Planetary Eyepieces

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Introduction:

As a current employer in amateur astronomy, it surprises me to see how many beginners are informed by more experienced observers that modern wide field's are the eyepieces they should have for practically every application, including planets. These are excellent eyepieces and they have their place, however, that advice couldn't be any further from the truth and sadly, many beginners are discouraged from this beautiful hobby because they can not afford these expensive wide fields. This is one of the errors I noticed in Phil Harrington's book Star Ware 1st edition, when he rated wide field's with 4 stars and narrow fields with 2 and 3 stars. There is no best type of eyepiece because they all serve different applications and excel in certain areas of observation. One thing I would like to say in Phil's defense though, is that he did make a point to mention that orthos and plossls do make wonderful planetary eyepieces. Another misleading note is that power is not important. What's the definition of power? Power is very important if it serves the purpose it was intended for.

The problem with it is that it's always related to X magnification instead of aperture, which is really the source of the power. The more aperture you have, the more power your telescope will have and finally, the more magnification your telescope can achieve without the object fading from view. The Keck telescope is referred to as one of the most powerful telescopes in the world. When have you ever heard that statement based in reference to Keck's magnification? There's a reason why beginners always seem to think power is important, that's because it really is, but they just don't know it's in reference to the wrong thing.

In this review, I will cover just about every eyepiece we have experimented with and like best for lunar & planetary observing at the highest level of scrutiny. I will also share some myths and tips based not only from my own experiences, but from the testimony of my fellow observing partners who have spent endless nights with me over the years observing the Moon and planets in fact, we have established an observing site specifically aimed at nothing else but lunar & planetary studies. The site is NOT very dark, which is actually advantageous for planetary observing (I'll explain why, later). The location is about an hour drive for us, but the seeing conditions are some of the steadiest in the world during the fall, do to the laminar air flow from the west coast's Pacific Ocean. The altitude is about 5,500 ft, which has set an incredible stage for learning what different eyepieces are capable of revealing. The planetary telescopes these observers use are nothing short of spectacular, in fact some of the large newtonians are equipped with ultra thin, three vane curved spiders, producing refractor like images without diffraction spikes. These guys are such fanatics, that they will observe planets for as long as 8 hours in one night. These eyepieces were tested using 4", 5" and 6" apos from Takahashi and Astro Physics as well as high end maksutovs and newtonians.

The quality of the telescopes used was very important in order to form these conclusions regarding

planetary eyepieces. It's also interesting to note how they performed in different apertures. Unfortunately, it takes allot of time and experimenting. The eyepieces covered are listed below and I will explain the differences of each one and why they excel in certain areas of observation in the field, where it really counts. These tests were based strictly on clarity, sharpness and optical resolution, not mechanical design or focal length.

University Optics Orthos
Televue Plossls
Pentex .965 Orthos
Celestron Ultima's
Televue Radian's
Brandon's
Edmund RKE's
Televue 3mm-6mm zoom (new)
Zeiss Abbe Orthos
Takahashi LE's
Televue Panoptic (only for example)

Each one of the eyepieces listed here has been put to the ultimate test. If there is an eyepiece you do not see here, it's because they have not been thoroughly tested or were not up to par. The reason the TV zoom was included is because it's pretty new right now. I will also eventually try Nikon microscope eyepieces in the future, as well as the new Sirius Optics planetary filter. The eyepiece conclusions will be last, but first some myths and tips.

Wide Fields for Planets:

You will notice that there is no mention of any exotic wide fields except for the Panoptic, which was only included as an example of how a wide field compares to plossls and orthos. This is because they are the least favorable eyepieces for lunar & planetary studies when it comes to detail. Any purist who really observes planets would not recommend them for the following reasons, especially for smaller apertures. Observing planets is different than observing deep sky objects because they are colorful and active subjects. All of a sudden, some new cloud or feature may appear, and that little bit of extra resolution can make a world of difference if you maximize your observing tools properly. Smaller apertures, for example 4" to 6" apo refractors do not gather a whole lot of light when compared to larger newtonians. Wide fields not only utilize more glass elements, but they also utilize thicker glass elements, which can make the images too warm or coffee colored, and this can absorb some of the precious light needed to make that tiny bit of difference when trying resolve delicate details on lunar & planetary surfaces at higher magnifications. In a nut shell, they reduce transparency. To a novice this may not be noticeable at first, but for observers like Joe Donahue and Ed Ting, it would not go unnoticed.

