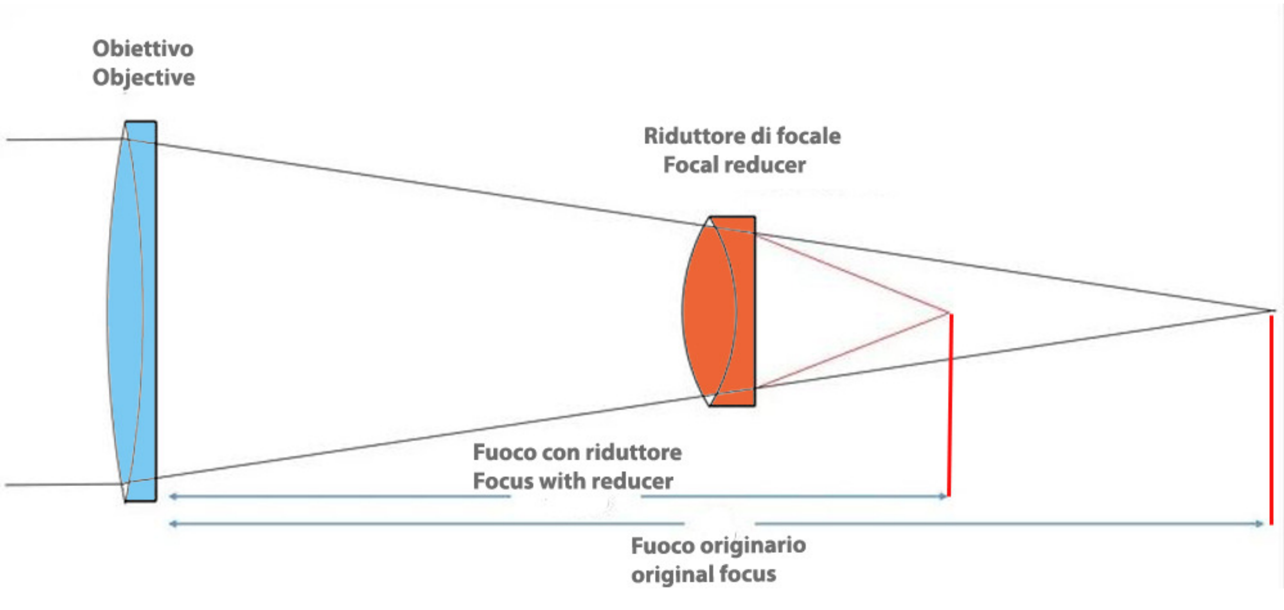
The focal reducers for Schmidt Cassegrain : lights and shadows of a widespread and interesting astronomical accessory

General informations on focal reducers

A focal reducer does just the opposite of a Barlow lens or focal extender. A reducer is a set of converging (or positive) lenses that cause the light from a telescope objective to converge at a wider angle to the focal plane as if it were coming from an objective with a faster (lower) focal ratio and a shorter focal length. When placed in the focal plane in front of a camera, CCD or CMOS or eyepiece, a focal reducer leads to a wider field of view and a brighter image of the objects observed, which is important for reducing the exposure times when imaging faint extended objects like nebulae or galaxies.



The reduction factor of a focal reducer is the relative amount by which the effective focal length of the telescope is reduced when the focal reducer is used at its specified working distance or back focus specified by the manufacturer. For example, with a 0.5x focal reducer, a telescope with a focal length of 1000mm will operate at 1000 x 0.5 = 500 mm when the reducer is placed at the working distance .Out of this distance, for some reducers, the amount of reduction could be different. Each focal reducer has a fixed specification called the working distance or required back focus, it's usually specified in millimeters and is the distance at which the reducer must be placed in front of the eyepiece or camera focal plane in order to operate at the design reduction factor. It's usually obtained from the base of the mounting male threads on the reducer's housing, or from the middle of the rear lens surface toward the eyepiece or the camera.This question has been source of confusion about the real backfous of Celestron and Meade reducer.

I think that the working distance of focal reducer must be measured from the center of the lens assembly for the simple reason that the nodal points of the optical system should be found in this position.In the following pages the focal length of the reducer will be therefore measured from this point.In any case,there is a difference of about 10 mm with the measure from the center of the lens toward the camera or eyepiece. Many focal reducers are meant to be used within a range of a few millimeters of the specified working distance to achieve the best possible image results without any decay of the image. If used before or beyond the working distance range, unwanted image distortion may result, especially when using cameras with larger sensors.Others may require a millimetric level of precision in the backfocus.In my experience, Celestron and Meade reducers falls in the first category, in the second Optec,that anyway give very good result. Finally there are reducers, such as Celestron and Meade for Schmidt Cassegrain, which, in addition to reducing the focal length, also act as field flatteners, to compensate, within certain limits, the curved field of this type of telescopes.

Basic features of the focal reducers

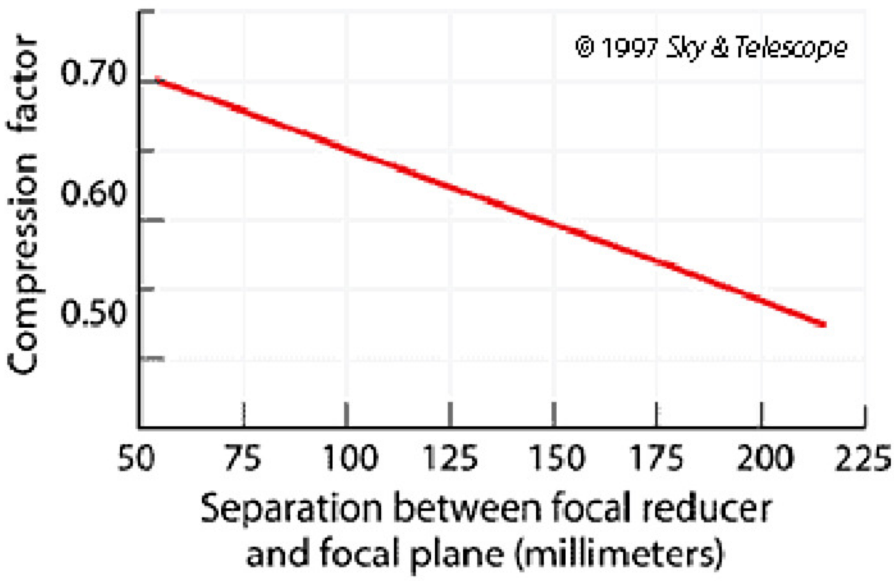
The important points of the reducers, common practically to all these optical accessories:

-A focal reducer will provide the reduction factor for which it is marketed only when it is placed at the exact distance from the focal plane of the eyepiece or camera expected in the design phase. However,as said before, some of them allow a minimum of tolerance, others do not.

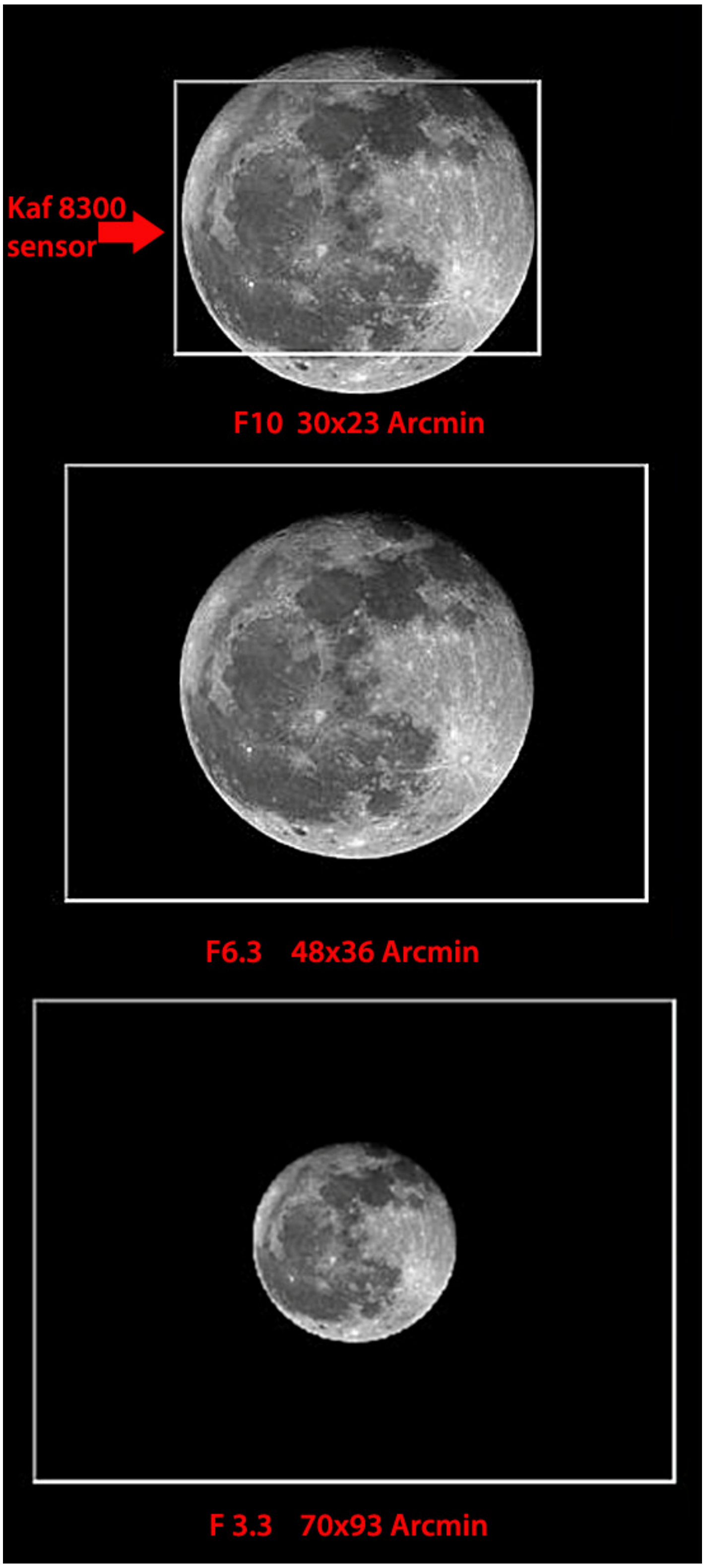
-Reducing the aforementioned working distance, i.e. by bringing the reducer closer to the focal plane, the F/D ratio of the telescope will increase and therefore its focal reduction factor will decrease: for example, a reducer at f 6.3 will work at f 7, and so on .

