Bright features on Neptune in 2015

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Introduction

Since the demotion of Pluto to the status of a dwarf planet, Neptune is the outermost planet in the Solar System. The discovery history of this planet was, and remains, a very special story. It started with the mathematical analysis by Urbain Le Verrier of deviations from predictions of the celestial course of Uranus at the Paris Observatory in the first half of the 19th century (Figure 1). He carried out calculations in order to identify an unknown planet, which was thought to cause these disturbances. On 1846 September 23 these calculations led to the discovery of the planet Neptune by Galle & d'Arrest at the Berlin Observatory, about one degree from the position predicted by Le Verrier. Later it turned out that at the same time in the UK John Adams had also calculated the position of the unknown planet close to Neptune's actual position.

For amateurs Neptune is a difficult object to study because of its small diameter of about 2.4 arcseconds. Even at the highest magnifications Neptune remains a tiny blueish disk with no detail. You need a telescope with a large aperture to visually observe the disk of the planet, but detection of its large satellite Triton is relatively easy in medium-sized telescopes due to its brightness at magnitude +13.5. Also for astrophotographers recording Neptune and Triton is a challenge (Figure 2). In general, no details on Neptune are visible, except that the southern hemisphere is sometimes slightly brighter than the northern, as several amateurs have shown.

Figure 2. Neptune and Triton, 2009 Sep 23. North is up. *(J. Sussenbach)*. C11 at f/20, DMK21AU04 camera & RGB filters.

The visit of *Voyager 2* in 1989 brought a major breakthrough in our understanding of Neptune. The spacecraft discovered dark and bright storms on the planet, which are sometimes very stable. It also became clear that there are very rapid atmospheric motions. In the equatorial zone atmospheric streams rage continuously at a speed of 1,200 km/h or more and the rotation period decreases towards the pole.

On 2015 July 13 Ricardo Hueso Alonso and colleagues (Escuela Técnica Superior de Ingeniería in Bilbao, Spain) discovered a bright spot on Neptune at latitude –41° with the 2.2 metre telescope of the Calar Alto Observatory.[1,2] Later, some other bright spots were also detected.[3] He asked amateur astronomers around the globe whether they could detect these features with their telescopes. There had been some amateur observations of features on Neptune in 2013–2014, but the number of observations was few.[1,2] Although the atmosphere in The Netherlands is often very turbulent two of us (Kivits and Sussenbach) accepted the challenge to detect the feature at latitude –41°.

Figure 1. Statue of Urbain Le Verrier in front of the Observatoire de Paris.

Equipment and image processing

Willem Kivits lived in the southern part of the Netherlands and used a 35cm C14 Schmidt–Cassegrain telescope as well as a 50cm Newtonian. John Sussenbach lives in the centre of the Netherlands and observes with a C14 telescope. By combining our data we were able to compare and refine our observations. In general, these telescopes were used at f/22.

Since the initial discovery images of bright spots on Neptune were obtained using infrared (IR) filters we also used filters in the near-infrared (NIR) range (Baader 685nm long pass filters). For the recording instruments we started with monochromic DMK21AU04 and QHY5LII cameras, but later we used the relatively new ZWO ASI224MC camera. This colour camera has remarkably good NIR sensitivity (Figure 3).

Above 800nm the camera has the same sensitivity in the red, green and blue channels, and behaves as a monochrome camera. Most of our images were obtained using 610 and 685nm long pass filters. AVIs were recorded at a frame rate of 20 frames per second.

The AVIs were processed using centring of the images by Planetary Imaging PreProcessor software (PIPP).[5] For quality selection

