Newtonian Poor on Planets

Question:
Why does my Newtonian appear to perform well on deep sky objects but disappoint on planets?

Reply:
Observing from La Palma last month with GAS committee member Anthony Ward, we had impressive low- and medium-power views of Omega Centauri using a local friend's 300mm Newtonian. Turning the same scope to Mars, we were treated to a featureless orange blob with suggestions of a double image. The image of Mars in my 140mm apo was sharp and detailed. Our friend, an optical engineer who used to work at the observatory, attributed the disappointing planetary image to poor collimation. We were all experienced observers and, moments before, had been wowed by the view of Omega. The point is that it's possible to enjoy rewarding low and medium power views of DSOs when things are less than perfect. Planetary observing is another matter - a tough test of instrument, conditions and observer.

Instrument

Was the apo image better than the Newtonian one because the Newtonian design is intrinsically no good for planetary observing? Emphatically not. But there are several things it's crucial to get right if a Newtonian is to perform properly. Former BAA President and expert observer Martin Mobberley, with whom I had some correspondence on this subject, said that his 250mm f 6.3 Newtonian was the best planetary scope he had ever used; there is a long history of Newtonians being used for exacting planetary observation.

For the record, the best planetary scope I've ever used is my TEC140 apo. There's no question that, *for a given aperture*, a high quality refractor gives the sharpest, highest contrast visual images of any design. The limitation, of course, is cost. Patrick Moore is quoted as saying that if money were no object, he'd buy the biggest refractor he could afford. But apos above 6” are the stuff that dreams are made on – technical considerations aside, for most people this sets a limit on affordable aperture. And, it's aperture that gives you not just light gathering power – which isn't a concern with the brighter planets – but, as far as the atmosphere allows, resolution.

Size for size, for *visual* observing of the planets, high quality Newtonians are second only to refractors – and some would say that specially optimised models come very close indeed. Despite the protestations of people who buy them, SCTs bring up the rear. High quality Maksutovs and a couple of other rather unusual scopes reportedly compete with good Newtonians but, again, are expensive aperture for aperture.

However when it comes to planetary *imaging*, the preferences of the best practitioners run in the opposite order, with SCTs topping the list, followed by optimised Newtonians and refractors coming last. I'll explain why shortly. For the moment, it's worth pointing out that this illustrates a very important general truth about telescope choice: no single design of instrument performs best or is most practical for all applications.

The disadvantage that Newtonians share with SCTs (and other compound scopes) is the need for a secondary mirror obstructing the light path. In the case of Newtonians, the secondary is usually supported by a spider. As you mentioned from your conversation with Steven, the diffraction effects of this can be significant. Curved vane spiders are available which have the effect of 'removing' the spikes on star images (and which exist on different scales elsewhere across the image). The curved vanes are meant to dissipate and generalise the diffraction effects contributed by the spider so that they are less clearly defined. Some expert observers swear by them and they have come to be considered the design of choice for optimised Newtonians. That said, I know of at least one experienced observer who tried a curved spider and went back to a conventional one.

It's not just the spider that's an issue but the presence of the central obstruction itself. The received wisdom is that below about 18-20% obstruction by diameter, the effects are visually insignificant. Most currently available Newtonians have bigger obstructions than this. Typical SCTs have secondary obstructions of at least 30%, although they have no spider as such, and this is one reason why, to critical observers at least, the visual images of planets they provide appear soft by comparison with those provided by a decent, properly set up refractor or Newtonian. Refractors, of course, have no central obstruction at all.

Basic optical quality is obviously important. Most current, 'off the shelf' Newtonians use optics from GSO (Taiwan) and sometimes these test fairly well. They are good value, giving affordable access to decent aperture and consequent light-gathering power. Low and medium power views of nebulae and other diffuse objects can appear quite rewarding but, other things being equal, they don't compare with the views provided by high quality instruments. For the exacting demands of planetary observation, the first requirement is well-figured, smooth, clean optics. And those, of course, come at a price.

The second absolutely crucial requirement is precise collimation. A properly made refractor, once collimated, is likely to stay that way. To perform at their best, Newtonians and SCTs, with their relatively mobile optics, need their collimation checked often, especially if they're carted around and bumped about in cars. Damian Peach, the renowned planetary imager, is reported to check and refine the collimation of his SCT several times during an observing session.

Optical quality matters all through the optical train from the primary through the flat to the eyepieces and optical accessories. To digress a little, this is not bad news with regard to choice of eyepieces. Exotic,expensive designs like the Ethos etc, superb though they are in some applications, are not the first choice for planetary observing. Their dramatically wide fields are not required – what's needed is on axis-sharpness, contrast and freedom from scatter. These qualities are best provided by simpler designs, notably orthoscopics, such as those sold by Baader, and high quality plossls, such as those made by Televue. You will encounter claims that the exotics are just as good on planets as these simpler designs. They're not – but the combination they achieve of very good sharpness, with good transmission and extraordinary field of view is nonetheless remarkable.

Before serious observing, the telescope's optics need time to reach thermal equilibrium internally and with their surroundings. This can take several hours with a big primary mirror or where the mirror is enclosed. It makes sense to house the scope outside or at least put it outside well before you plan to start observing. Don't take it from a warm room or a hot car on a winter's night and expect it to be at its best. Incidentally, eyepieces and other optical accessories also need some settling time. Significant ambient temperature changes through the night can also affect the figure of the optics.