-Increasing the working distance, ie placing the reducer further from the focal plane decreases the F/D ratio, eg. from f 6.3 to f 5 and will increase its reduction factor of the original focal length of the telescope.

These requirements are summarized in the graph below (source Sky & Telescope.1997) for SC reducers.



In addition, the reducers allow you to expand the field of view of the telescope by reducing the integration time in CCD and CMOS imaging. The image below shows the field of view of the moon and the field of view of a Kodak KAF 8300 sensor (18 x 13.5 mm) with an 8 "f 10, f 6.3 and f 3.3 Schmidt Cassegrain telescope.About the necessity of decreasing the original F/D ratio on a telescope in CCD imaging, the question has been and is debated: there has been talk of the "myth of the F/D ratio", rightly or wrongly. In summary, the number of photons falling on each pixel is increased, and therefore the S/R ratio, but at the expense of the lower resolution of the framed subject.In no case does the number of photons entering the telescope increase as the F/D ratio decrease.


Kaf 8300
sensor
F10 30x23 Arcmin
F6.3 48x36 Arcmin
F 3.3 70x93 Arcmin

1- Focal reducers for refractors from F6 to F 8

In addition to reducing the focal length, the focal reducers for refractors from f 6 to f8 also have the task of smoothing out the curved field and reducing coma at the edges, especially in large format CCD cameras and digital SLR. Some manufacturers of short focus apo refractors also offer dedicated reducers and/or flatteners for their instruments: this is the case of Skywatcher, William Optics, Tele Vue,Optec, Sharpstar etc.

2- Focal reducers for Schmidt Cassegrain telescopes

Taking into account their optical design, the Schmidt Cassegrains have specially designed reducers, which also act as flatteners (within certain limits) of the curved field they have, at least in the classic non-aplanatic models.

The most common focal reducers for non-aplanatic SCs are the Celestron f 6.3 and the Meade f 6.3, supplied by the two manufacturers for their instruments, both for visual and photographic purposes: there are also others, such as the Antares, always with this reduction factor, which it would be more correct to specify in 0.63. Meade also produced a reducer f 3.3, indicated only for photographic use with small sensors., currently no longer in production, but which is occasionally found in the second-hand market

Celestron f 6.3 reducer

The Meade f 6.3 and f 3.3 reducers

Unlike classic SCs, the latest generation aplanatic ones, such as Celestron Edge HD and Meade ACFs, have internal optics (Celestron) or aspheric secondary mirror (Meade) such as to smooth out the field, and require dedicated reducers, which, unlike the previous ones, only act as focal reducers, without flattening the field, already flattened by the internal optical system. In the following image, the Celestron 4-element reducer dedicated to the C8 Edge HD, with a reduction factor of 0.7 and a back focus of 105 mm similar to the model for the normal C 8: the cost, however, is considerably higher than this.Other similar reducers are in catalog for C9.25, C11, C14 Edge HD.

Meade has not developed its own system of dedicated FR for ACF at f 10 ,for the new project of f 8 ACF

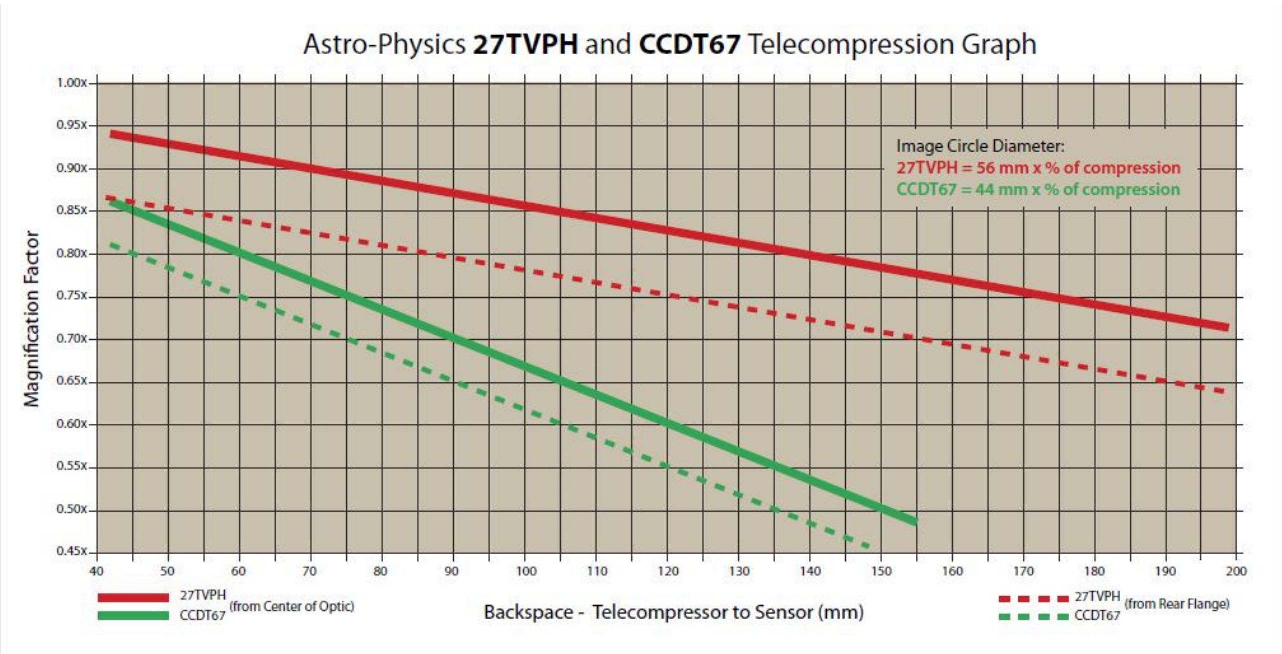
3- Focal reducers for Ritchey Cretien telescopes

For Ritchey Cretien aplanatic telescopes, the GSO brand has in its catalog a 0.75X two-element reducer with a back focus of 80 mm from the threaded part of the 2 "barrel which, despite the modest price, does its job quite well, but it has a 15mm image circle, which is enough for not very large sensors.For RC models there is also a TS optics 0.67 X 2 ″reducer, which provides an illuminated field of 29 mm and a back focus of 85 mm measured by the M48 thread.

4- An "all-rounder" focal reducer: the Astro Physics CCD T67

The focal reducer produced by the American firm Astro Phisycs works well with aplanatic instruments such as Meade ACF and Ritchey Cretien and is recommended for use on instruments with an F/D ratio of F 9 or greater.It has a diameter of 44 mm, and a focal length of 305 mm: used at a distance of 101 mm from the sensor, it provides a compression factor of 0.67 X with an illuminated circle of 29 mm (44 x 0.67).
Choosing a less aggressive compression factor, such as 0.78X, which is obtained by placing it at a distance of 66 mm, makes it suitable for telescopes with an F/D ratio lower than F 9. With this compression ratio it provides an illuminated circle of 44 x 0 , 78 = 34 mm.

In the following images (source Astro-Physics) the reducer and the graph of the relationship between magnification factor and back focus is shown, with the distance measured from the center of the lens and from the rear attachment.



Some simple formulas on reducers

These formulas, from the tests carried out by me, are applicable to telescopes with fixed focal length and that do not have a focusing system by moving the primary mirror such as the SC and some Matsukovs.

