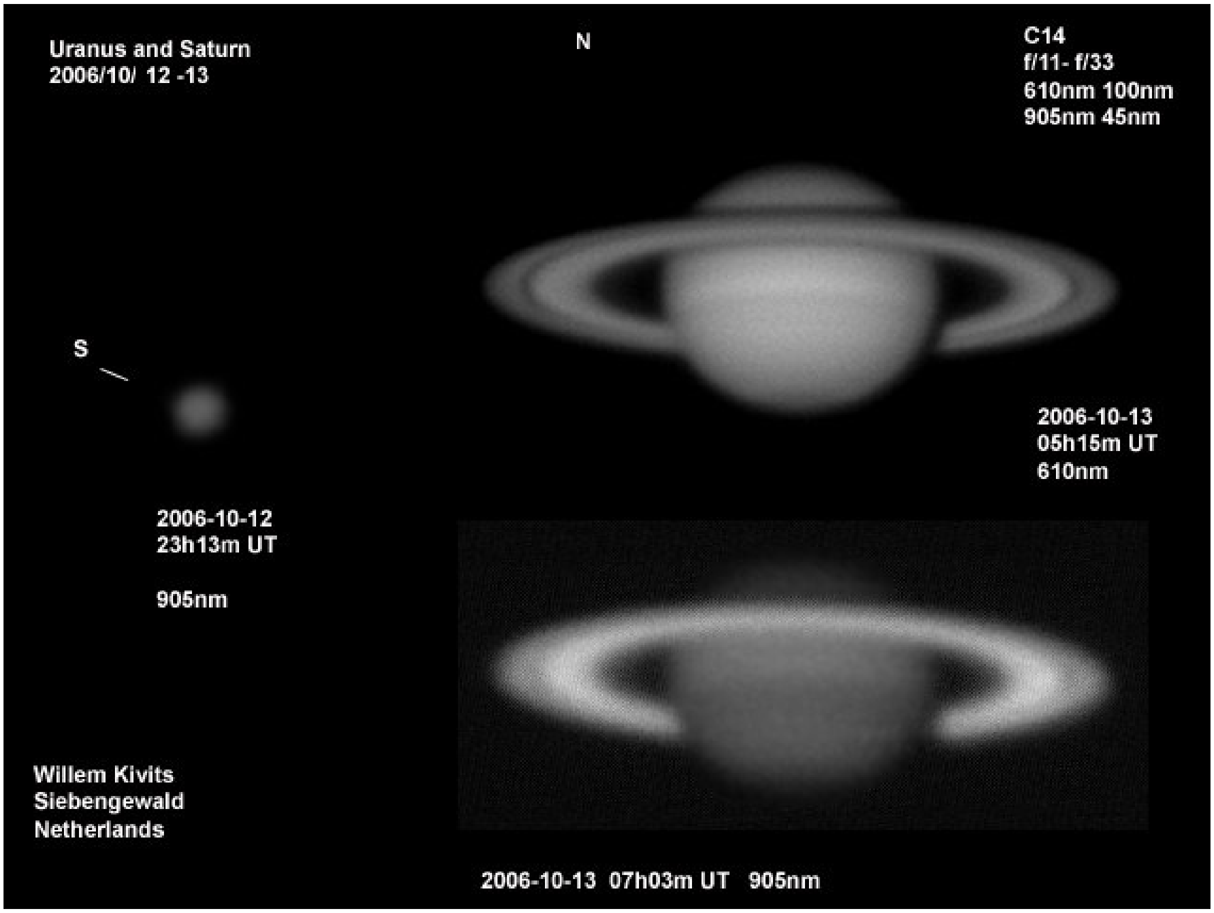


Fig. 13 Uranus and Saturn imaged with a 610 and a 905 nm band pass filter, respectively

The potentials of for example of the 905 nm filter is illustrated in Fig. 13 in which Uranus and Saturn are compared. Also Saturn has methane in its atmosphere, but it is absence in the rings. This is nicely demonstrated, because with this filter the rings are much brighter than the globe of Saturn.

2.1.3 Jan Adelaar

This observer uses a 9.25 Schmidt-Cassegrain telescope equipped with a B/W modified webcam camera. He mused a 685 nm Astronomik IR filter (Fig. 14). Also Jan observes a blue disk with rim darkening, but no other details are detected.

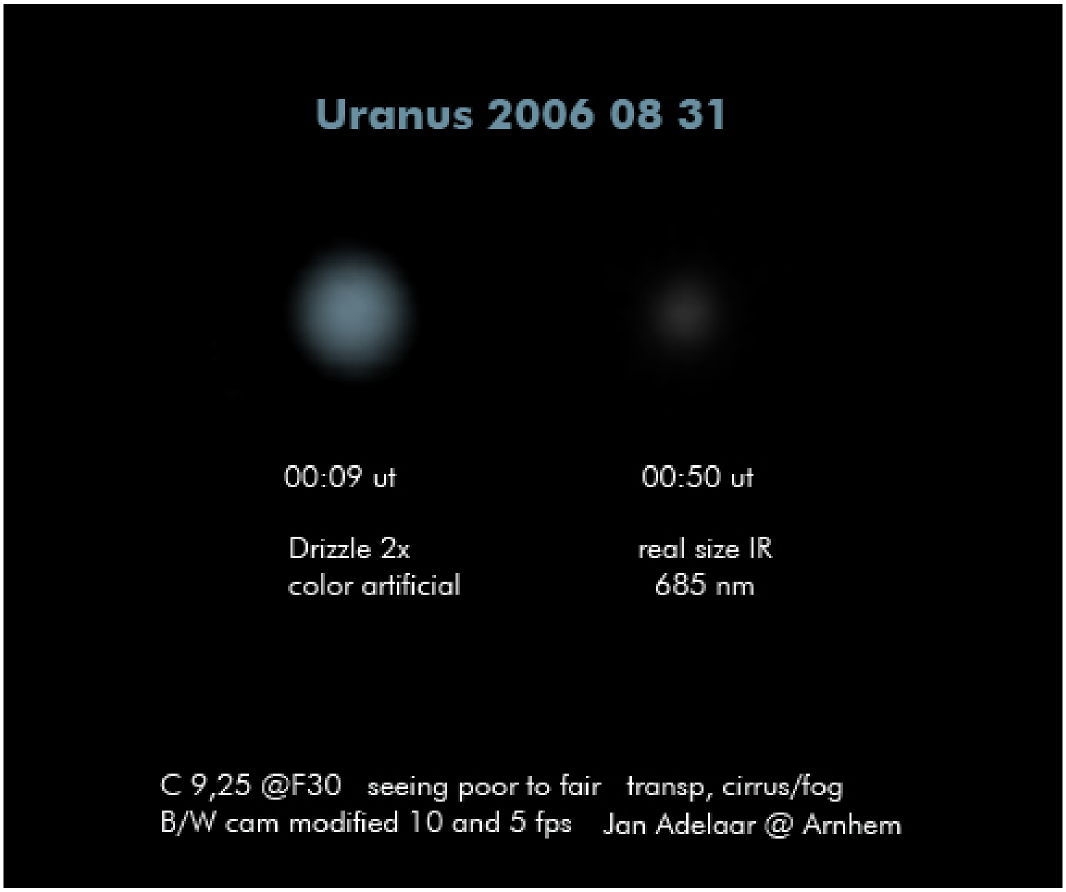
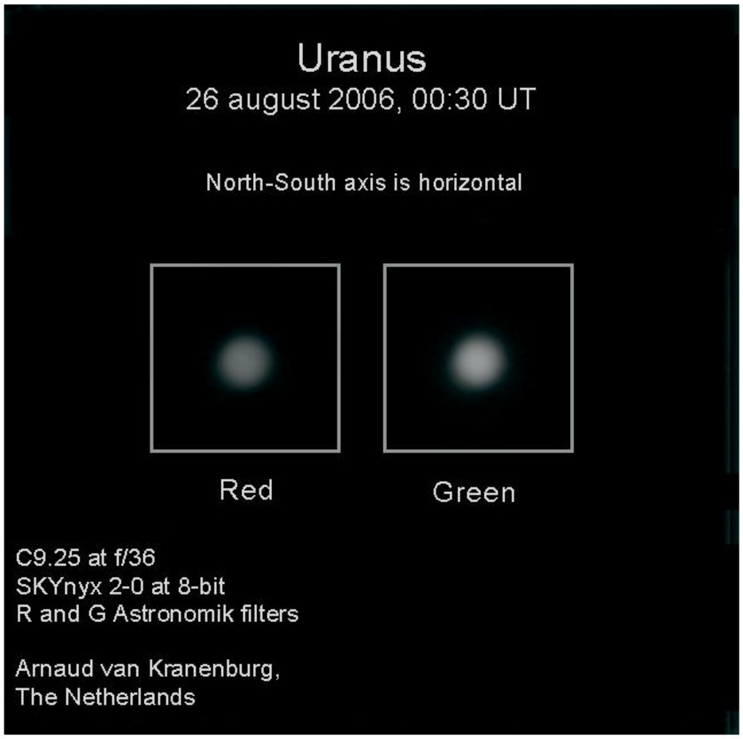


