Mars Edge-Rind: Methods of Mitigation

Martin Lewis

This article extends the discussion of this subject in the paper in the 2020 October BAA Journal.

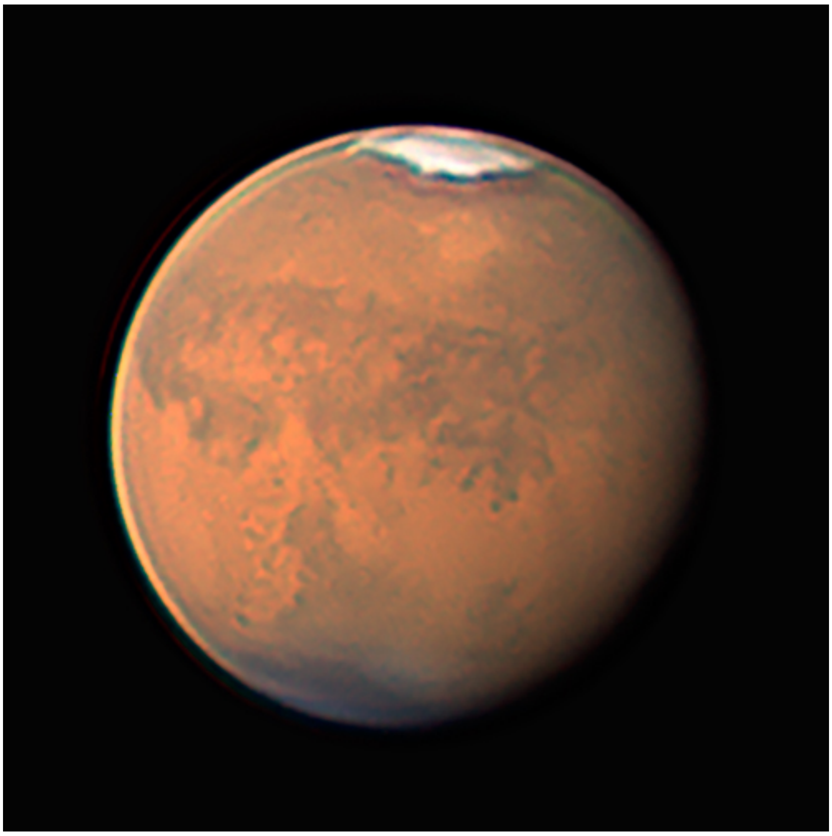

Figure 1 Edge-ring artefact on left-hand edge Mars on 2018 Aug 29 at 21.3" diameter, Imaged by C. Foster, S. Africa, with a 355mm SCT

Influencing Factors

The list below from the main Journal article, summarises all the factors believed to influence both the width and the severity of the edge-rind.

Width factors

Angular width (in radians from limb to middle of dark arc) = $0.6 \times 2.44\lambda/D$. Hence the factors affecting width are:

– λ, wavelength (width proportional to wavelength, so wider with longer wavelengths);

– D, telescope aperture (width inversely proportional to aperture, so wider with smaller apertures).

General severity factors

– *Secondary size*: edge-rind worse as this increases as percentage of total aperture;

– *Spherical aberration*: edge-rind worse if optics are more affected by spherical aberration;

– *Brightness distribution*: edge-rind worse if brightest part of planet is at the sharp limb rather than the middle;

– *Degree of wavelet processing or unsharp masking*: edge-rind more visible if a higher amount of processing is used;

– *Seeing in general*: edge-rind worse in good seeing as it is seen as 'real' detail by *Autostakkert!/Registax.*

Local severity factors

– *Miscollimation*: can either make the effect better or worse, depending on which side the edge-rind is on relative to miscollimation direction;

– *Astigmatism*: thought to impact uniformity of edge-rind;

– *Pinched optics*: thought to impact uniformity of edge-rind;

– *Dark albedo features* close to the edge of the planet can accentuate the dark arc.