Lf focal lenght of reducer;
Fr reduction ratio
D distance between reducer and focal plane
Ci illuminated field
Dr diameter of reducer's lens

(values in mm)

Will be:

$$\mathbf{Fr = (Lf - D) / Lf} \qquad (1)$$

If, for example. A reducer of focal lenght of 230 mm is placed at 94 mm from the focal plane, then its reduction ratio will be 230-94/230 = 136/230= 0.59

From the (1)is:

$$\mathbf{D = Lf - (Fr \times Lf)} \qquad (2)$$

A reducer of 230 mm focal lenght with a reduction of 0.59 will be placed at a distance from focal plane of: 230- (0.59 x 230) = 230-136 = 94

The illuminated field will be:

$$\mathbf{Ci = Dr \times Fr} \qquad (3)$$

A reducer of free aperture of 40 mm and a compression ratio of 0.6 will have an illuminated circle of 40 x 0.6= 24 mm

Optimal distance in reducers-flatteners for Schmidt Cassegrains and telescopes with focusing with primary mirror movement

The the design distance between the reducer for classic SC and the focal plane with the reducer, as well as the focal length of the reducer itself are almost never declared by the manufacturers of these accessories. Often on the web there are contradictory solutions that lead to confusion. however, it is not trivial, as in this category of instruments the focus is reached by translation of the primary mirror to and from the secondary and this translation in turn causes a change in the focal length and in the original F/D ratio of the instrument.

Wanting to clarify the matter with an example, a Celestron 8 "SC is given for a back focus of 5" or 127 mm from the rear attachment, which should correspond to its native focal length of 2032 mm and an F / D ratio of 10.The insertion of the reducer will require a shift of focus towards the outside, with movement of the primary towards the secondary, at a distance of about 187 mm from the attachment instead of the original 127, which changes the F/D ratio of the instrument , which must be taken into account.

Be :

D2 the design distance of the focal plane with the reducer

D1 the distance deriving from the displacement of the primary towards the secondary due to the presence of the reducer

(Both measured from the center of the lens group of the reducer)

Fr the reduction factor

Then it will be:

$$\mathbf{D2 = Fr \times D1} \qquad (4)$$

Going back to the example above for an 8 "Celestron and reducer of the same house with a reduction ratio of 0.63, considering an additional distance from the original project focal plane (127mm) towards the outside of 60 mm, equal to a total distance of 187 mm from the external attachment of the lens hood (the 50 mm male threaded ring nut to which the accessories are fixed) and a thickness of 23 mm of the reducer the distance (D1) from the reducer itself due to its presence in the optical train will be 187-23 = 164 mm and you will have an optimal distance from the sensor or eyepiece plane of 105mm, a distance that allows to contain vignetting and aberrations at the edges of the accessory:

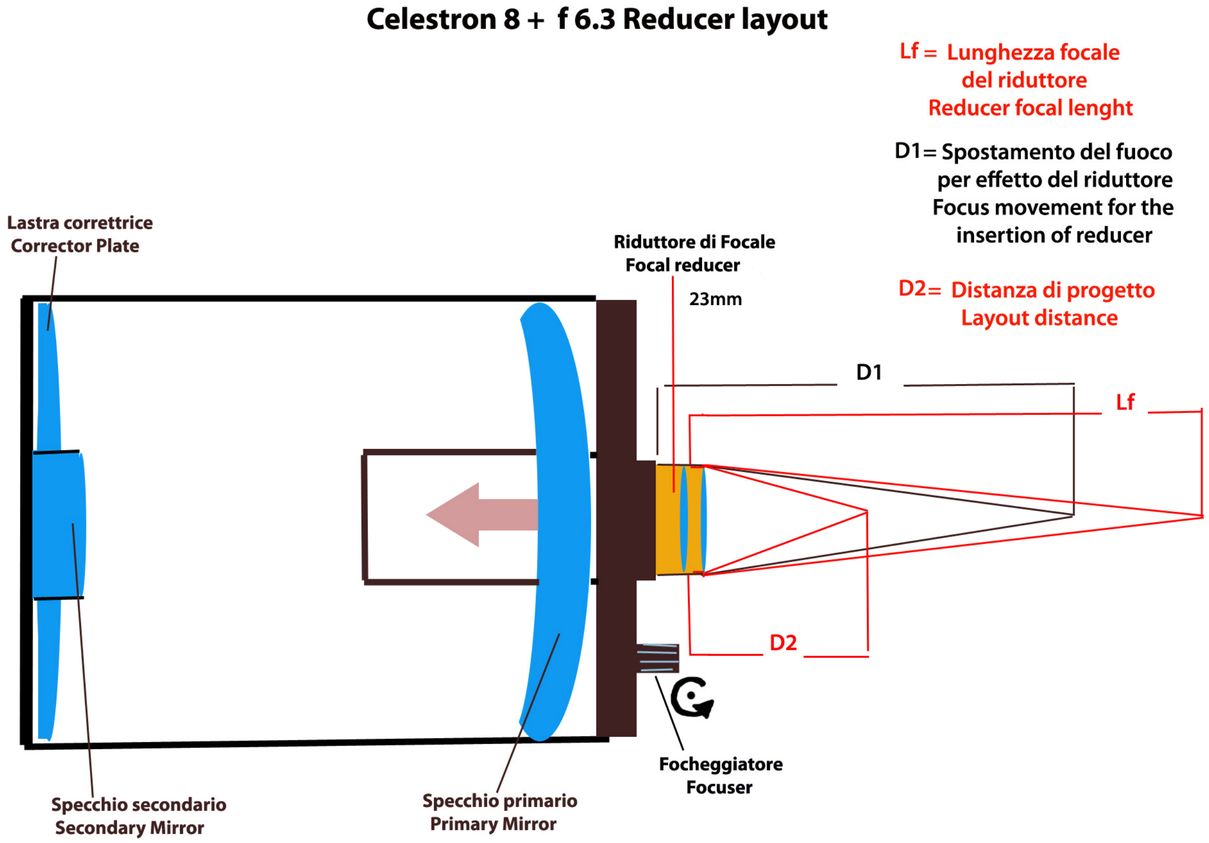
$$D2 = 0.63 \times 164 = 105 \text{ mm}$$

Obviously will be also:

$$Fr = D2/D1 \qquad (5)$$

Or, in the previous case: Fr = 105/164 = 0.63

The problem is illustrated in the following image



From practical tests carried out by me with my Celestron 8 (years 2000) and the Celestron reducer at f 6.3, with the adapters at my disposal and an Atik 314 L camera, it turned out:

Backfocus D1 (from the telescope threaded male attachment)	Reducer-sensor distance D2	Reduction factor D2/D1
190	107	0.64
250	120	0.53

The values D1 and D2 are consistent with those of the previous formulas and with the general formula of thin lenses for a focal length of the reducer of 230 mm, and considering that D1 is negative:

$1 / Lf = -1 / D1 + 1 / D2$

In the second of the two previous examples it is in fact:

$1/230 = -1/250 + 1/120$
$0.0043 = 0.0043$

For those wishing to try the experience with their reducer, telescope and CCD camera (recommended), the procedure is as follows:

- With adapters, extensions tubes and so on,make an optical train from the reducer to the camera that brings the reducer-sensor distance to the one you want (100, 105, 120 mm etc) ,compatibly with the end of the focus knob stroke , which should never be forced. Then focus on a star.
- The aforementioned optical train is disassembled and a second one is mounted , much longer than the first (about 2.5-3 times) without reducer and with the CCD camera, then focus again without touching the telescope knob, with longitudinal movement along the camera- telescope rear male thread distance. I used a Meade variable tele extender, which slides along its own axis, plus some extension tubes.
-Take note of the two distances, which will be D2 and D1