Fig. 14. Uranus with an IR filter

2.1.4 Arnaud van Kranenburg

Also this observer uses a Celestron C9.25 telescope. This telescope is equipped with a SKYnix camera and Astronomik filters. A tiny disk with no other details than rim darkening is observed.



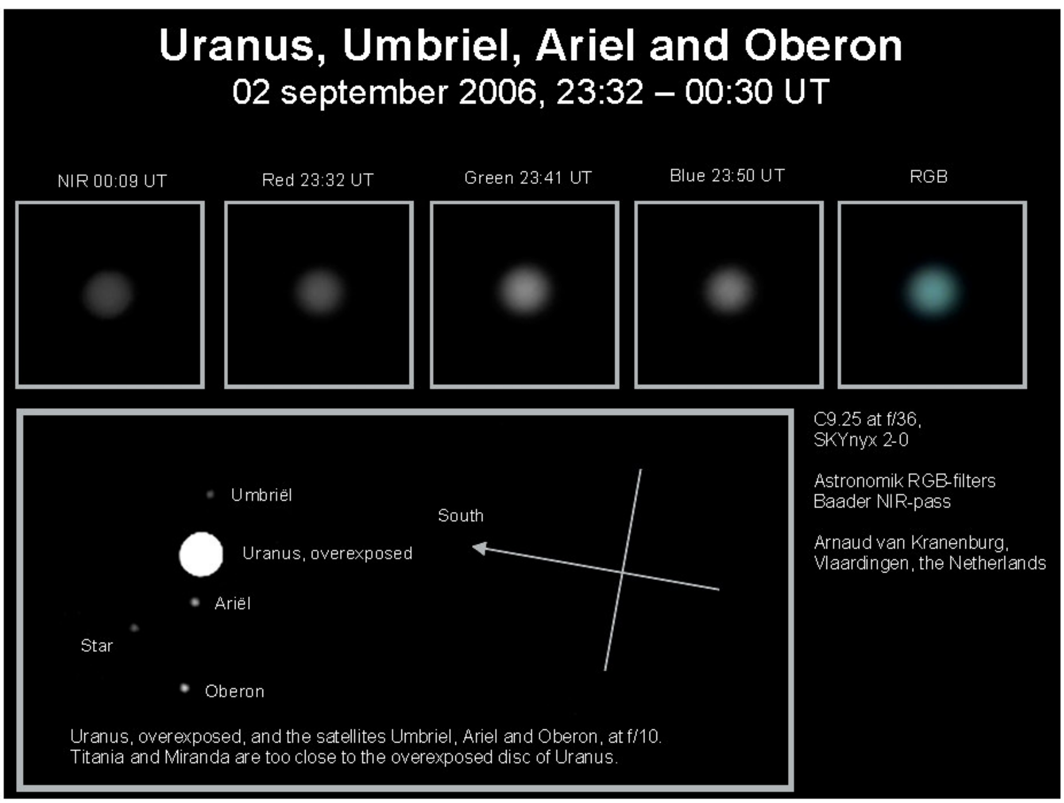


Fig. 15. Uranus with different colour filters

2.1.5 John Sussenbach

This observer uses a Celestron C11 Schmidt-Cassegrain telescope and an ATK2HS camera. The color images were made using Astronomik RGB filters. The Uranus disk shows no details except rim darkening(Fig. 16). Some images show weak brightening of the Southern hemisphere, but doubts about this phenomenon still remain.