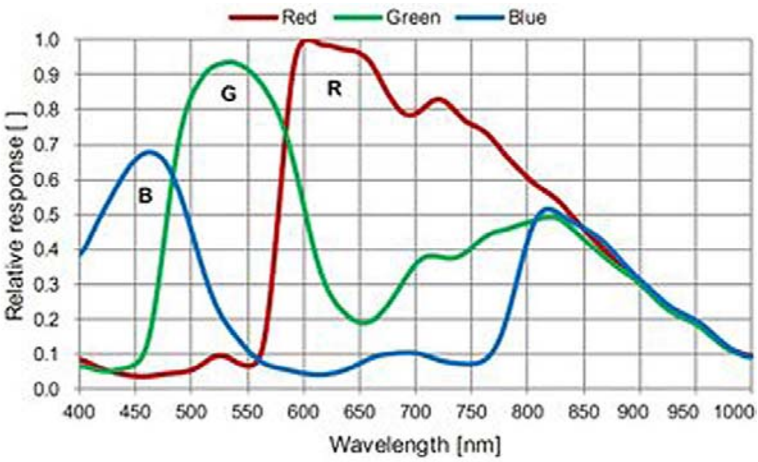

Figure 3. Spectral sensitivity of an ASI224MC camera (ZWO) according to the manufacturer.[4]

and stacking of frames, *Autostakkert2!*[6] and *Registax 6.1*[7] were used, and the final processing was performed with Adobe *Photoshop CS2*.

Results

Detection of bright spots

The first opportunity to detect the brightest feature discovered by Hueso and colleagues was 2015 July 20. Processing of the AVIs captured during that night yielded images which show a spot in the vicinity of the predicted position at the central meridian. Comparison of the images of 1:11UT and 1:59UT shows that the feature moves with the planet's rotation (Figure 4).

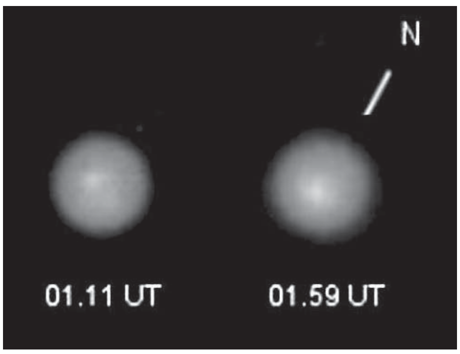

Figure 4. Neptune on 2015 July 20. *(J. Sussenbach)*. CM 265°.1 at 01.11 UT and 283°.0 at 01.59UT. C14 f/22, QHY5LII camera and 610nm red long-pass filter. North is up.

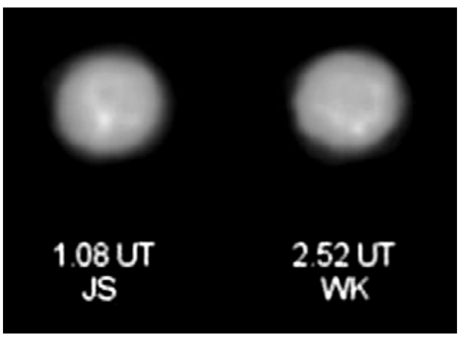

Figure 5. Neptune on 2015 August 1. North is up. Combination of images of J. Sussenbach & W. Kivits. CM 220°.4 at 1.08UT and 259°.1 at 2.52UT. C14 f/22, QH5LII camera & Red 610nm long-pass filter.

In the weeks and months that followed the bright spot proved to be very stable. This spot was now renamed Spot A.[3] On 2015 August 1 Spot A was captured by both of us, albeit at different times. Sussenbach captured the spot around 1:08UT and Kivits at 2:52UT (Figure 5). The rotation of the bright spot is clearly visible.

The drift rate of Spot A located at latitude –41°[3] was fairly constant and it remained visible through September and into October. A second feature, Spot B, at latitude +20° also became visible in September[3] and is visible in the two images of Neptune on 2015 Sep 10 depicted in Figure 6.

Sussenbach also managed to detect both Spot A and Spot B on 2015 Oct 11 (Figure 7). As Neptune was migrating to the west the observing conditions at Sussenbach's location were getting worse, so it became increasingly difficult to detect the spots from his location.