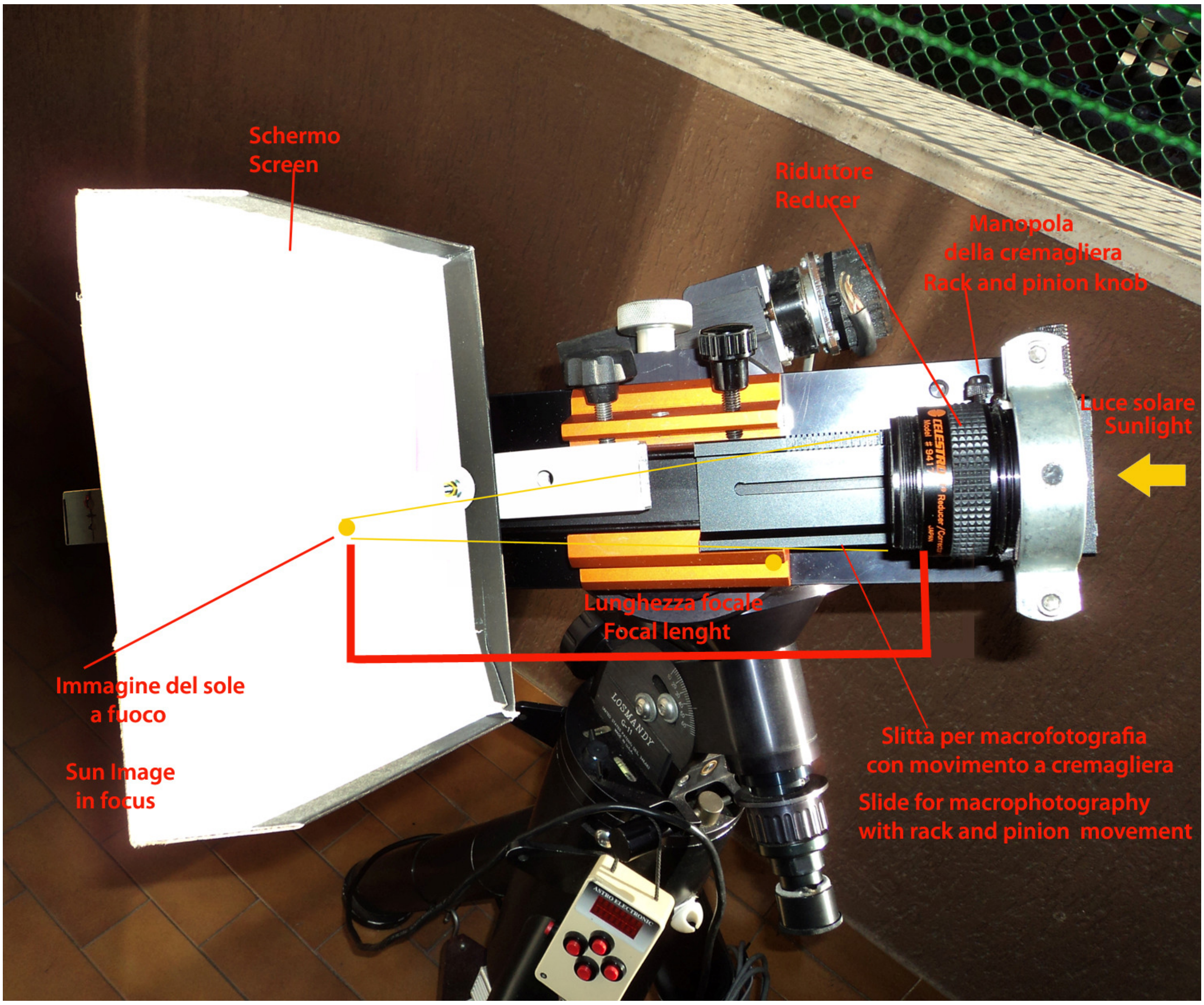
Finally, a reflection should be made: with the distance formula (2) on page 10 we would have obtained, for a SC from 8 "to f 6.3 with a Celestron reducer: 230- (230 x 0.63) = 230 - 145 = 85, a result different from the 105 mm known to be accepted and resulting from the above formula.

We talked about the focal length of the reducers, but it is important to know from which point of the accessory to start in order to measure the focal length with the method that will be seen . Here too there is some confusion: some start from the last lens, others from the center of the reducer, still others (correctly, in my opinion), from the center of the lens group.In a complex symmetrical lens the focal length is measured from the rear nodal point, in practice between the lenses, near the rear lens.Now,we don’t know the optical design and the characteristics of the objective in question, it is reasonable with a minimum approximation, to place the point from which to carry out the measurement in the center of the two groups of lenses.

How to measure the focal length of focal reducers and other optical accessories with a simple system

In the world of amateur astronomers there is often the need to measure the focal length of optical accessories with a certain degree of reliability, such as that of focal reducers in this article. There are several methods, but this time I intend to refer to the simplest one: the measurement of the focal point on a very bright object placed at infinity like the sun. The following setup can be useful for this purpose, consisting of a rack sled for macro photography of Chinese production (cost € 20) placed upside down on a Vixen bar and on whose lower anchor (now upper, with a photographic threaded hole) a ring has been fixed on which to insert the accessory whose focal length is to be measured.

On the opposite side there is another movable bar with a white plastic or cardboard screen.When, by moving the rack, the solar image is perfectly clear and in focus, the distance between screen (obviously orthogonal to the plane of the optics) and the accessory, is measured with a caliper or other measuring instrument in the desired point of accessory itself (ends of the lenses and / or center between the lenses themselves). It is not an extremely rigorous system, but it provides sufficient precision.



However,as I said before, the question arises from which point of the reducer to measure the distance, and here we need to make a clarification.Taking for example the Celestron af 6.3 reducer (but the Meade 6.3 and 3.3 are very similar if not the same, having probably been produced by the same factory) the situation is that illustrated in the image that follows: then, willing to take the measurement between the lenses of the optical group it will be taken at 9 mm from the last lens of the reducer, at the beginning of the male threaded part.

With this system I measured the distance of the three SC reducers in my possession, with the following result:

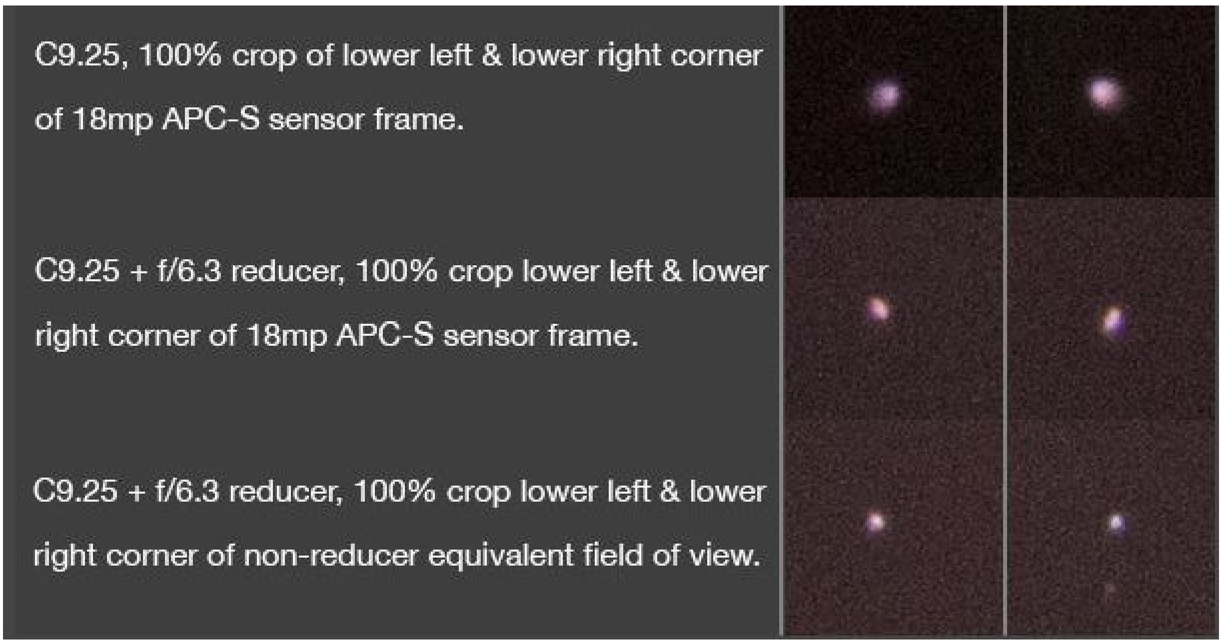
	Center of reducer lens group	Last lens
Celestron f 6.3	**230 mm**	**221 mm**
Meade f 6.3 serie 4000	**220 mm**	**211 mm**
Meade f 3.3 serie 4000	**90 mm**	**81 mm**

The distance was measured from the center of the lenses, to obtain the distance from the last lens just remove 9 mm,(the half of the thickness of optical group) as seen in the previous image. All three reducers date back to the early 2000s and are made in Japan. Reducers of the same type made in China could give different results.In particular, it seems that some Meade 6.3 reducers dating back to the early 2000s, in the period of the passage of production from Japan to China, were produced with a focal length of about 130-140 mm.<<

After this general overview of the most common reducers and reducers-flatteners on the market or available on the second-hand market, I will go on to talk in more detail about Celestron and Meade classic reducers-flatteners for Schmidt Cassegrain which have had a great diffusion among the owners of this category of telescopes, and that I own from a longtime.