Techniques to reduce edge-rind visibility

Reducing edge-rind in the original data

As briefly summarised above and expanded in the main Journal article, a number of aspects potentially under the imager's control will influence the severity of the edge-rind present in the raw data. These include telescope aperture, secondary size, imaging wavelength and the presence of optical aberrations. For many imagers, however, such aspects are actually difficult to change and it should be considered whether there are other techniques that might be easier to alter which will help in reducing the edge-rind in the recorded data.

The original article discussed the idea of purposely misaligning a telescope to produce an asymmetric Airy pattern that may boost the diffraction pattern on one side and reduce it on the other side. If done with the right orientation and magnitude, then on one side of the planet the internal dark arc may be reduced at the expense of brighter secondary ringing effects outside the limb. On the other side of the planet the miscollimation will make any dark arc worse (and extra bright ringing better) but as long as you are away from opposition and the terminator has crept around the edge here, the much softer edge will mean diffraction effect will be almost entirely absent and there will no impact of the miscollimation.

The miscollimation method may hold some promise, as illustrated in Figure 3 below, but could result in deterioration in image quality and loss of detail in the main planetary disc.

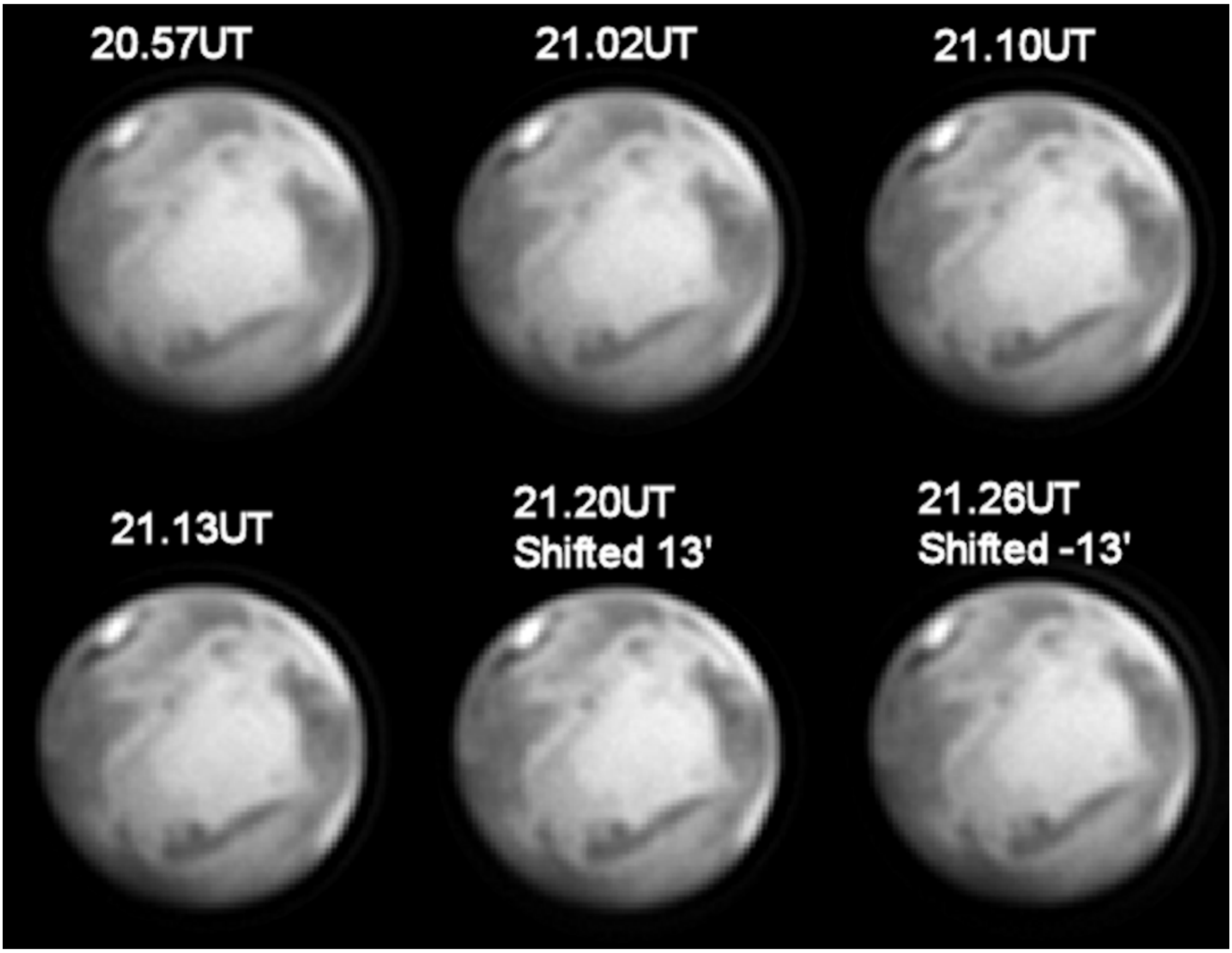

Figure 3. Mars imaged in fairly stable conditions in red light, exploring the impact of purposely miscollimating the telescope – tilting the primary by 6.5′ to move the sweet spot by 13′ from the centre of the field. The results might suggest the edge-rind at the two o'clock position is worse with the collimation sweet spot shifted by +13′, but better when shifted –13′. 2012 Mar 29, 222mm Newtonian.

Another method that may help with the issue is occasionally discussed in telescope forums, but backed up by a relatively small amount of empirical evidence. The technique uses a gauze, graded apodising mask to effectively soften the edges of the telescope aperture. Use of such an apodising mask should soften and spread out the Airy pattern, reducing contrast between bright and dark rings and so reduce the edge-rind effect. Experimentation by planetary imager Simon Kidd on Mars images in early 2019 showed little benefit in the use of such a mask with a C14 telescope and he concluded that the edge-rind might have actually been made worse. He speculated that the mask effectively reduced the aperture and made the secondary diameter larger, offsetting any benefits due to the softening of the edge of the aperture. His home-made apodising mask is shown in figure 4.