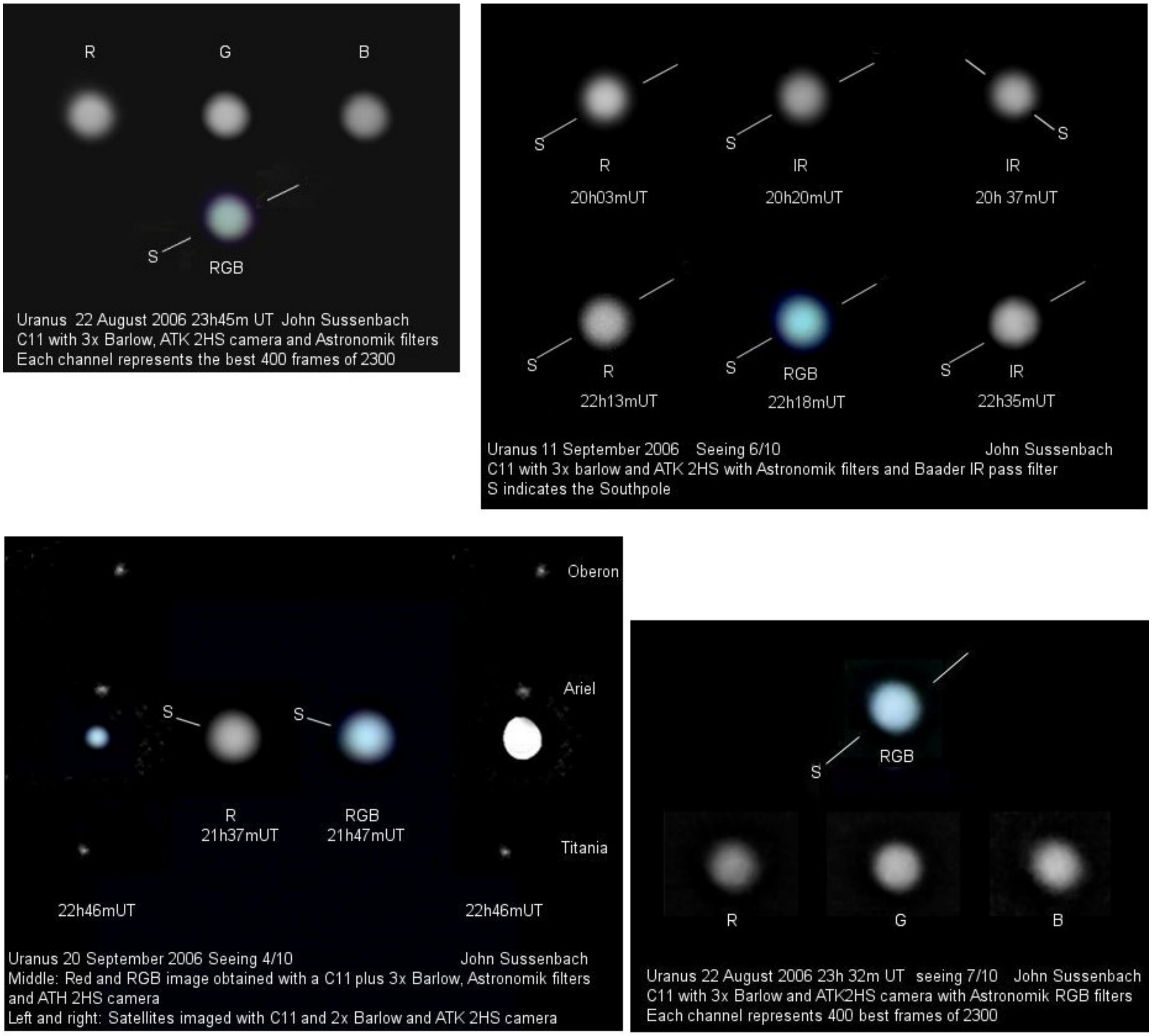


Fig. 16 Uranus imaged with Astronomik RGB filters

2.1.6 Ralf Vandebergh

This observer uses a 10 inch Newton telescope and an ATK 1HS camera. He also uses an RGB colour filter set. In his images light and dark spots are visible on the Uranus disk and also a bright spot at the South pole (Fig 17 and 18). In contrast to the images of the other observers Ralfs red channel images reveal a bright rim, which indicates extensive image processing. Unfortunately, no control experiments are reported (e.g. rotation of the camera or using time intervals) to exclude the possibility that these spots are the result of overprocessing. Without further information on the quality of collimation and the detailed description of the image processing technique it is impossible to evaluate the origin of these details.

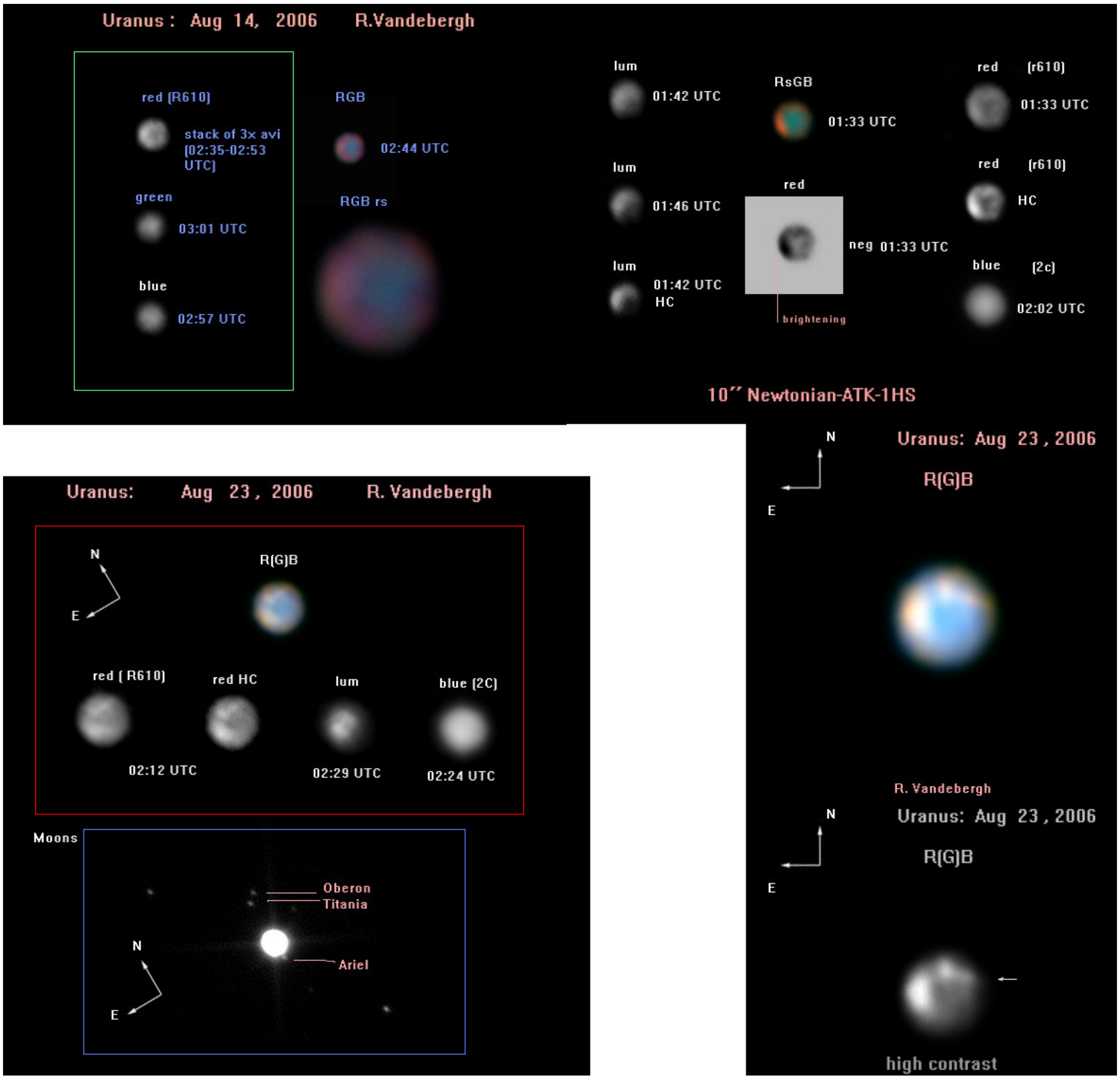


Fig. 17. Uranus in different colour channels (1)