What if you have a large telescope to compensate for light loss in the eyepiece? In many cases, these telescopes gather so much light, that they actually begin to reveal internal reflections from within the

eyepieces themselves if the coatings are not good enough and even then, it's still not a sure thing. This is because there are as many as 6 or 8 glass elements in them. There have been a number of instances where we would have to keep a planet dead centered so that the reflections stayed directly on top of the planet's light path. Any deviation of the planet in these eyepieces would reveal internal reflections off to the side while observing through the eyepiece and this can be very annoying. To prove this, take a flash light and point it through the bottom of a wide field and look through the eyepiece at various angles in order to simulate a planet that it not perfectly centered. Not all wide fields reveal internal reflections, but they still rob you of sharpness at the highest level when studying the precious delicate details of a planet's surface when compared to plossls, orthos and surprisingly even certain Kellners. In a nut shell, don't waste your money on wide field's if you're serious about lunar & planetary observing.

Color Filters and Lunar Polarizing Filters

color filters can be enticing because they are inexpensive, however the stories about them enhancing detail can be a bit miss leading. Color filters may reveal a certain feature by making them appear more obvious, but they do not enhance detail. To prove this, use your color filter to find a particular feature that you wish to study, then remove the filter and focus your attention on that same feature. You will see that it not only looks clearer, but will also reveal better detail. If anything, color filters degrade images and block out the precious light that's needed to achieve the highest magnification without optical degradation to study small details. The only way to enhance detail on certain regions of a planet, is to observe them in a different wave length or band width, in which case I can assure you would cost more than a 15$ color filter. Read Sol Robbins Sirius Optics review regarding this matter. color filters are not recommended. Polarizing filters are another mistake when scrutinizing small details at high magnification. Most beginners are alarmed at the brightness of the Moon because they've never seen it before, but the light you are suppressing is the very thing that allows you to see the maximum amount of detail, not to mention that you are also degrading the image by adding more optical surfaces and glass and even possible internal reflections. Using these filters is like reducing aperture and aperture is what resolves finer details on the Moon.

Adding a color or polarizing filters to high quality optics is like adding and equalizer to an expensive tube amplifier. Why spend thousands of dollars on it's rich sound, only to change it with a 100$ equalizer? it defeats the purpose. None of these filters are recommended. Although it is true that an ND PL filter can reduce glare and make images appear more aesthetic, seeing conditions that require the use of them are not the kind of seeing conditions that are conducive to achieving the finest detail anyway. Proper seeing conditions do not require the use of any of these filters. I do wish to note that because Venus is usually in a bad position with regard to seeing conditions, that the use of one of these filters can be helpful when trying to study its phases do to its tremendous brightness. There also isn't any surface detail to lose either, so a filter should be helpful in this regard.

Enhanced Gold Plated Star Diagonals

We have had a good opportunity to observe planets with this type of diagonal from Vernon Scope.

Although there are claims to it's benefits, we did not really notice any particular enhancements from its use over aluminized diagonals on the Moon or planets. They're also very expensive. Not recommended.

Planetary Tips for SCT and Maks

I do not recommend SCT's for lunar and planetary observing as I feel there are better designs for serious observation. However, if you already own a SCT telescope, I strongly suggest that you point the tube downward and open the rear cell for about 30 to 40 minutes before you observe. This will allow any heat to rise up and out of the optical tube assembly before you observe. If you think warm temperatures and tube currents are not an important factor when it comes to lunar and planetary observing, then you are greatly mistaken. Any heat currents in your tube will only be amplified when trying to discern delicate details on the surface of a planet at higher magnifications, not to mention that the internal optics need the proper time to stabilize. This procedure also applies to maks as well and can make a world of difference, in fact, one of our observers has improved his views dramatically by doing this. If you own a SCT, make absolutely sure you double check your collimation. If it's not exact, then you are robbing yourself of better surface detail. SCT's need every advantage they can get.

