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To Wear or Not to Wear Glasses? — Howard L. Cohen

Even if you have astigmatic eyes, higher powers may allow you to remove eyeglasses when observing through a telescope

Beginners to astronomy often ask if they should remove eyeglasses when looking through a telescope. Advanced observers know eyeglasses can keep the eye too far back from the eyepiece causing possible "tunnel vision" or loss of the outer zones of the viewing field. This can be especially annoying when using short focal length eyepieces for higher powers that have small *eye relief*.

Eye relief is the distance from the last surface of the eyepiece eye lens to where all light rays focuses to form the image. This is where you should place your eye to see the full field of view (Fig. 1). Eyeglass wearers may need at least 15 mm of "useful" eye relief to see the full field of view. However, many eyepieces often have much less eye relief making it difficult or awkward to see through the telescope easily. (High end eyepieces usually have greater eye relief.)

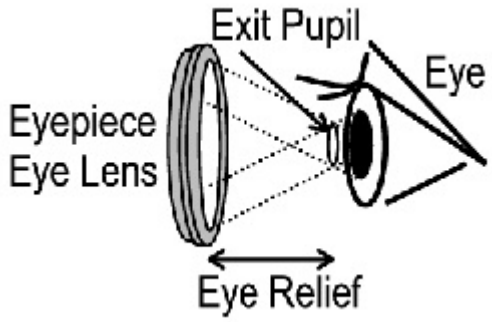

Figure 1 Eye Relief and Exit Pupil. Best eye position is near exit pupil.

Since refocusing a telescope can correct for either nearsighted (myopic) or farsighted (hyperopic) vision, one usually answers "yes" to the question about wearing eyeglasses—remove them *and refocus the telescope* for best viewing!

Nevertheless, removing eyeglasses carries some caveats—telescopes cannot correct for other vision problems such as *astigmatism*,[1] a common vision problem.

Therefore, we commonly tell people with appreciable astigmatism in their observing eye to wear eyeglasses when observing through a telescope. Unfortunately the observer then often fails to see the entire field of view making it more difficult to appreciate and grasp the full impact of the object they are observing.

But, did you know this may not always be true, especially at higher powers? As magnification increases, the telescope's *exit pupil*, diminishes in diameter. *Exit pupil* is the small circular beam of light that emerges from the eyepiece and is an image of the telescope's aperture (Fig. 1). In fact, *exit pupil diameter* = *telescope aperture* ÷ *magnification*.

Small exit pupils resulting from high magnifications allow uncorrected eyes to contribute

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[1] *Astigmatism* is a visual defect preventing light rays that enter the eye in different planes from focusing clearly on the retina.

less and less to astigmatic blurred vision. So, observers may achieve adequate image quality with astigmatic eyes when using higher magnifications, such as high power views of the Moon and planets.

People may need to experiment with a given telescope and different power eyepieces to decide whether image quality is better with or without glasses. (Don't forget to *refocus the telescope when you remove your eyeglasses.*)

However, Dr. Richard A. Buchroeder, an expert optical engineer, has provided a simple "rule" to use as a guideline.[2] (Dr. Buchroeder designed the five-element correctors used on Spacewatch telescopes and has an asteroid named for him, discovered using his optics *Asteroid15465 Buchroeder!*)

Buchroeder's Rule: Use an eyepiece that gives an **exit pupil (in mm) approximately less than or equal to 1 ÷ √D**, where **D** is your *eyeglass prescription for astigmatism*, often designated by the word "cylinder" in *diopters*.[3] (The symbol, √, means *square root*.)

Example: Assume your eyeglass **cylinder correction = 0.8 diopters** and you are using a **200 mm aperture, f/10** telescope (a typical, 8-inch Schmidt-Cassegrain instrument).

By *Buchroeder's Rule*, maximum exit pupil to use = 1 ÷ √0.8 or about 1 ÷ 0.9 = **1.1 mm**.

So, use an eyepiece giving a 1.1 mm exit pupil or less if you wish to remove glasses.

What magnifying power does this correspond to using this telescope?

Since exit pupil = aperture ÷ magnification, then **magnification = aperture ÷ exit pupil**.