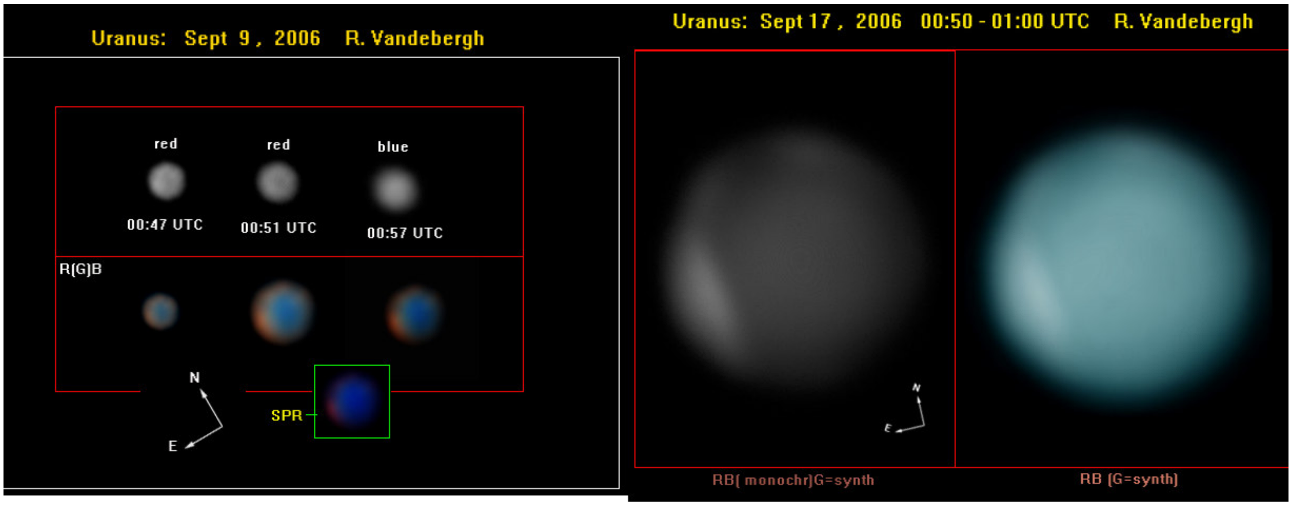
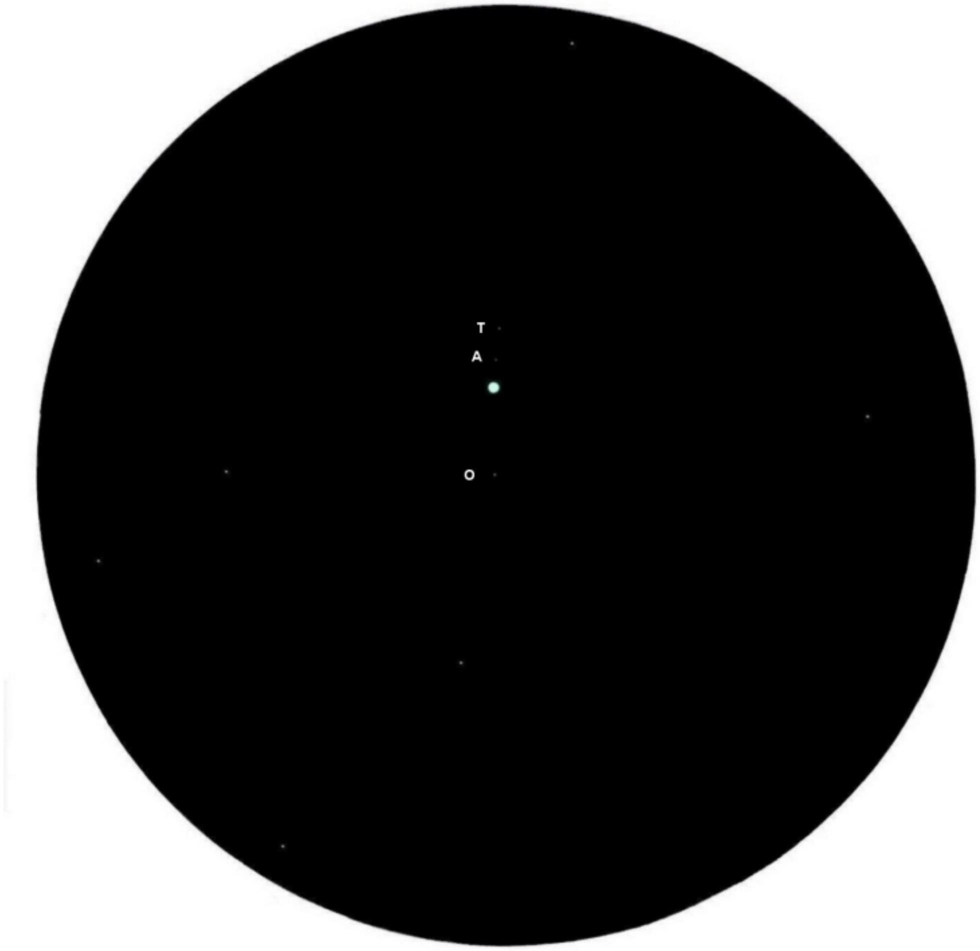


Fig. 18. Uranus in different colour channels (2)

2.1.7 Conrad van Ruissen

Conrad has observed Uranus visually with a 305 mm Newton telescope. Uranus has been drawn as a tiny blue disk without details (Fig. 19). However, three different satellites of Uranus could be detected..