During cool down (it's usually that way round), currents near the surface of the mirror and within the telescope tube can degrade image quality. Many scopes incorporate fans to smooth the airflow. There is much debate around whether these should suck or blow, blow across the mirror or up through the tube, etc. Most votes go to fans placed behind the primary, blowing on the back of the mirror and past its edges, the argument being that as well as cooling the mirror (albeit unevenly) this promotes a smooth flow up the tube in line with the optical axis.

There is an advantage for planetary observing in relatively long focal lengths. So-called 'planetary' Newtonians, if you can find one, are typically f6.3 or higher. This has nothing to do with any magical quality of higher f ratios. It's because longer focal lengths result in bigger image scales. In a Newtonian, this goes hand in hand with keeping the secondary obstruction small which, as I've said is highly desirable. It also means that the magnification required to exploit visually the resolving capacity of the scope can be achieved with eyepieces that are relatively comfortable and easy to use.

Some experienced observers flock the insides of their scopes and install baffles, the idea being to increase image contrast by minimising stray light and reflections. With a Newtonian it certainly makes sense to shield the top end in particular; with open tubes, a light shroud keeps out intrusive light. The visual effect of shielding the top end of the open tube Holmbury 20.5 inch against ambient light is quite dramatic.

The mechanical construction of the scope matters. It's important that collimation, once established, is retained and that the focuser allows fine adjustments and precise positioning. A tracking mount allows higher powers to be used more conveniently and removes the distraction of having to nudge the scope to keep the planet in view.

To summarise, the key requirements for a Newtonian designed for planetary viewing are: decent optics, smallest possible central obstruction, sound mechanics, accurate collimation, thermal settling, freedom from tube currents.

One final point on this and returning to my first example, whereas DSOs can still look quite impressive through a scope that is not optimised or well adjusted, they too acquire a clear edge of definition and contrast when viewed through one that is. Aperture for aperture, a scope that is optimised for planetary observing is a scope that has been built and tuned to perform extremely well. For 'optimised for planetary observing' read simply 'optimised'. Globular clusters, for example, illustrate this point quite dramatically. At first sight, this might not seem to matter for the observation of diffuse nebulae or with wide-field views … until you experience it.

Conditions

As you know, poor seeing all too frequently compromises visual observing from the UK. You'll notice it more with the Moon and planets than with more extended and diffuse DSOs. Every observer knows that there are nights when the limb of the Moon appears to seethe and boil, killing fine detail and capping the scope's resolution. Assuming that the scope is settled and that you're not observing over some terrestrial source of turbulence, the atmosphere is, of course, to blame. On such nights, big scopes will appear to underperform and, unless sheer light gathering is the only consideration, smaller scopes will seem to do pretty much as well.

The lower you look in the sky, the greater the air mass and the worse the effects of what is known as atmospheric dispersion. The atmosphere acts like a prism and disperses the incoming light into 'rainbow' colours which are most obvious at the 'top' and 'bottom' limbs of a planet, aligning with the vertical gradient of the air mass. The effect is clearly visible in modest instruments and degrades image quality. At the time of writing, Mars and Saturn, for example, are low in the sky from the UK, and that is going to be the case for the bright planets for some time. Some help is available, for the price of a mid-range eyepiece, in the form of an atmospheric dispersion corrector (ADC) which effectively 'reassembles' the colours that the atmosphere has dispersed.

Observer

There is another element to include and that's the observer. Observing planets takes practice – it's a matter of 'learning to see' and is a perceptual not a purely optical process. For UK observers, at least, it rests on the ability to capture those elusive moments when detail suddenly pops into view.

The impressive drawings you see by experienced UK observers can lead to high expectations that aren't realised when you first look through the eyepiece. They are typically not snapshots of a steadily held, detailed view. Rather they are assembled painstakingly from many patiently registered glimpses, perhaps using different magnifications and filters, the picture of the planet being built up incrementally from these.

It's easy to overdo magnification. There is a useful guideline here. Leaving aside the qualities of the individual observer's eye, the capacity of your telescope to resolve detail is reached when you use a magnification roughly equal to its aperture in millimetres. So, x140 for my apo and x200 for your 200mm. Remember, resolution is determined by *aperture*. Below that guideline figure, some of the native resolution of your scope is not being used. More importantly for planetary observing, magnifications exceeding the 'rule of thumb' guideline do *not* enable the scope to resolve any more detail - they simply make the image look bigger. You may prefer the appearance of a bigger image and that's fine but many observers, myself included, feel that we see all there is to see and prefer the appearance of the crisper, brighter images you get when you don't push the magnification too high.

A couple more points. A stable mount helps a great deal. A binocular viewer is hugely advantageous when observing the Moon and planets – less use for faint objects. To lapse anecdotal again with a view to illustrating some of the points made above, Anthony Ward and I enjoyed our best ever views of Saturn last month from La Palma using the following set up: 140mm apo refractor on an EQ6 mount, Zeiss-Baader prism, Zeiss-Baader bino-viewer and accessories and a pair of 11mm Televue plossl eyepieces, yielding a magnification of around x150. The seeing conditions were exceptional but, here's the point, increasing the magnification showed no detail that we couldn't see already and, to our eyes at least, the lower power image was aesthetically more pleasing.

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