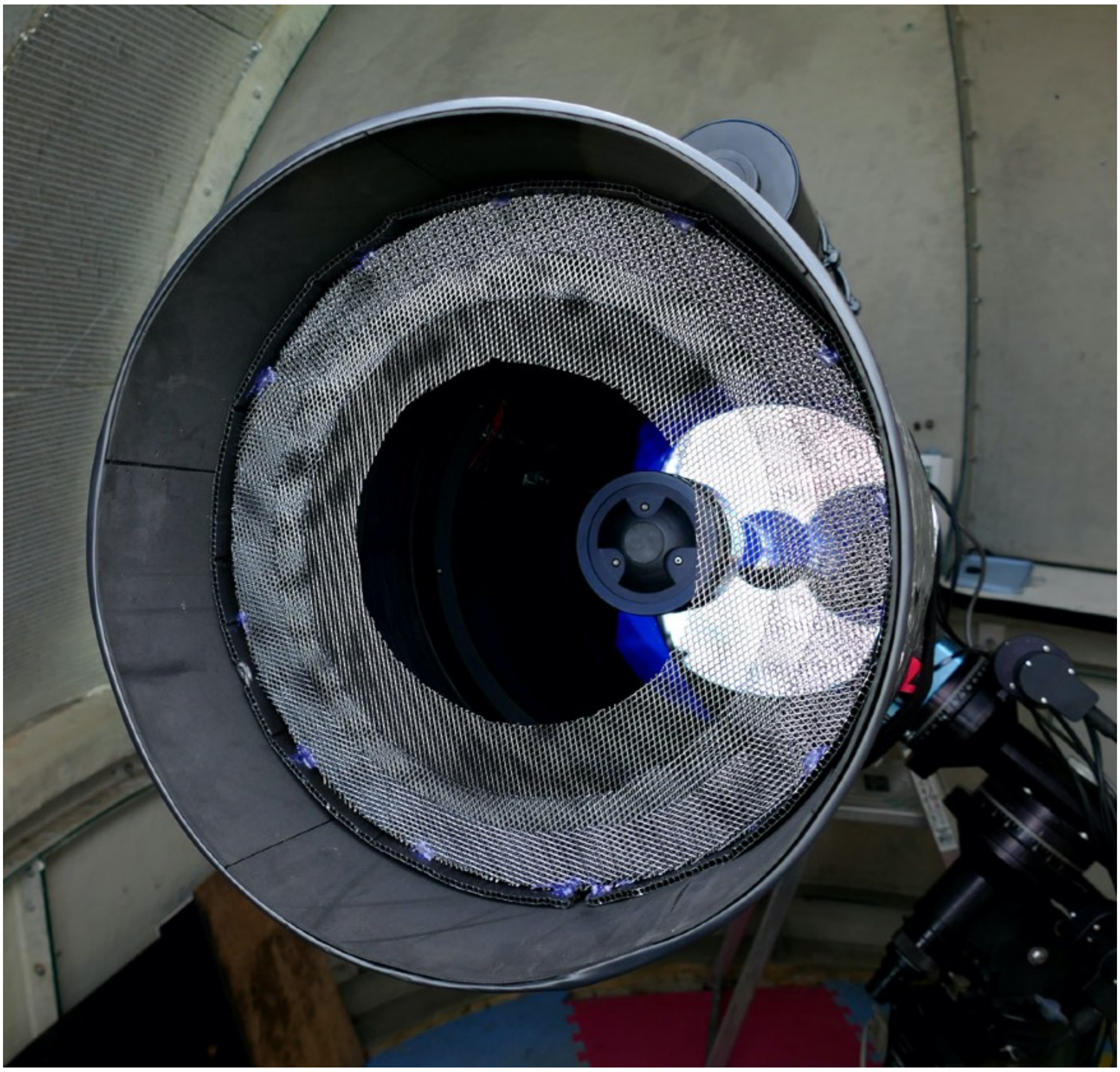

Figure 4. Home-made apodising mask (image courtesy of S.Kidd)

Experienced visual observer David Gray, on the other hand, finds some benefit from the use of such a mask to make observations for mid-scale seeing. It seems that more experimentation is needed in different seeing conditions to check if the same seeing dependent benefit holds with imaging.

Techniques to reduce edge-rind in the final image

The simplest approach in dealing with edge-rind is to leave it in place, letting it stand as a tacitly acknowledged artefact. If this is felt to be unacceptable, however, a number of techniques exist which can be used to try to remove it.

Edge retouching

A conceptually simple method is to retouch the dark arc in *Photoshop* using the clone tool – sampling pixels from the adjacent unaffected area and using these to paint over the dark arc. Although this is in principle a simple method, great skill is required to wipe out the edge-rind without creating an even more visually disturbing feature. One also risks introducing personal bias and creating local features where none existed before.

Dual-process method

Easier to accomplish and less prone to personal bias, the dual-process method involves first creating two images with different levels of processing. One image is processed as normal to maximise detail in the centre of the planet, whilst a second is more softly processed – showing less detail but also less edge-rind. In Photoshop, the more detailed image is then placed in a layer above the softer image and the two are aligned. The reduction in edge rind is achieved by erasing away the edges of the sharper disc, to reveal the edges of the more softly processed disc in the layer below that shows less rind. A feathered circular selection tool can be used to generate an arc-shaped selection area which covers the whole affected edge. This allows one to erase the offending area in one go. The softer bottom layer can then be adjusted to show through at an identical brightness to almost perfectly match the surrounding area on the top layer.

Simon Kidd has been using this technique to some considerable success on Mercury images and the method is shown below in figure 5.