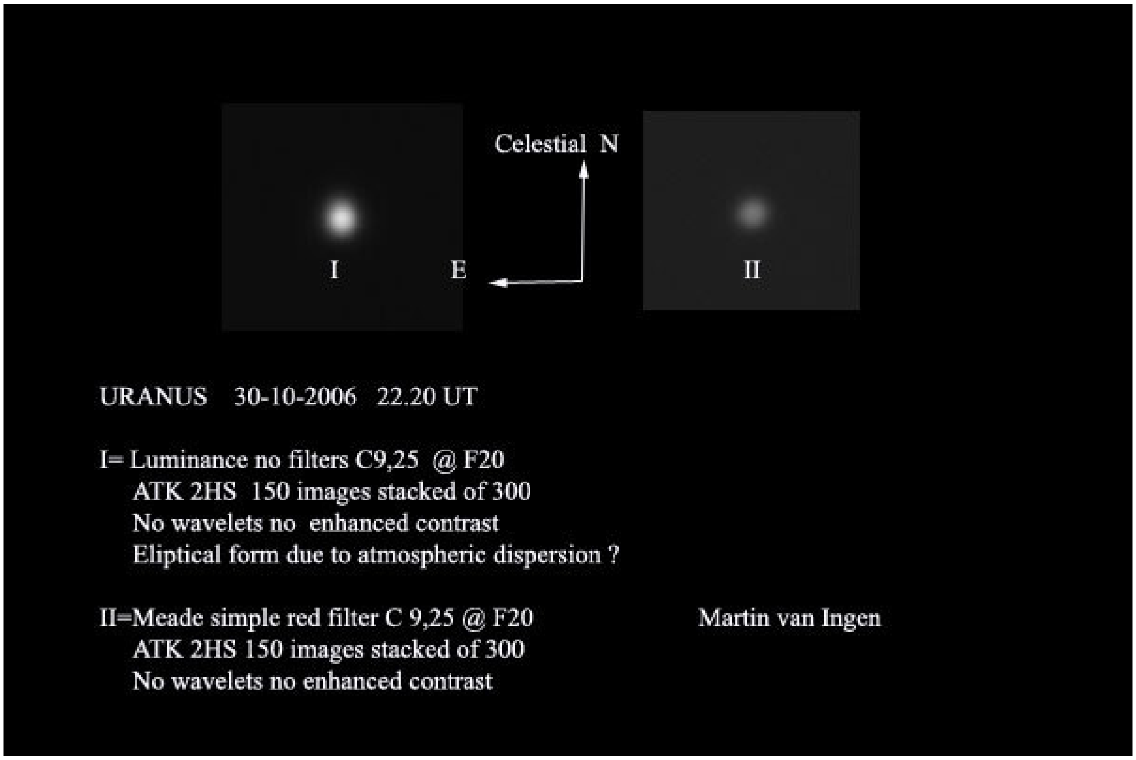


Uranus, 21-09-2006 om 02.00 uur MEZT, met 3 satellieten.
Verklaring: T = Titania, O = Oberon, A = Ariel.
Ariel is ten gevolge van de overstraling door Uranus zeer moeilijk te zien.
Telescoop: reflector D = 305 mm en F = 1524 mm.
Vergroting: 435 maal (oculair Vixen LV-W 3,5 mm). De tekening toont het gehele beeldveld van het oculair (9 boogminuten).
Seeing: 5 - 6 / 10.
Transparantie: 7 / 10.

Fig. 19. Drawing of Uranus with satellites

2.1.8 Martin van Ingen

This observer uses a C9.25 Schmidt-Cassegrain telescope and a ATK 2HS camera.
No details could be detected on the tiny disk of Uranus (Fig. 20). Several satellites were detected.



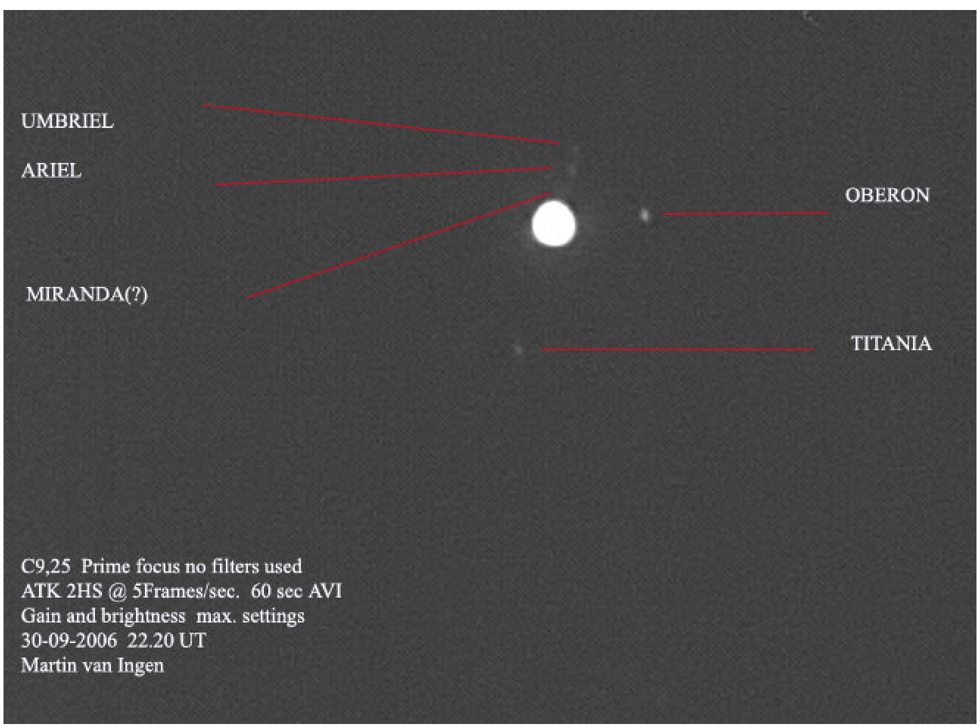


Fig. 20. Uranus with satellites

2.2 Control experiments

2.2.1 Rotation of the camera

In particular, to detect artefacts Willem Kivits has performed a number of control experiments. He has shown that using normal image processing techniques (slight unsharp masking and limited contrast enhancement) the Uranus disk is a pale blue disk. He demonstrated that employing multiple rounds of sharpening and contrast enhancement, a pattern of light and dark spots is fabricated. To evaluate the relevance of these spots he imaged Uranus with two different positions of the camera and used extensive image processing (Fig.21). The pattern of spots obtained with two different positions of the camera shows no relationship indicating that they are artefacts.