Seeing Conditions

One of the biggest mistakes I see with amateurs, is their timing for observing planets. They usually end up blaming the optics instead of themselves because they haven't done their homework. For example, some observers often think that the clear skies after the rain are a good sign, when in fact it's the worst. Ironically, smog in the city is a good sign that skies may be steady. As a rule of thumb, skies can take as long as two to three days to settle down after the rain, so stay vigilant. Also, check the jet stream analysis on the internet. I guarantee you that it's a waste of time setting up for planets if there's a jet stream. This has improved our observing dramatically. These high altitude jet streams can be deceiving if they are not checked. Check the flick rate on stars. This is when the stars flicker from bad seeing conditions, which can be checked using a simple technique. Look at the stars near the horizon where it's the worst. If it's pretty good on the horizon, then it should be better at zenith, which is directly above. Ideal flick rates are about 1 or 2 per second. This means that the star should not flicker more than about 1 or 2 times per second. Watch the stars and count one one thousand, two one thousand, three one thousand and so on. Also, check the position of the planets relative to the horizon. Catch them when they are rising high out of the east and up to zenith. If you do not take these factors into consideration, then you are making a big mistake. Do your homework first. Whenever someone asks to see a planet through my telescope while I'm observing deep sky objects, I'm usually reluctant to show them anything unless these factors are accounted for. I do not want to leave a novice with an everlasting impression that planets look terrible. They have no idea how incredible planets look under the proper conditions, following the correct procedures. I had incredible views of Saturn in my 4" Takahashi and invited my neighbor over to see it. I barely viewed anymore that night because he was planted in my observing chair in a trance for the rest of the night under wonderful seeing conditions. That's the kind of memory that will last forever.

Twilight Factor

This factor may surprise you. If you think Jupiter looks best under very dark skies, it doesn't. The best images with regard to Jupiter usually occur under ambient light. This topic was also discussed by expert planetary observer John B. Murray, Department of Earth Sciences. Sometimes it is the contrast of a dark sky and bright disk that renders details difficult to see, and observations during bright twilight, when a planet first becomes visible to the naked eye may show surface features much more clearly than against a dark sky. This has proven to be absolutely true in our experiences. This is why observing planets from a city can be beneficial over dark skies. There has even been some conversations about experimenting with artificial light by the telescope in order to achieve this incredible effect.

Phillips Effect

This may be noticeable by more experienced planetary observers, especially Jupiter. This is where the the edge or one side of Jupiter's disk appears to be sharper or more illuminated than the other, when the planet is outside of opposition near quadrature. This effect is not caused by your optics, but by a phenomenon known as the Phillips effect. Quadrature is a configuration in which the angular separation of two celestial bodies, as measured from a third, is 90 degrees. This effect causes some difficulty for observers attempting to calculate precise transit times across Jupiter's central meridian. The uneven illumination of the planet shifts the perception of the central meridian slightly to one side of the center of the illuminated disk. This issue was also discussed by John B Murray.

Magnification

This is one of the most simple, yet controversial and misunderstood subjects to this day. In Sky&Telescope's May, 91 issue, Al Nagler explained this perfectly. For the best low-power views, use the highest magnification that will frame the subject or subjects nicely. For the best high-power views, use the lowest magnification that will reveal the detail you are looking for. This is completely true. Often, you will hear about observers stating over 300x on planets in a 4" apo, however, magnifications that high are completely unrealistic and surface detail is not achieved without sacrifice under any circumstances, even if the seeing conditions are absolutely perfect. This issue has nothing to do with seeing conditions, it has to do with angular resolution. It's simple math and nothing more. There is only so much light that certain apertures can take in before the images start to fade, and this is why the most serious planetary observers do not use thick glass, color filters, etc. They know that every bit of light is precious. Some observers just like larger image scale, but no matter how much more you magnify the image, you will not gain any more detail. Once you find the highest magnification you can achieve without degrading the color and image, that's the magnification you should stick with. The only way to increase resolution and detail, is to increase aperture and it's as simple as that.