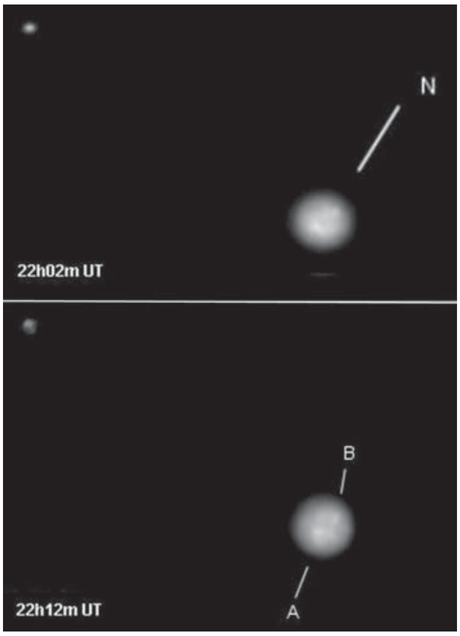

Figure 6. Neptune on 2015 Sep 10. Spot A and Spot B are visible *(W. Kivits)*. CM 181°.5 at 22.02UT and 185°.2 at 22.12 UT. 50cm Newtonian telescope, ASI224MC camera.

Drift of bright Spot A

The coordinates of the bright features on Neptune's disk were measured by Delcroix using the program *WinJUPOS*.[8] Two sets of eight images by Kivits and Sussenbach, respectively, were used to establish the drift of spot A.

To determine the orientation of the planet we also visualised the position of Triton. In version 10.2.2 of *WinJUPOS* Grischa Hahn and coworkers have included predictions of the positions of this moon. Applying this position and the position of the centre of the Neptunian disk, each image with spots could be matched with the *WinJUPOS* simulation. Subsequently, the position of the spots could be determined.

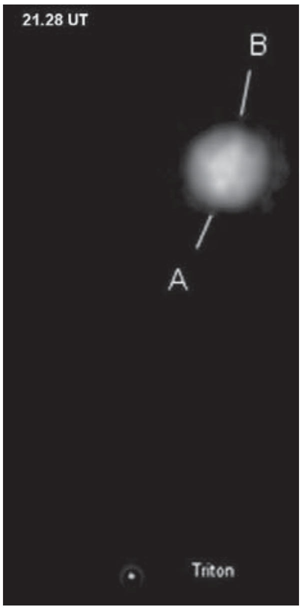

Figure 7. Neptune on 2015 Oct 11. Spot A & Spot B *(J. Sussenbach)*. North is up. CM 234°.6. C14 f/22, ASI224MC camera & red 610nm long-pass filter.

Since the image scale of Neptune is rather small, the standard deviation of the measured coordinates is ±5°. The resulting coordinates of Spot A over time are presented in Figure 8. From this graph the drift rate of the spots could be determined. Kivits' data yielded a drift of 23.7°/day and Sussenbach's a value of 24.1°/day. Our combined data yielded a drift of 24.0°/day. This fits reasonably well with the drift of 24.27°/day reported by Hueso *et al.*[1] using a combination of 90 measurements obtained with amateur telescopes and 9 with professional telescopes. From these data they could also derive a longitudinal oscillation of Spot A reported by Hueso *et al.*[1,2] However, our data are insufficient to detect such an oscillation.

The data of Spot B were very sparse. For that reason no drift rate was established for this spot.

Spectral properties of the features

The outer atmosphere of Neptune contains different components including methane. When we use an ASI224MC camera in combination with a Baader red long-pass filter (>610nm) we capture that

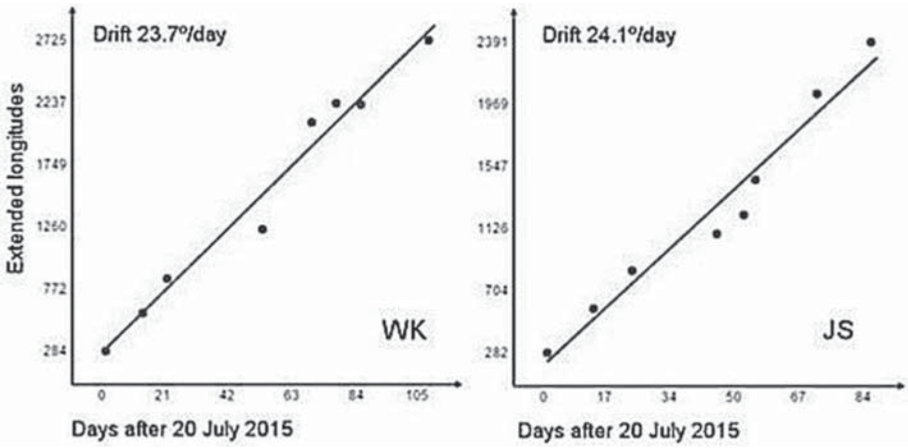

Figure 8. Drift of Spot A measured in images of W. Kivits (WK) & J. Sussenbach (JS) respectively.