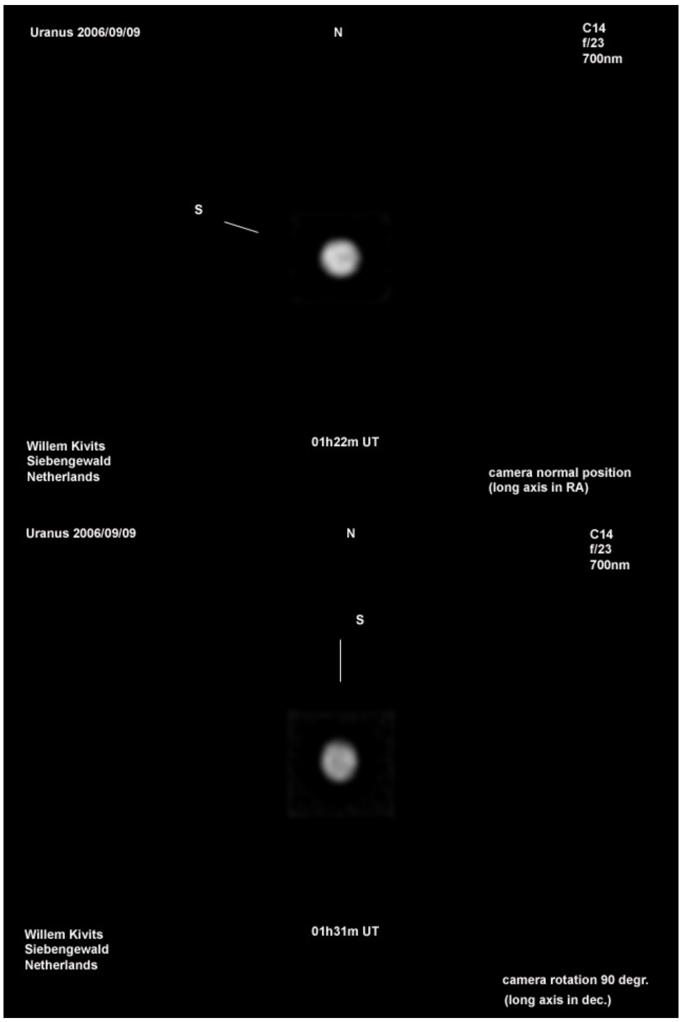


Fig. 21 Uranus imaged with two different positions of the camera

2.2.2 Rotation of the planet

An other control experiment is to image Uranus with a time interval of about 1 hour and to compare the position of the spots (Fig. 22), There is a certain degree of similarity in the patterns of spots and they seem to have moved Eastward. Unfortunately, in reality the planet rotates in the Western direction. This indicates again that the spots are most likely artefacts generated by the image processing procedure. From this perspective, it is obvious that proper evaluation of the spot patterns detected by Ralf Vandebergh (2.1.6) is only possible when this type of controls would have been available.

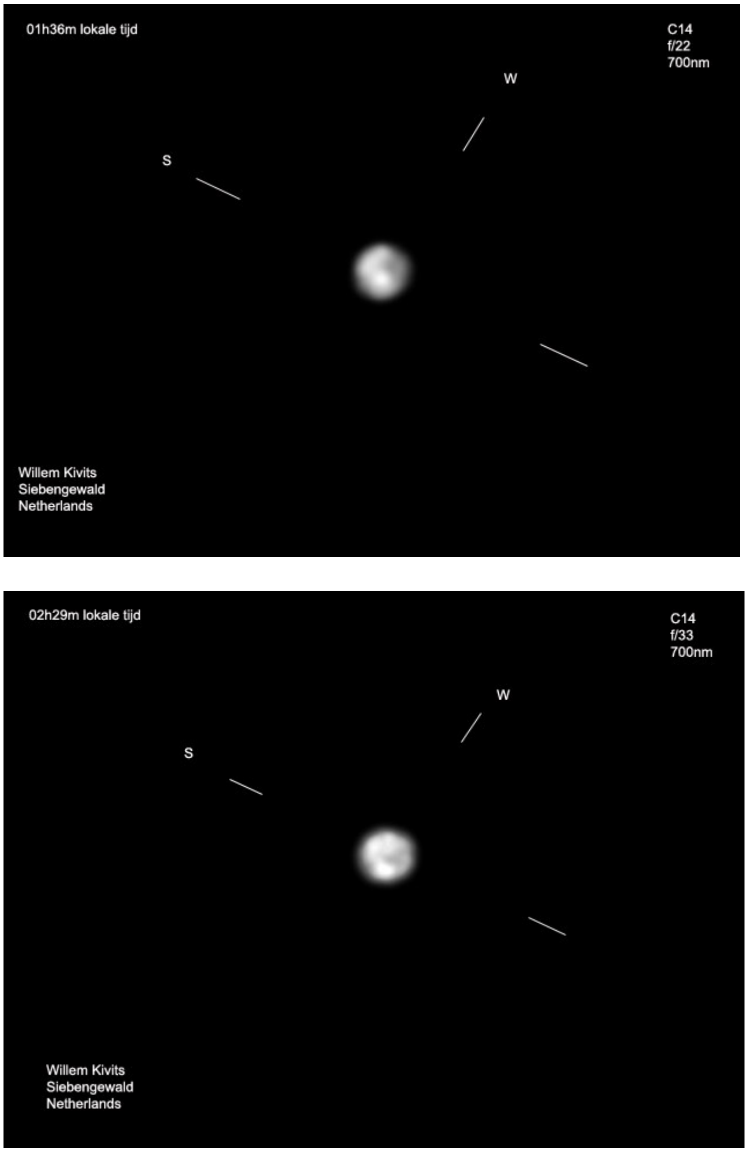


Fig. 22. Images of Uranus obtained with an interval of 53 minutes

2.2.3 Splitting the colour channels

Unfortunately, as shown above no other preliminary conclusion can be drawn: the detected spots are artefacts, probably generated by the image processing procedure. This raises the question how extensive processing can be recognized.. Here the *Adobe Photoshop* program or any other program, that allows splitting of an image in its R ,G and B channels, is helpful. In the case of extensive processing a bright rim appears in the planetary disk, whereas normally the disks shows a bright central section with rim darkening A good example is shown in Fig 23. The red channel has been processed to such an extent that only a bright ring is left.

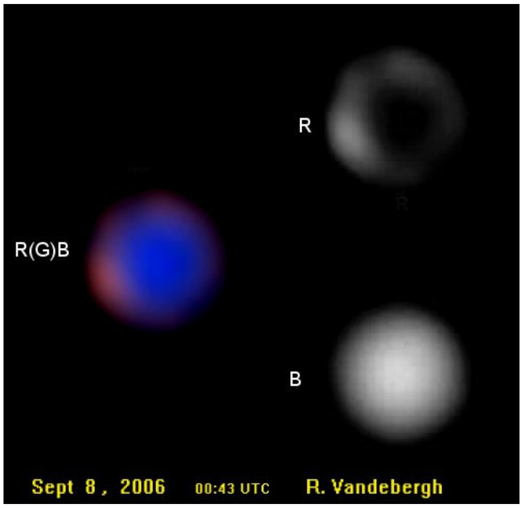


Fig. 23 Uranus image split in its red and blue channels

On the other hand, the blue channel shows a more natural appearance. Also on different sites on the Internet, such as the websites of ALPO (http://www.lpl.arizona.edu/~rhill/alpo/alpo_index.html) and JALPO (http://www.kk-system.co.jp/Alpo/Latest/Uranus.htm) images are presented that have been heavily processed as is revealed with *Adobe Photoshop*. Without proper control experiments it is impossible to establish the relevance of the details detected..

3. General discussion

3.1 General

Despite the fair observation conditions in The Netherlands Uranus was studied in August and September 2006 by a number of Dutch amateurs. Most observers used image processing procedures, that they employed previously to image Mars, Jupiter or Saturn with excellent results. Under similar conditions the planet Uranus exhibits as a faint pale blue disk with distinct rim darkening, but no other details or albedo differences have been detected.. The better the seeing, the sharper the image. In particular, the images of Richard Bosman and Willem Kivits are of high quality. Several observers have detected the larger satellites of Uranus. Very special is the visual observation of three satellites by Conrad van Ruissen Very interesting are the images of Willem Kivits obtained with Davin filters of 620, 727 and 905 nm. These are filters with transmission in the regions of the methane bands. Although no additional details have been observed sofar, it is certainly worthwhile to use them under better conditions.