So, why do Mars, Saturn, Uranus, Neptune always seem to take more magnification than Jupiter without looking as degraded? This happens for two reasons. One, is that Jupiter is bigger and brighter, which in turn makes anything that degrades the image more evident, whether it's bad optics, seeing conditions,

etc. To prove this, just take a look at Jupiter and Venus when they are in the same position off the horizon. Venus will almost always reveal itself like a blob at the same magnification as Jupiter because it's so much brighter and the only way to clean the bad image, is to reduce magnification until you're unable to see it. This is why smaller optics can often reveal a finer image than big telescopes under average seeing conditions, which simulate the same effect do to their big aperture. The second reason is because Jupiter is a very colorful and dynamic planet, and it's easier to judge optical degradation against something that's colorful than something that's opaque like Saturn. This is why you can magnify faint stars very high an not notice too much degradation to the star itself. Under most circumstances, the sharpest and most resolved views under perfect seeing conditions in our 4" apos were about 180x on Jupiter and around 180x to 200x at most on Saturn and Mars. These powers will usually offer the best surface color to magnification ratio. This is about 45 to 50x per inch. Although you can increase magnification, it will not happen without sacrifice. Fainter stars can be pushed as far as far as 80x or 100x per inch because they have no surface features to lose to angular resolution. You're simply looking at a faceless pale dot. If you're not sure what magnification you need, then just experiment with your telescope's magnification on a given subject. Some telescopes react differently under certain circumstances and thus, it can be hard to say which magnification is the best one. Only you can decide, but remember to fallow Al Nagler's advice.

On Axis Off Axis

Although eyepieces do have a sweet spot, it's important to mention that when viewing the planets under terrific seeing conditions, this has allowed us to push the envelope regarding magnification with larger apertures and we have had no difficulty detecting incredible detail slightly off axis with the eyepieces mentioned. We have just about all the focal lengths of eyepieces between us and used barlows as well in many cases.

Telescopes used in Eyepiece Comparisons

Each of these scopes except the C14 has been granted plenty of time to reveal how the views were in most of the eyepieces in this review.

AP Traveler,
AP 6" F-12 apo
AP 155EDF
Tak FC100
Tak FS102
Tak FS128
Tak FS152
Tak FSQ106
Televue NP101
Tak 8" Mewlon
Custom 8", 12.5" and 16" newtonians (Beck mirrors)

10" Teleport (best views of Jupiter)
12.5" Portaball (best views of Saturn)
12.5" Lightspeed (Wilkinson Optics)
16" F-5.8 Lightspeed (Wilkinson Optics) (best views of Mars)
TEC 8" Mak
15" Obsession (cooling issues)
C14

Glass and Coating Tones:

Before beginning this section, I would like to thank Joe Donahue of Cloudy Nights as well as a couple of others for their interesting input and opinions regarding this controversial matter. Because of this, I have decided to share some brief input regarding optical coatings in this review. Although different glass may appear to give slight coffee tones, it's important to mention optical coatings may also be a contributing factor in some cases too. For example, Brunton optics has a line of binoculars called the Eternal series which utilize a coating called Emerald Fire, which gives terrestrial observations a very obvious coffee tone when compared to their Lite Tech series. Most optical coatings used in eyepieces are magnesium fluoride coatings which are designed to improve light transmission and reduce flare as much as 1.5% to 0.5% per surface. This issue was discussed in Phil Harrington's book, "Star Ware". These coatings take on a greenish and purplish appearance depending on how much magnesium fluoride is applied to each glass surface.