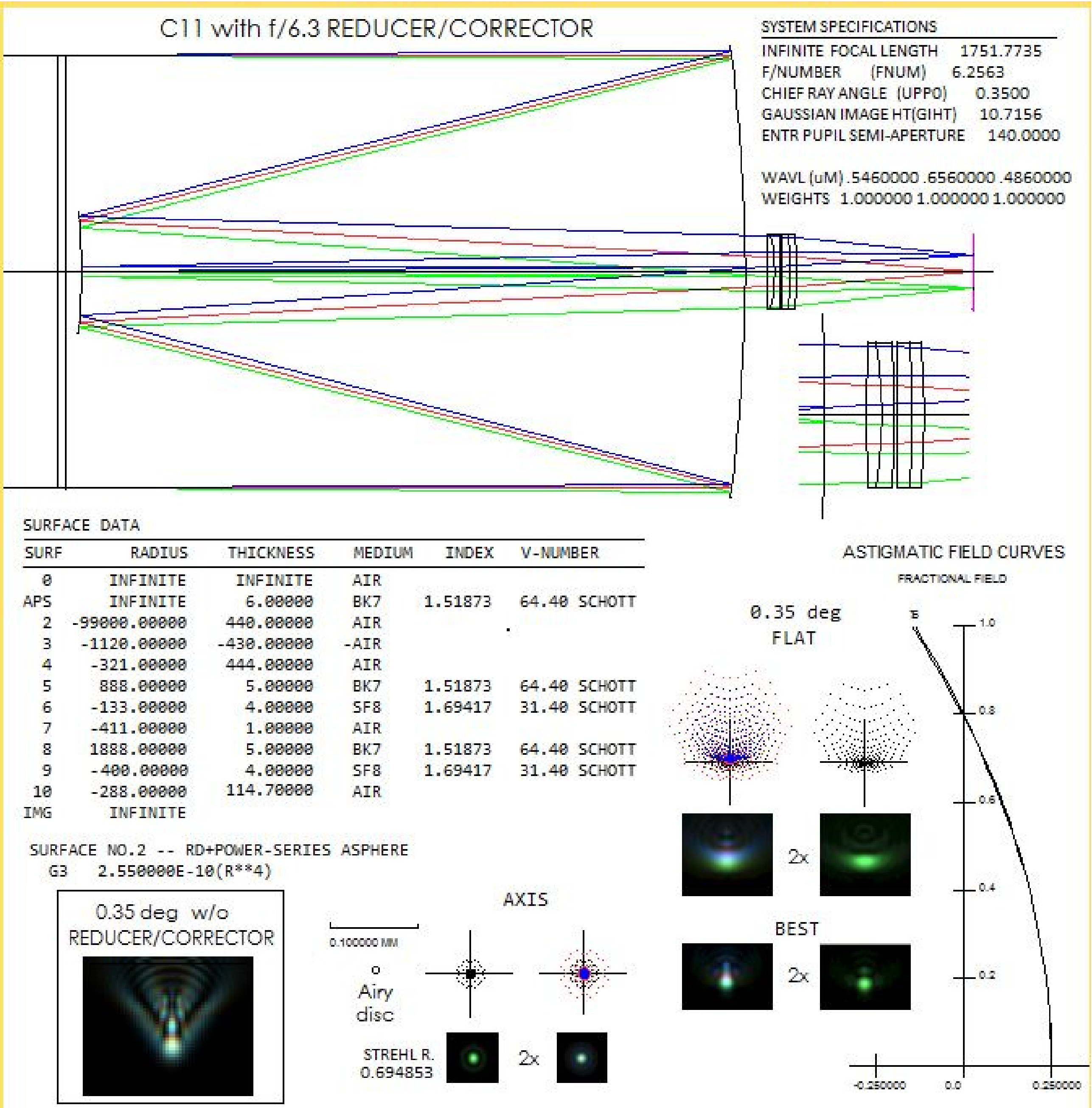
1 - Celestron f 6.3 reducer-flattener

This reducer - flattener has been designed for all Celestron SC telescopes at f10 (but also works with Meade af 10), with C14 being a f11, however, the reduction factor increases to f 7. According to the manufacturer, it reduces by 3 times the exposure time in astrophotography with a wider field. In addition to reducing the focal length and the F/D ratio of the telescope, it also reduces the field curvature common to all SCs, although it does not completely eliminate it. I add that in astrophoto the flattening effect is better with sensors up to the diagonal of the KAF 3200 (the sensor of the ST 10) while for the APS-C format it proves insufficient. In the following images (source astro-ecuadors.net) the correction at the edges of the frame of a Canon 600D and the illuminated field on the sensor are shown.The reducer is to be screwed in the male thread on the back of the telescope. As seen above, the optimal distance to reduce aberrations and maintain the factory reduction ratio is 105mm.



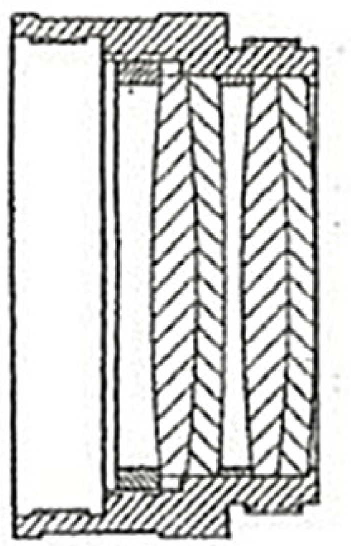
In the image that follows the result obtained by my C14 at f 7 on a 2x2 binning of the galaxy M64 with the Kodak KAF 3200 chip of my SBIG ST10: the stars are quite point-like at the corners, but already here the illuminated field is insufficient.

Technically, the design consists of two cemented doublets and it is similar to the Meade of the same type.In the following image(source: Telescope-optics.net/miscellaneous _optics)is illustrated the performance level with a C11 at f 10.The configuration corrects the coma but adds some astigmatism of the same sign, and therefore the field is not completely smoothed. However the smoothing of the field is significantly improved. Center line correction reaches Strehl of 0.8.

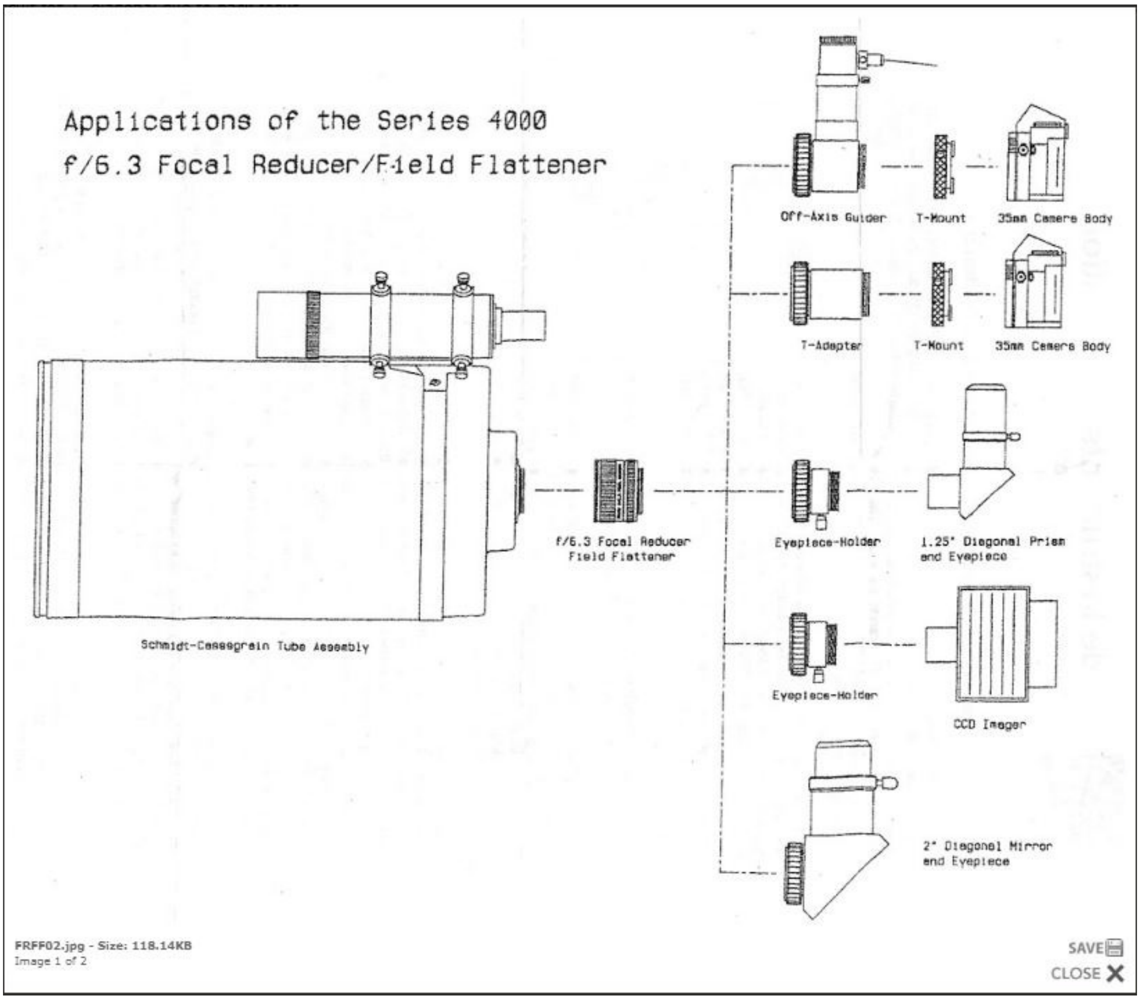


2- Reducer-Flattener f6.3 Meade series 4000

The optical scheme of the Meade at f 6.3, as seen in the following image (source Meade Corp.) is very similar, if not identical, to Celestron, and consists of 4 lenses in two groups with the surfaces multi-treated to maximize contrast. In the reducer instructions, unfortunately dating back to the 90s, it is suggested, for astrophotography, an optical train equal to a T adapter (about 40 mm) + a T2 ring (15 mm) + the normal photographic backfocus, oscillating around 45 - 46 mm, about 100-101 mm in all. However, I wanted to carry out the same test as the Celestron reducer, obtaining the following result: D2 107; D1 185 mm, and, considering the thickness of 25 mm of the reducer D2 / D1 = 107/160, which would give a reduction factor of 0.67. Now, imagining the same D2-D1 relationship rate of Celestron, at 108 mm of D2 it should be D1 = 194 and therefore D2 / D1 = 108/169 = 0.63 It would therefore appear that the distance of 108 mm from the focal plane is that which conforms to the design reduction ratio (if used with Celestron SC). About optical perfomances,, I could say that both the Meade and Celestron 6.3 reducers have high contrast and decent edge correction, at least on the medium sized sensors. Vignetting is still sensitive in both on the medium chips, but can be eliminated. with a good flat field frame.