part of the reflectance spectrum of Neptune that covers the methane absorption bands at 619, 727, 862 and 889nm (see Figure 3). The deeper the sunlight penetrates into the Neptunian atmosphere the more light can be absorbed by methane. When high altitude clouds are present in the atmosphere, they will appear as bright spots, because the reflected sunlight does not pass through a thick layer of methane-containing atmosphere.

To study the spectral properties of the bright features we captured an image of Neptune with an ASI224MC camera plus red long-pass filter. Subsequently the image was split into its red, green and blue channels (Figure 9). The brightest channel is the red channel and the blue channel is the faintest. This is in agreement with the relative spectral sensitivity of the camera in the three channels as indicated in Figure 3. Interestingly, spot A is visible in all three channels, but best in the blue channel.

Obviously, the red channel contains a lot of background signal outside the methane absorption bands which hampers the detection of spot A. Although in the blue channel the image is rather grainy due to less signal being transmitted, spot A can be detected the best in this channel. This is due to the fact that the 610nm red long-pass filter in combination with the blue channel, acts rather like a 780nm long-pass filter, letting the deepest methane absorption band (889nm) signal pass. Along with less background signal, this leads to better contrast for spot A, although overall a smaller signal is obtained.

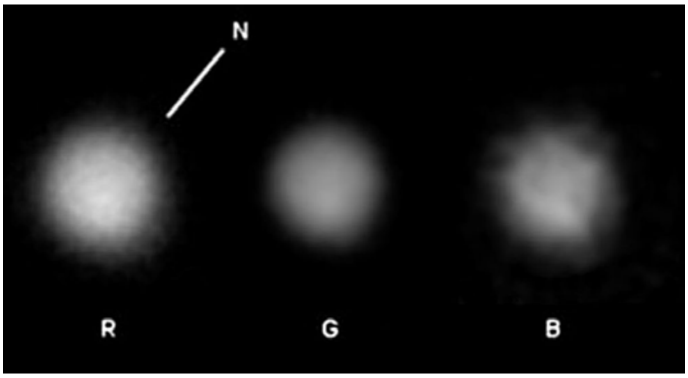

Figure 9. Red, green and blue channels of Neptune on 2015 Aug 10 at 23.35 UT with spot A. North is up. CM 149°.4. C14 f/28, ASI224MC camera & Baader 610nm red long-pass filter. *(J. Sussenbach).* Channels were separated in Adobe Photoshop CS2.

Concluding remarks

The above observations show that with current amateur telescopes and digital cameras, bright features on Neptune can be detected even from the Netherlands. The good sensitivity in the infrared of the ASI224MC camera makes it a valuable tool to capture these phenomena. It is likely that these spots indicate the presence of heavy storms on this planet.

A particular aspect of the observation of these features is that there is great interest from the professional world in amateur observations. The problem that professionals have is that they have limited access to large telescopes and therefore cannot easily carry out long, and frequent, observing runs with these instruments. Amateurs always have access to their own telescopes and if it is cloudy at one location, it is likely that it is clear at another location, so there is continuity in the observations.

We trust that in the future the number of pro-am collaborations in planatery imaging will increase, which in turn will stimulate amateurs to improve the scientific quality of their observations.

Finally, W. Kivits sadly passed away on 2016 February 23. This paper is a tribute to him and his never-ending perseverance to seek the limits of amateur astronomy.

Acknowledgment

We gratefully acknowledge the support of Dr Ricardo Hueso Alonso (Escuela Técnica Superior de Ingeniería Bilbao (Spain)), who after discovering spot A on Neptune on 2016 July 13 immediately informed amateur astronomers about this finding and stimulated them to detect and to continue observing the development of this bright spot. We thank him for his assistance and instructions.

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7 **http://www.astronomie.be/registax/**
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