It may be difficult to notice this, but it can make a world of difference to the surface of a planet. Let's take two different eyepieces and discuss what happens to them at higher magnifications on the Moon and planets. If we observe the Moon at low magnifications with Zeiss Abbes against Tele Vue plossls, you may not notice that much difference at first, but when you push them to higher magnifications, something starts to become noticeable. Zeiss Abbe Orthos utilize a very cool or white transparent crystal called Schott glass, which makes planets appear more dull or opaque, while Tele Vue plossls appear to give a warmer and slightly less transparent view. It's almost like an extremely subtle coffee tone in the Tele Vue's It may be easier for you to notice this when boosting magnification against the Moon's pale or opaque surface. Although this may sound negative, it is by no means meant to imply that Tele Vue's are bad, in fact they have an advantage over the Zeiss Abbes. Because the Zeiss Abbes give images which appear whiter or cooler, Jupiter's colorful cloud bands also tend to look bleached, cooler or pale, while the Tele Vue's appear to help Jupiter's clouds appear more dynamic and colorful. To prove this in an easier and more obvious way, compare a Tele Vue wide field and their abundant glass and coatings on the Moon at high magnification to any of the brands mentioned above which have a similar focal length, and you should notice it pretty quickly.

About two days after a first quarter lunar phase, there are some lunar domes with tiny little summit craterlits near Hortensius and Milichius which are visible to a trained eye. One of my fellow observer's and I were testing a couple of these wide fields against a simple plossl of the same focal length at high magnification using a 5" Takahashi apo, and every time we switched them back and forth, we could see the tiny summit craterlits reappear and disappear simply by changing the eyepieces. The wide field was

obviously inferior to the plossel for this application and this is the difference I'm referring to. Not only were the wide field's images too warm at this magnification, but their thick multiple glass elements degraded the image as well. Warm and cool tones suggest a couple of things. If you're observing a planet which reveals color, for example Jupiter and Mars, you will get more color fidelity by observing with a warmer glass. If you are observing more pale or opaque objects, for example the Moon and Saturn, do to the haze of ammonia ice crystals in its upper atmosphere, then you would probably be better suited observing with a cooler glass to achieve the best transparency at higher magnifications since there isn't all that much color to lose anyway depending on the aperture of your telescope. I have provided a brief review of each of these eyepieces and once again, this review is based strictly on color tone, optical quality and resolution at the highest level, not mechanical design and focal length. The colors are expressed from cool to med to warm. Note, that it may be possible for other observers to notice a different tone, however, this is what my observing partners and I have noticed in the field over the years of using them under perfect seeing conditions. Although these eyepieces may not be as good in one area, they may excel in another. I also wish to mention that we have used just about every focal length in each of the eyepieces tested.

Tele Vue 3MM - 6MM ZOOM- Although this eyepiece is regarded by Tele Vue to be a contender for planetary observing, it was unquestionably inferior to all the others tested in this group with regard to crystal clarity and optical resolution at the highest level. It's functions work good, but are not worth the optical sacrifice for very serious lunar & planetary observations at high magnification. Not recommended. Glass - WARM

UNIVERSITY OPTICS ORTHOS- Although these eyepieces are well regarded by many observers, they exhibited very slight chromatic aberrations around the edges of planets, when compared to the rest of the pack at high magnification, which was a bit of a distraction. They worked good as a general purpose lunar & planetary eyepiece, but did not excel at any particular subject when compared to others. Recommended. Glass - MED

BRANDON - Although these eyepieces are highly regarded by many purists, they are one the less favorable for bringing out the subtle color variations on Jupiter's cloud bands and Martian surface. These eyepieces are over rated for planets when compared to this pack. Very good optical quality for lunar observations. Recommended. Glass - COOL.