Cross-section of the Series 4000 f/6.3 Focal Reducer/Field Flattener.



3- Reducer – flattener f 3.3 Meade series 4000

Unlike the f6.3 reducers, the Meade f 3.3 is not suitable for visual use, but only for CCD imaging with non-large sensors in which it produces significant vignetting and aberrations at the edges of the field. In fact,the corrected field should be around 9-10 mm, as it was designed at the time for use with Meade Pictor series CCD cameras, such as the 416 XT with a small sensor (4.6 x 6.9 mm). Its optics have three lenses, with a focal length of 80-90 mm depending on the point of measurement, as seen above. Like the others, it must be screwed to the male thread in the rear of the SC and Meade supplied it with two spacers, one of 30 mm, which with a f 10 telescope gave the ratio of F 3.3, and another of 15 mm, with which the ratio would have been F 5. The optimal spacing, considering the back focus of the camera sensor, should therefore be around 50-60 mm.

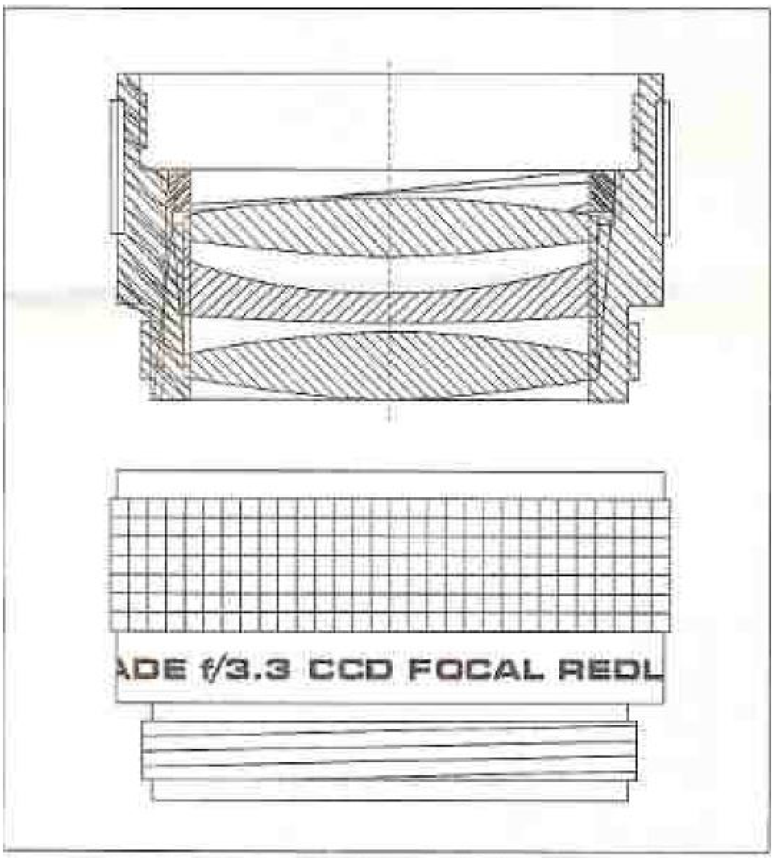


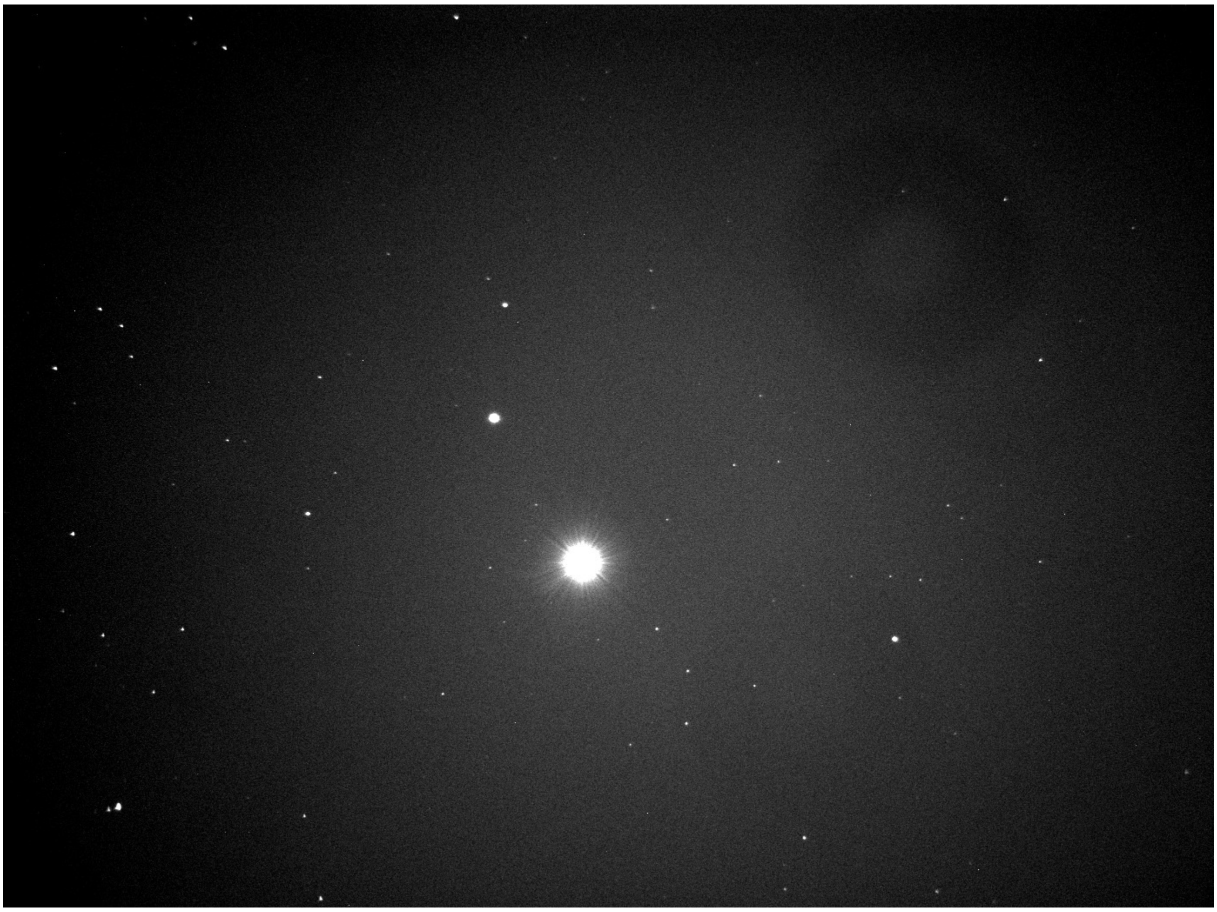
Fig. 1: f/3.3 CCD Focal Reducer/Field Flattener

So far the official news, as regards my personal experience with this reducer, I remember that I used it in the early 2000s with my C11 of the period, with satisfactory results on a Starlight Xpress MX716 CCD camera, with a Sony ICX 249 AL sensor 7.95 x 6.45 mm in size. Then this reducer was used by me to design and build one of my spectroscopes (CLAUS) and I didn't think about it anymore, since I have always used it with my C14 and other catadioptric devices in my possession (C9.25 and C8) the Meade and Celestron af 6.3 reducers.An offer on used items from a large Italian seller recently revived in me the idea of taking it to try it on some cameras with small sensors, such as a Lodestar X1 and a ZWO ASI 290. Then, the appetite comes with eating, during the writing of this article it occurred to me to try it, out of curiosity, on the Sony ICX 285 AL sensor of 10.2x 8.3 mm that equips the Atik 314 L on the Celestron 8 that I am using in this period of pandemy (I'm writing in February 2021) from my home in Rome, since I haven't been to my observatory in Ponte di Nona for some time.