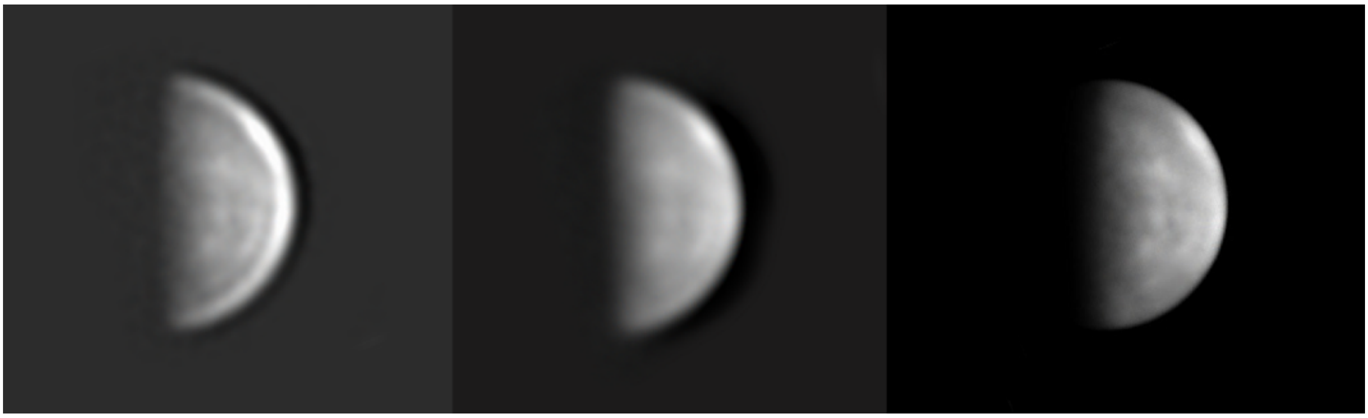

Figure 5. Mercury (L) with standard processing showing details on the disc but bad edge-rind; Middle- processed more gently for the edge details; Right- the two different regions combined to show both disc and edge details (Images courtesy of S.Kidd)

Spin blur masking

The author has developed a method that uses the planet itself as its own radial mask to reduce the severity of the rind. Therefore, if the edge-rind is worse, the technique acts more strongly to decrease the brightness of that rind. Local intervention or decisions on where to apply a correction are not needed, as the method automatically chooses the local degree of correction itself. It works best with Mercury, where the edge-rind is even along the edge. Figure 6 illustrates the method, which is achieved in an image editing program like *Photoshop* or *PaintShop pro*.

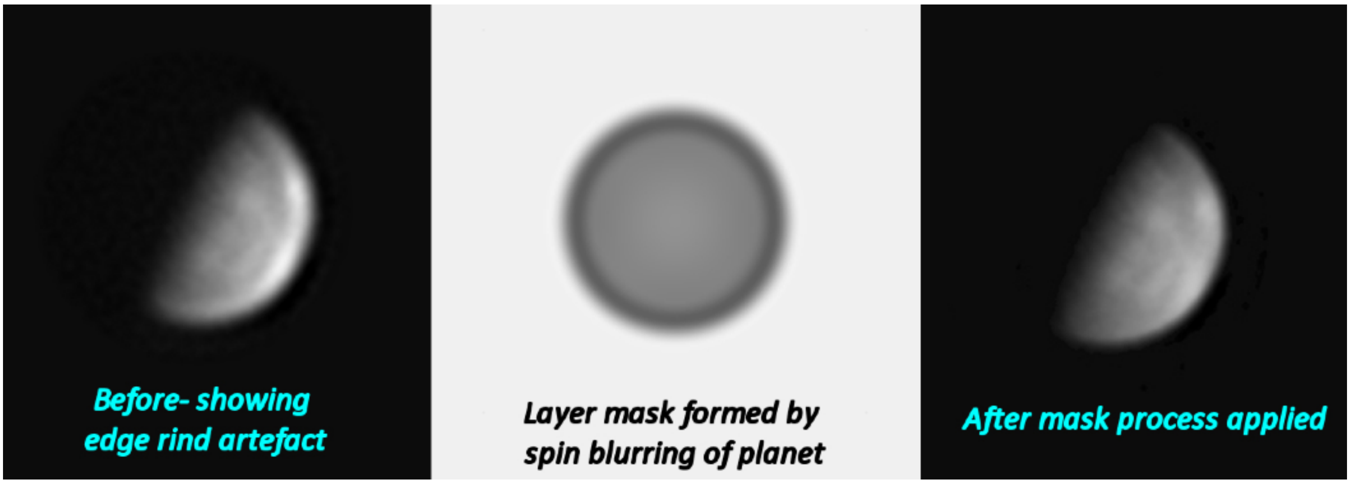

Figure 6. Spin blur masking technique to suppress edge rind on Mercury 24th Feb 2019

The method involves a number of steps whose main ones are detailed below:

- Start with edge-rind affected image of Mercury

- Use the *Radial Blur* tool at max strength and max rotation to make a spin blurred version of the image- alter the position of the centre of rotation to ensure centre of rotation of the spin matches the exact centre of the planet - see figure 7. When correctly chosen the spun image will have the same diameter as the original planet.