Therefore, use a power of at least 200 mm ÷ 1.1 mm = **181x**.

Want to know the eyepiece focal length needed to give 181 power?

Since *magnification = telescope focal length ÷ eyepiece focal length*, then calculate **eyepiece focal length = telescope focal length ÷ magnification**.

First find the *telescope's focal length*. The telescope has a focal ratio of f/10,[4] which means **telescope focal length = f-ratio x telescope aperture** so the *telescopes' focal length is 10 times the aperture* = 200 mm x 10 = **2000 mm**.

So, the eyepiece focal length should be no larger than about 2000 mm ÷ 181x or **11 mm**.

Therefore, moderate magnifications of roughly 180x should allow people with a small amount of cylinder (about 0.8 diopters) to remove their eyeglasses *with this telescope*.

Since shorter focal length eyepieces sometimes also have smaller eye relief, the 11 mm eyepiece may require placing the eye closer to the eyepiece than a longer focus eyepiece. So, If astigmatism is small, removing glasses could be especially beneficial with an 11 mm

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[2] G. Seronik, *Sky and Telescope*, 2004 Sept., p. 132.

[3] A *diopter* is a unit of refractive power measurement equal to the reciprocal of focal length in meters.

[4] *Focal ratio* or *f-ratio* (designated f/) is **f-ratio = telescope's focal length ÷ telescope's aperture**. For example, a 1200 mm focal length telescope with a 150 mm aperture has an f-ratio of 1200 mm ÷ 150 mm = 8, designated as f/8.

or shorter focal length eyepiece on this telescope. (If you do not have an 11 mm eyepiece, use an eyepiece that has about the same focal length.)

For those not mathematically inclined, I have computed the following sample table for a **200 mm, f/10 telescope** used with several different focal length eyepieces.

Minimum Telescope Magnification Limit for Eyeglass Removal

Eyepiece Focal Length (mm)	Telescope Exit Pupil (mm)	Cylinder (Diopters)	Minimum Telescope Magnification
40 mm	4.0 mm	0.06D	50x
32 mm	3.2 mm	0.10D	63x
25 mm	2.5 mm	0.16D	80x
16 mm	1.6 mm	0.39D	125x
12 mm	1.2 mm	0.69D	167x
9 mm	0.9 mm	1.23D	222x
6 mm	0.6 mm	2.78D	333x
4 mm	0.4 mm	6.25D	500x

For example, this table shows that someone with an eyeglass prescription that lists a cylinder of **about 0.7 diopters** (see grayed row above) will probably not see image astigmatic blurring if one uses this telescope at a magnification of approximately 170x or more (corresponding to an exit pupil of about 1.2 mm or less). So, the eyepiece focal length should be no more than 12 mm. And, someone with severe astigmatism probably cannot remove their glasses at all unless the telescope is used at rare and difficult to use extremely high powers.

In addition, I have developed a *Microsoft Excel spreadsheet* to produce similar tables as above for your own chosen telescope parameters. The spreadsheet also has a second section that allows you to enter your eyeglass cylinder correction directly into the spreadsheet. After entering your telescope aperture and f-ratio, the spreadsheet finds the maximum exit pupil or minimum magnification needed if you want to remove your glasses.

A copy of this Excel spreadsheet is at:

http://www.astroadventures.net/cohen/articles/misc/BuchroederRule.xls

Still, remember that *Buchroeder's Rule* is just a rule or a guide. So, you may need to experiment to learn how well the rule works (see note below). Nevertheless, if you can remove your eyeglasses, you will enter a portal to the heavens not always accessible by wearers of spectacles!

Note: Tele Vue (http://www.televue.com) manufactures an astigmatism accessory (DIOPTRX™) for many of their eyepieces to compensate for your astigmatism. These units attach and lock onto the top of the Tele Vue eyepiece and are available in various diopters from 0.25 to 3.50 diopters in 0.25 diopter increments (street price about $98.00). And if you

wish to do further experimenting to find when to wear eyeglasses, read “Determining When To Use Eyeglasses” by Albert Nagler, President of Tele Vue Optics, at http://www.televue.com/engine/page.asp?ID=245. ¤

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