The first problem was to identify the design distance D2 which, as mentioned, should have been around 50-60 mm. So I started from a distance between the center of the lens and the sensor of a total of 70 mm, only to realize that at this distance the focuser of the C8, in its movement of the primary mirror towards the secondary, reached the end of the stroke very shortly before the exact focus point: this distance (70 mm from the lens center - 61 mm from the last lens) was therefore to be considered as the maximum limit for the system of focus of the Celestron 8. My adapter park allowed me, around 60 mm, a distance of 68 mm from the lens center and 59 mm from the last lens , then I placed the camera at this distance and made 10 integrations of 10 seconds each, then stacked with Astroart.

The result is in the following images: as can be seen in the first 10 sec raw image, vignetting is present, but acceptable: it is almost completely eliminated with the flat (2nd image, stack of 10 frames of 10 sec, with flat and dark):about aberrations at the edge, they are present but all in all contained in relation to the noticeable compression ratio. This last factor was the most interesting, as, based on the distances used,of 68 mm for D2 and 260 mm for D1, it was equal to 68/260 = 0.26, a truly remarkable result, which transforms the C8 , which is a long-focus instrument, in a wide-field telephoto lens with a resulting focal length of only 528 mm.

Obviously the correct field of a 70-80 mm apo with flattener cannot be expected, but the aperture is 20 cm, and, for those who already own this accessory it is free, while for those who do not have it, and it is able to find it in the second-hand market, the cost is negligible (on average 80-90 €) given the current diffusion of digital DLRs and large sensors on which the reducer in question does not work or works badly.



Focal reducers for Schmidt Cassegrain Meade and Celestron as reducers and field flatteners of short focus refractors in CCD imaging

There is a widespread belief that the reducers-flatteners for Schmidt Cassegrain are exclusively dedicated to this category of telescopes: this is only partially true, as I will try to demonstrate. In fact, even refractors have a curved field and aberrations at the edges.

For that in astronomical photography there is a large variety of flatteners and flatteners-reducers dedicated to the various models of apochromatic refractors on the market, in order to make them suitable for photography with large sensors, such as those of digital SLRs in the formats APS C and 24 x 36.The sore point is that these accessories often cost almost half the cost of the telescope, while the refractors that have already implemented them in the optical scheme, such as Petzval, also have a high price in relation to their diameter .
Why then, for those who already own a reducer-flattener for SC, to try to use it for their 60 or 80 mm Apo at no additional cost, is such a solution possible, and to what extent? In order to answer this question, since last summer I have carried out some tests on two Apo refractors in my possession: a Sharpstar 50/330, ED doublet f 6.6 with FPL53 glasses and a Tecnosky 80/560, with glued triplet lens, f 7.

1- Sharpstar 50/330 ED

This small telescope, just bigger than a 50 mm finder scope, is sold under several brands: Sharpstar, TS, Stellarvue, etc: it is an ED refractor at f 6.6, which I bought second-hand for only 180 € from a friend amateur astronomer in Rome. The instrument struck me right from the start for its pinpoint star images and contrast, the problem is that it, photographically, covers a format equal to the Atik 314L sensor (10.2 x 8.3 mm), going further, vignetting and coma appear at the edges. Even with a good flattener, like the Astrotech AT2FF, with a spacing of 55 mm, it cannot cover the APS C format of digital SLRs, as reported by an American amateur astronomer on Cloudynights.
It was therefore the ideal candidate for the test I was going to carry out on the SBIG CCD cameras in my possession, an ST10 and a ST 8300, the latter with a sensor that is very close to the APS C format

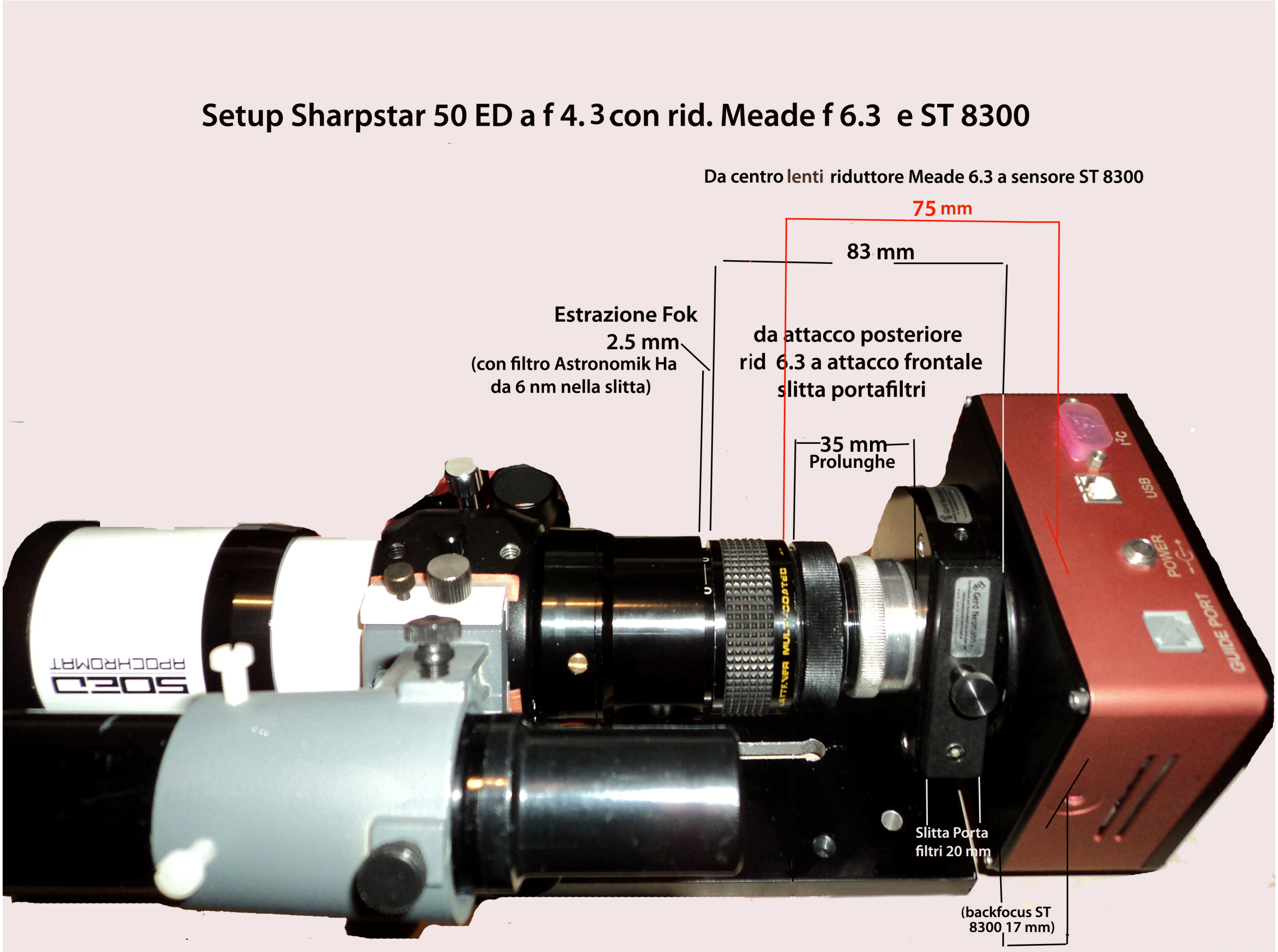
The first test was carried out last summer of 2019 from my apartment in the Arcinazzo highlands, with the Sbig ST 10 with a Kodak Kaf 3200 NABG full frame sensor of 14.85 x 10.26 mm and a TC 237 for the built-in autoguider.The astronomical object to capture was the NGC 7000 Nebula which, due to its considerable angular extension, that made a good target to perform the test. The final image is the union of three images of 3600 sec total each obtained respectively with a Baader H alpha 35 nm filter, an Astronomik H alpha 6 nm filter, and an Astronomik IR pass> 742 nm filter, in order to to highlight both the Hydrogen ionized gas of the nebula and the stars hidden behind it.

As can be seen from the image, even if reduced compared to the original, the stars appeared point-like up to the edge on the format in question, and the contrast was high despite the interposition between the telescope and the camera of a Meade 6.3 focal reducer.
The field appeared uniformly illuminated thanks also to a flat made with a special accessory (luminescent panel).

Given the (unexpected) success of the first test, in the days of last January 2021 I wanted to try again the same instrumental configuration from my home in Rome, with a large sensor, the Kodak KAF 8300, of 18 x13.5 mm of the my Sbig ST 8300, on an object of the period NGC 2237, the so-called Rosette Nebula, an H II region formed by clouds of hydrogen ionized by ultraviolet radiation emitted by hot stars (class 0 and B) belonging to the open cluster NGC 2244 located at the center of the nebula. From the city it is a rather elusive object, given the considerable angular extension. I have taken a series of frames of 30 and 60 sec in Ha and IR, without autoguiding.