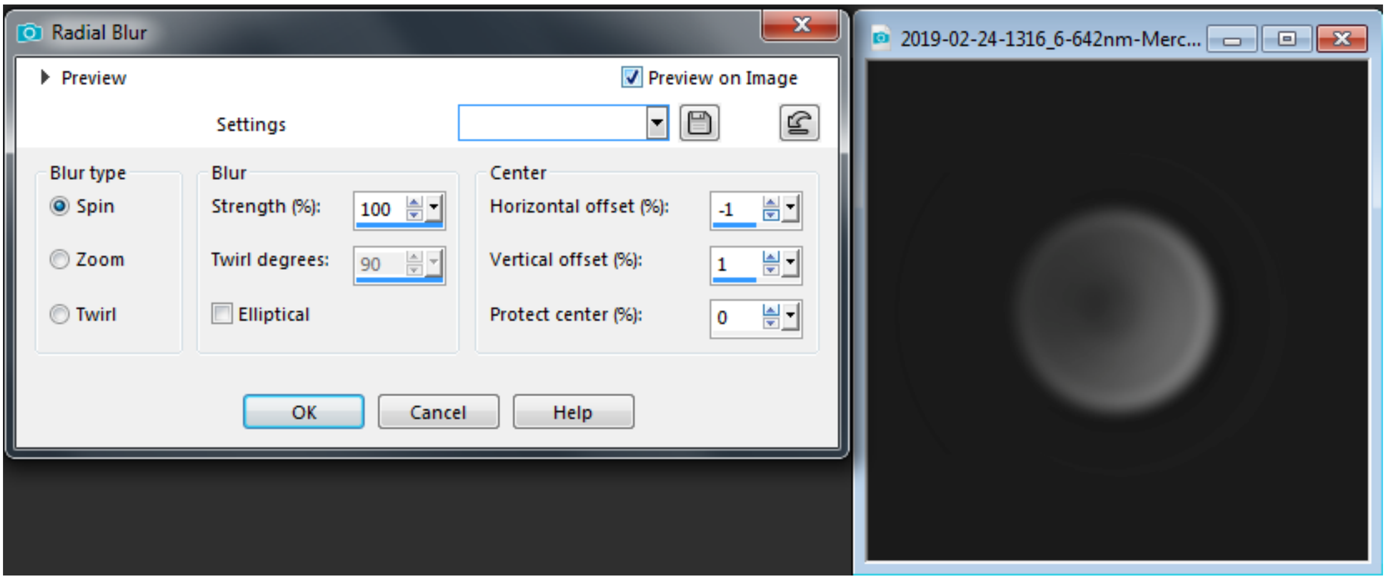

Figure 7. Radial Blur to produce a mask to suppress edge-rind on Mercury

- If the radial blur can only do 90° maximum spin then repeat the spin process to produce a more rotationally even disc
- Draw a circular selection around the centre of the blurred disc and perform a Gaussian blur here with a large pixel size to even out the hole in the centre. You should now have an even centre with a brighter edge to the disc
- Invert the blurred disk and use it as a mask layer acting on the original image of the planet. Carefully line up the mask with the planet so the edges match
- The edge of the mask will be darker and so reduce the opacity of the planet's rind whilst in the centre it will have less effect.
- Place a black raster layer behind the planet and mask layer. Then where the mask is darker the planet will be lower opacity showing the black more and so dimming the edge rind
- Alter the opacity of the mask to fine tune the degree of edge correction

Background brightness method

We have seen that planetary processing methods commonly used to bring out surface details on the bulk of the disc can produce unwanted edge artefacts, exaggerating any edge diffraction latent in the image. Artificially reducing the edge contrast by brightening the background can theoretically reduce this effect and lessen the degree to which edge diffraction effects are amplified in the processing.