3.2 Brightening of the South Polar Region

In some pictures (e.g. of Willem Kivits and John Sussenbach) the Southern hemisphere is somewhat brighter than the Northern hemisphere. On the JALPO site Robert Heffner and Paolo Lazzarotti have presented images with brightening of the South Polar region. Also Ralf Vandebergh has demonstrated brightening of the South pole, but his pictures demonstrate the signs of severe processing. It is not clear whether this brightening is real or an artefact of the processing procedure. In this respect it is noteworthy that even with the Hubble Space Telescope the brightening of the South pole is a very subtle phenomenon (see Fig. 24). There is some doubt whether the brightening of the Southern hemisphere as observed by some observers is the same feature as the brightening detected with the Hubble Space Telescope. With the latter telescope the region of brightening is much more restricted in size than what is observed by the amateurs. Interestingly, the polar brightening is much more distinct in Hubble pictures obtained with special infrared cameras and filters (1600 nm or higher). For the moment, pictures at these wavelengths are not yet within reach of amateurs.

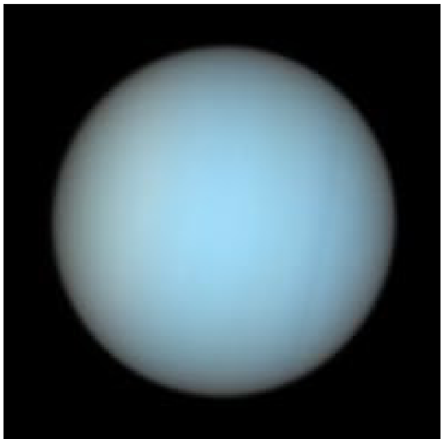
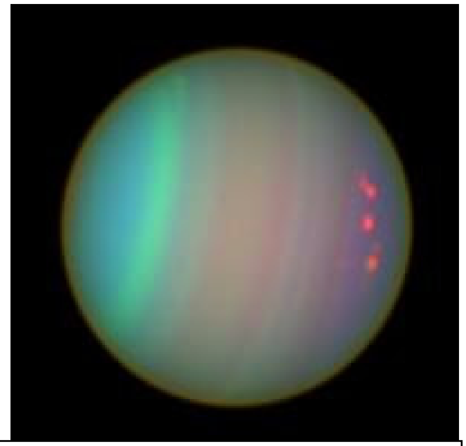
 

Fig. 24. Uranus in visible light (left) and in false colours (right). Pictures of the Hubble Space Telescope in August 2003

3.3 Albedo differences

Ralf Vandebergh reports albedo differences on the disk of Uranus, in particular in the red channel. In his pictures several bright spots are seen, very often with one of them located in the neighbourhood of the South pole. Analyse of these pictures reveals that considerable contrast enhancement and image sharpening has been applied. This is demonstrated by the fact that the red channel images show a bright rim, instead of rim darkening. Of course, sometimes extreme contrast enhancement is necessary to emphasise and exaggerate certain details, but certainly under these conditions control experiments are a must. Unfortunately, none of the previously mentioned control experiments have been reported, such as rotation of the camera, showing interval exposures and checks of the collimation. Therefore,unfortunately, it can not be established whether the presented details are genuine or not. The extensive degree of image processing and the fact that none of the other experienced observers could reproduce these results suggests that at least part of the spots are artefacts. Further reseach is required to settle this issue.

3.2 International observations

It is interesting to note that not only in the Netherlands the discussion about detection of details on Uranus by amateurs has started. Also on the international scene it is a matter of debate. During our campaign some of the working group members have had frequent contacts with observers from abroad such as Christophe Pellier, Paolo Lazzarotti and Dominique Dierick. Some of them have presented images on the sites of ALPO en JALPO, in which a brightening of the South pole has been detected, but more and more these observers themselves critically comment their own images. Here, with permission of the observes , a couple of comments are cited.

3.2.1 Christophe Pellier (France):

This observer has shown South Polar Band gives the following comment::

"I think the South brightening is true. The point is where you put the limit to interpretation. The other albedo details perceptible on these images can't be taken for granted and the images shouldn't be over-interpreted. The difference is while we've got professional evidences for the South Pole's albedo, we don't have for the other "details" visible here... just a question of being reasonable ! No one would ever believe details on an image of Jupiter or Mars processed like that (especially when we're doing 400x enlargements...), so why should it be different for Uranus? Personally, I can say that, without knowing the HST and Pic du Midi images from the last years, I would blame my personal work of 2004 for being completely unreal...

3.2.2 Paolo Lazarotti (Italy):
"Yes, the SPC is definitively an almost mission impossible to me, too. On yesterday I had my best opportunity to image the pea planet, I had some spell with good seeing so I pushed for the first time the exposure up to 3 seconds in unbinned mode!! I filled any bit out of 12 with a very low gain, I was able to record nonetheless an interesting number of sharp and neat raw frames. I used my trusty red filter by Edmund: if the SPC won't pop up here, I'll give it up!!"

3.2.3 Dominique Dierick (Belgium):
"Yesterday night the seeing was fair and sometimes even good. I spend two hours with collimation of the telescoop (Mewlon) with a 3x Barlow lens to get the diffraction rings as good as possible. There is still a little deviation, but the seeing showed flares in that direction. So, I am not 100% certain whether it is a little bit of imperfect collimation or due to seeing effects. However, it is a fact that the Mewlon produces razor-sharp images. After that I made exposures at the visual wavelengths, infrared and blue with the DMK camera. Carefully sharpening was performed with an electrical focuser on a nearby star, because sharpening on Uranus is very difficult. To exclude any form of artefacts I did not use a compression codec, so that I could work over the Firewire without any compression. All images were stacked with Registax and further processed with Adobe Photoshop. I could not detect any hint of detail and also no polar brightening. The only thing I dare to say is that there is rim darkening of the globe of Uranus and even that might be due to seeing effects. As I note how difficult this observation session was, how faint the planet is and consider the quality of the telescope and camera used, the more and more I am inclined to say that – if there is anything to see at all on Uranus, it is impossible to detect from our latitudes with smaller telescopes. The cause of observing details on the surface of Uranus is probably due to e.g. compression by the camera, camera artefacts, imperfect collimation or seeing flares. There are many options and I am afraid that we have reached the limits of observation. In summary, with the best intentions, it is impossible with my equipment to detect any detail on Uranus."