Tele Vue PANOPTIC - Optically inferior to the pack in every category at higher magnifications. Not recommended. Glass - WARMEST

CELESTRON ULTIMA - This eyepiece is good for general lunar and planetary studies, however they do not excel over the pack in any specific area of observation regarding the Moon and planets. Very good optical quality. Recommended. Glass - MED

Tele Vue RADIAN - This eyepiece is not as favorable when compared to the pack at higher magnifications in any area of lunar & planetary observations. Good optical quality but not recommended

when compared to the best in the pack. Glass - WARMEST

TAKAHASHI LE - This eyepiece is very similar to the Celestron Ultima in every regard. It does not excel in any particular area of observations do to medium glass tones at higher magnifications. Good for general lunar & planetary observations. Very good optical quality. Recommended. Glass - MED

PENTEX .965 ORTHOS - This eyepiece provides very good optical quality, however, they did not excel in any particular area when compared to the best in the pack. More of a general purpose eyepiece. Recommended. Glass - MED

Tele Vue PLOSSEL - This eyepiece is unsurpassed so far with regard to revealing color on Jupiter''s cloud belts, Saturn's globe in larger apertures and Martian surface with the most color fidelity. they are less favorable at high magnifications of the Moon and high magnification studies of Saturn's ring system in smaller telescopes because of their warmer tone. Very good optical quality. Highly recommended. Glass - WARM

EDMUND RKE - This eyepiece is a reversed 3 element Kellner design. Unsurpassed and most favorable at revealing Saturn's ring divisions and lunar detail at the highest level. Possible top choice for detecting Saturn's spokes. Less favorable at revealing color fidelity on Jupiter's cloud belts, Saturn's globe and Martian color when compared to the TV plossls. Excellent light transmission over the pack, very bright. Highly recommended. Very good optical quality. Glass - COOL

ZEISS ABBE ORTHOS - Unsurpassed optical quality and practically identical to the Edmund RKE with respect to maximum light transmission, Saturn's ring system and lunar applications at higher magnifications. Less favorable with regard to cosmetic bleached appearance on Jupiter's cloud belts. Highly recommended. Glass - COOL

Summary

The goal of this review was to find the purist eyepiece that would excel in the area it was asked to perform. If you are surprised at the comments regarding Radian's, then I will tell you that there is no such thing as magic Tele Vue's Tele Vue's all use the same ingredients put together in different designs, and the Radian only houses more glass than it plossel design. It would be nice to see Al come up with a three element modified Kellner or an ortho and get away from so much glass for a change, but that's the price one pays for better eye relief. Don't be fooled by optical marketing tactics, you would be shocked at what some of these cheap eyepieces out there can do on the Moon and planets when compared to many of these fancy modern eyepieces. Keep an open mind and just experiment with them and learn for yourself. Here's an example, I took an experienced observer and asked him to judge the optical performance of two eyepieces of the same focal length. I cupped my hand around them so he could not see which one I put in. I kept switching them back and forth and he unquestionably made up his mind. Without even realizing it, he chose a Parks 40$ Kellner over what is supposed to be Parks top of the line eyepiece, the modified Gold Series plossel He was dumbfounded. I came up with the exact same

conclusion and actually plan to test these cheap Kellners during the next planetary season.

When I noticed Ed Ting's plans to test Brandon's line of eyepieces, I informed him not to get his hopes up too high. I personally expected more from them when compared to others and sure enough, he came up with a similar conclusion. It also doesn't surprise me that the Edmund RKE is one of Terence Dickinson's favorites. This eyepiece was first brought to my attention by eagle eyed optical buff and telescope designer, Charles Ridell of Light Speed Telescopes and we all own a set now. In a nut shell, the eyepieces we like most so far, are the Edmund RKE's, which have a street value of about 20$ and can sell new for about 35$, Tele Vue plossls and Zeiss Abbe Orthos. As far as we could see, they were undoubtedly capable of out performing the rest of the bunch in the category they were asked to perform in. You will notice the gravitation toward the eyepiece that revealed the finest color fidelity on subjects that have color and the eyepieces that revealed the best transparency against more opaque subjects like Saturn's rings and lunar details. I hope this helps you save some pennies, Zeiss excluded. I especially would like to thank Allister for all his wonderful contributions toward this hobby that has brought so much joy.

Clearer Skies!!!