Simon Kidd has been exploring this technique on Mars images, with some encouraging results, by pasting an image of the planet onto a bright background with a small amount of dark space around it. This seems to cause the wavelet processing to act less strongly on the edge, so that diffraction-induced edge-rind remains ‘unamplified’. The method is illustrated in figure 8.

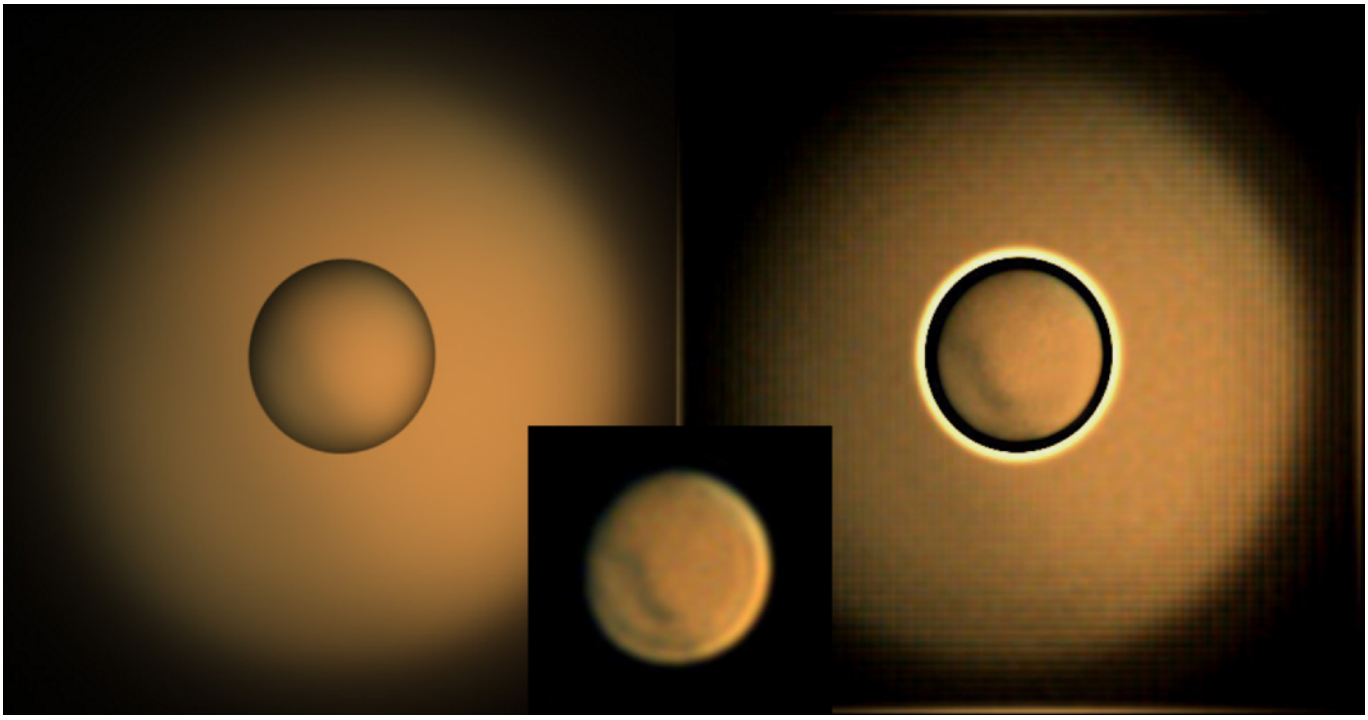

Figure 8. Background brightness method on Mars. At left, before sharpening, an image of Mars is pasted onto an enlarged version of the planet as a background. In the sharpened image (R) the background mask fools the wavelet about where the planet edge is and the edge-rind in the true planet image is, as a result, not enhanced. Inset is the normally processed image without the use of the experimental method (images courtesy S.Kidd)

The method needs care in setting up, but the principle seems to work and one day it could be incorporated into planetary processing software as an automated process.