4. Conclusions

a. During this campaign a number of beautiful pictures of Uranus have been made showing a little blue disk without details. In some cases a brightness gradient from South to North is observed. Possibly, this is the previously reported South Polar Brightening, but this phenomenon requires further investigation. Until now to solid evidence for details on the surface of Uranus has been presented and, unfortunately, in the case that details are reported, no control data are available.

b. Very interesting are the pictures of Willem Kivits made with far red filters in the region of the methane absorption bands. It is definitely worthwhile to pursue and extend these studies at these wave lengths in the future, because it might be expected that methane clouds can be detected with these filters.

c. This campaign has demonstrated that it is absolutely necessary to perform control experiments in the case that details are detected on the surface of Uranus. It is recommended that image processing should be performed cautiously and extensive processing should be avoided.

Finally, I want to thank all observers that have contributed to this campaign. I am grateful for al the pictures and drawings that were made available to me. In the years to come Uranus will show improving conditions for observation and the last word is certainly not yet said..

Addendum 1. Protocol Uranus campaign 2006

Introduction

After my calll to participate in an Uranus campaign to investigate what amateurs can observe on the surface of this planet I received several positive responses. I herewith propose a number of rules we willl try to keep to make our results as reliable as possible and also reproducible for others. Therefore, a brief protocol has been designed. I propose that as much as possible the following information is provided with each image.

Technical informaton and weather conditions

1. Name, location
2. Telescope used, Barlow lenses or eyepiece projection, filters and type of camera
3. Effective focal length, exposure times, time over which the data were collected and the number of stacked frames
4. Weather conditions (seeing, transparency, cloudiness and wind)
5. Used image processing programs and roughly the details of the processing procedures (adaptation of brightness, contrast enhancement, unsharp masking).

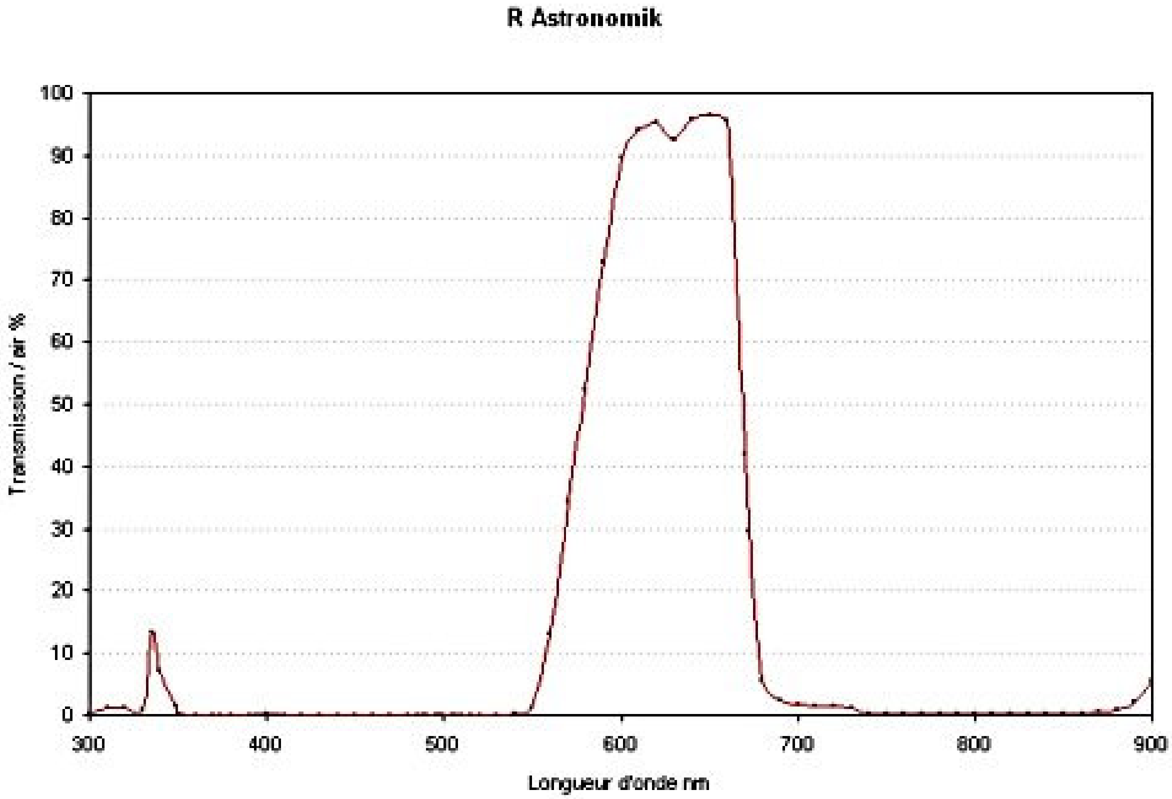
Protocol

1. *Number of frames*

As is well known for reliable images the signal/noise ratio should be as favourable as possible. . Processing of a limited number of frames, even of good quality, might lead to artefacts when the images are overprocessed. Although ATK camera's give better results than the Philips ToUcam still this needs special attention. A number of at least 100-150 frames seems to be the minimum for an ATK camera or another camera with a B/W chip. For a Toucam exposure 800-1000 frames is a better number. Mention in any case the number of frames used for stacking.
In order to confirm the existence of details it is important to demonstrate that they rotate with the planet.. Uranus rotates once in 17 hours and 14 minutes. So, it is advised to make pictures with an interval of a few hours. Details in the tropical and moderate zones should have migrated in that period.

2. *Filters*

Imaging of Uranus can be improved by using different types of filters. It is important to report the brand and type of the filters and their properties. For colour images the Philips ToUcam camera and the ATK series are very useful. The black and white ATK cameras are used in combination with RGB filters. Very informative are the pictures made with red filters, because they might cover the wave lengths of the methane bands. These bands are located around 620, 727 and 890 nm. In particular, the R filter of Astronomik with its peak at 620 nm and a halve width of 70 nm looks promising to detect South Polar Brightening (see the transmission spectrum that was determined by Philippe Rousselle (http://astrosurf.com/spectrohelio/filtres.htm#Rastronomik)).
Of course there are specific methane filters, but these are relatively expensive. Davin seems to be a good and not to expensive brand . Note that certain filters might require relatively long exposure times ranging from 1 to 10 seconds. Reaching a reasonable number of frames might take quite long.



3. Orientation and atmospheric conditions

Due to the special orientation of the polar axis of Uranus and the absence of surface details it is not easy to establish the orientation of the planet. An exposure of Uranus and its satellites will yield a reliable determination of the polar axis. Further, the shape of the images of the satellites gives a good impression of the seeing conditions

4. Image processing

Most observers will apply the program *Registax* to select frames, put them in register and stack. Several observers use a pre-selection with the program *K3CCDTools* and take the best 35% for processing with *Registax*. After stacking in most cases *Photoshop* and *Neat Image* are used. Everybody has of course his favourite image processing procedure. Therefore, it is informative to report the general steps and settings of the processing procedure. For *Registax* it might be useful to report the wavelet settings.