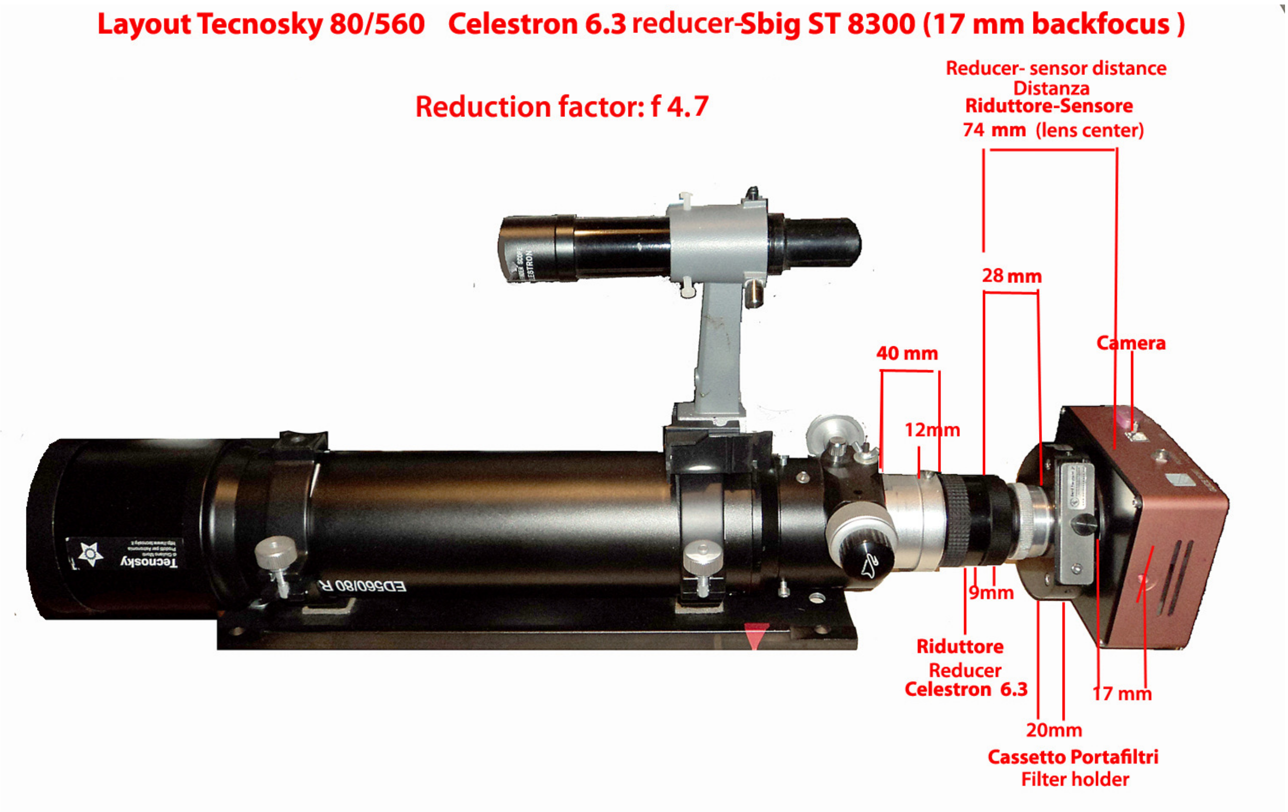
In the first 6 nm H alpha image in a 30 sec frame, it can be observed that the stars are quite pinpoint up to the edge. Also in the second image, stacking of 14 Ha frames of 30 sec and 14 IR 60 sec each, processed with AA and Psp, there is a good punctiformity of star images on the edges not perfect, but acceptable.

About the technical data: the following image shows the spacing used between the reducer and the camera. Applying the formula (1) at page 10 we have: Fr = (Lf - D) / Lf and therefore Fr = 220-75 / 220 = 0.66 (which by the way is exactly the 6.6 F/D ratio of the telescope). So we have 0.66 (original F/D ratio) x 0.66 (new ratio induced by the reducer) = 0.43 actual reduction ratio. Ultimately, the "strange couple" can be said to be usable up to sensors of the size of the KAF 8300, and this is already a good result, which however cannot be "tout court" extended to all apo refractors, as, in my opinion, it also depends on the aperture and the F/D ratio of the refractor used. Let's say that it is a stimulus to carry out interesting tests without any, or with minimal expense. Surely this setup will not cover the APS C format of digital SLRs, but even in this case you can get acceptable results with a crop of the final image.



Tecnosky 80/560 triplet

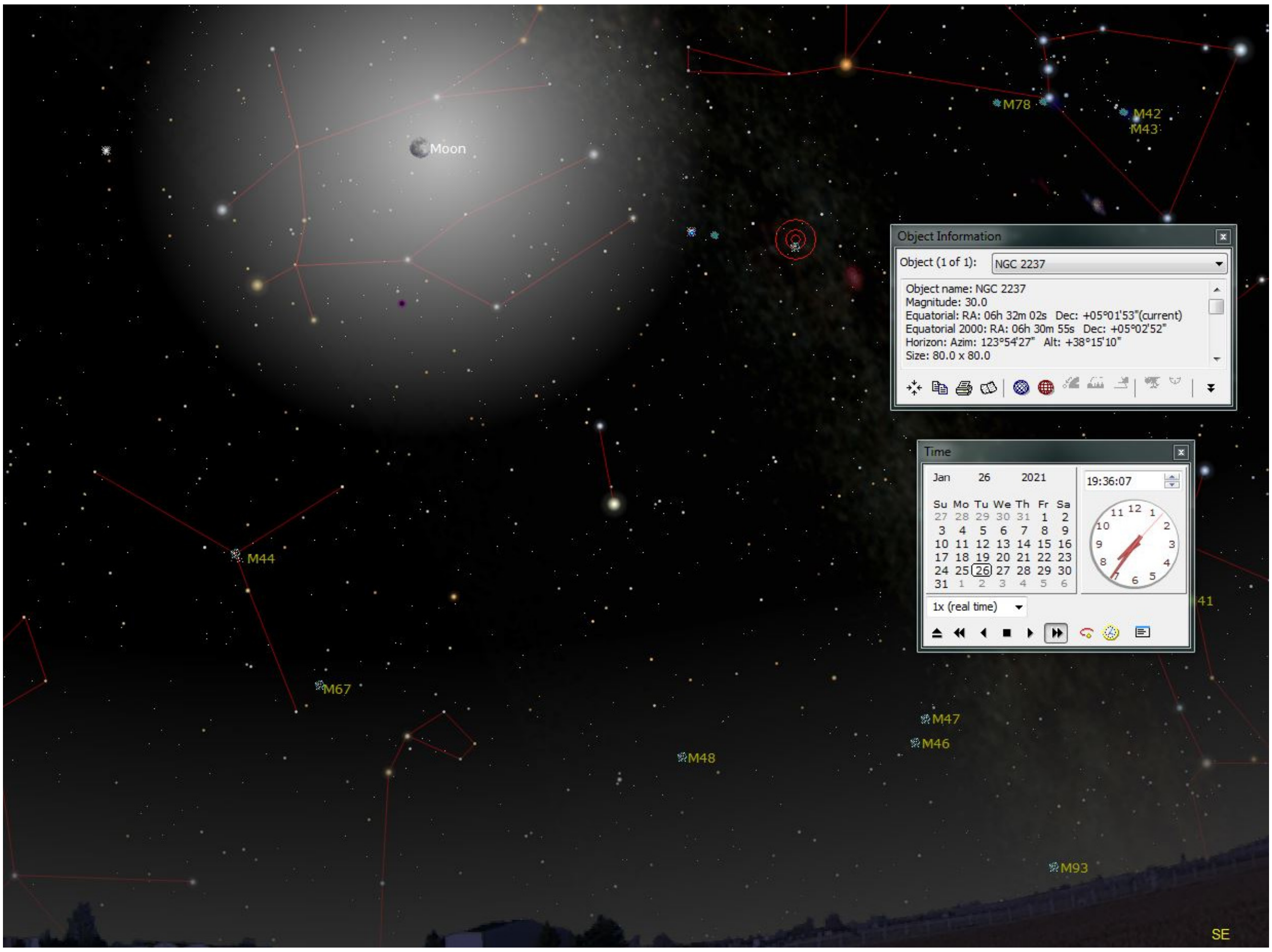
Intrigued by the previous test, I also wanted to try a larger diameter, and precisely an apo refractor in my possession,a Tecnosky 80 mm and 560 mm focal length, f 7, whose lens is a glued triplet, undeclared glass type lens, which behaves quite well in astrophotography, giving pinpoint star images with very low chromatism, I would say almost absent. However, in terms of planeness, this instrument barely covered the Sbig ST8 field. I decided, also to carry out the test on the Celestron reducer at f 6.3, similar to the Meade.The test was carried out with the setup shown in the following image.



As can be seen, the reducer (lens center)- sensor distance was 74 mm, therefore similar to that of the previous case, the focus point, of course, was found at a distance greater than that of 50/330, given the greater focal length , and the focuser of the instrument has been extracted by about 28 mm, instead of 2.5 mm. The reduction ratio was equal to 230-74 / 230 = 156/230 = 0.68 and the final one 0.68 x 0.7 = f 4.7

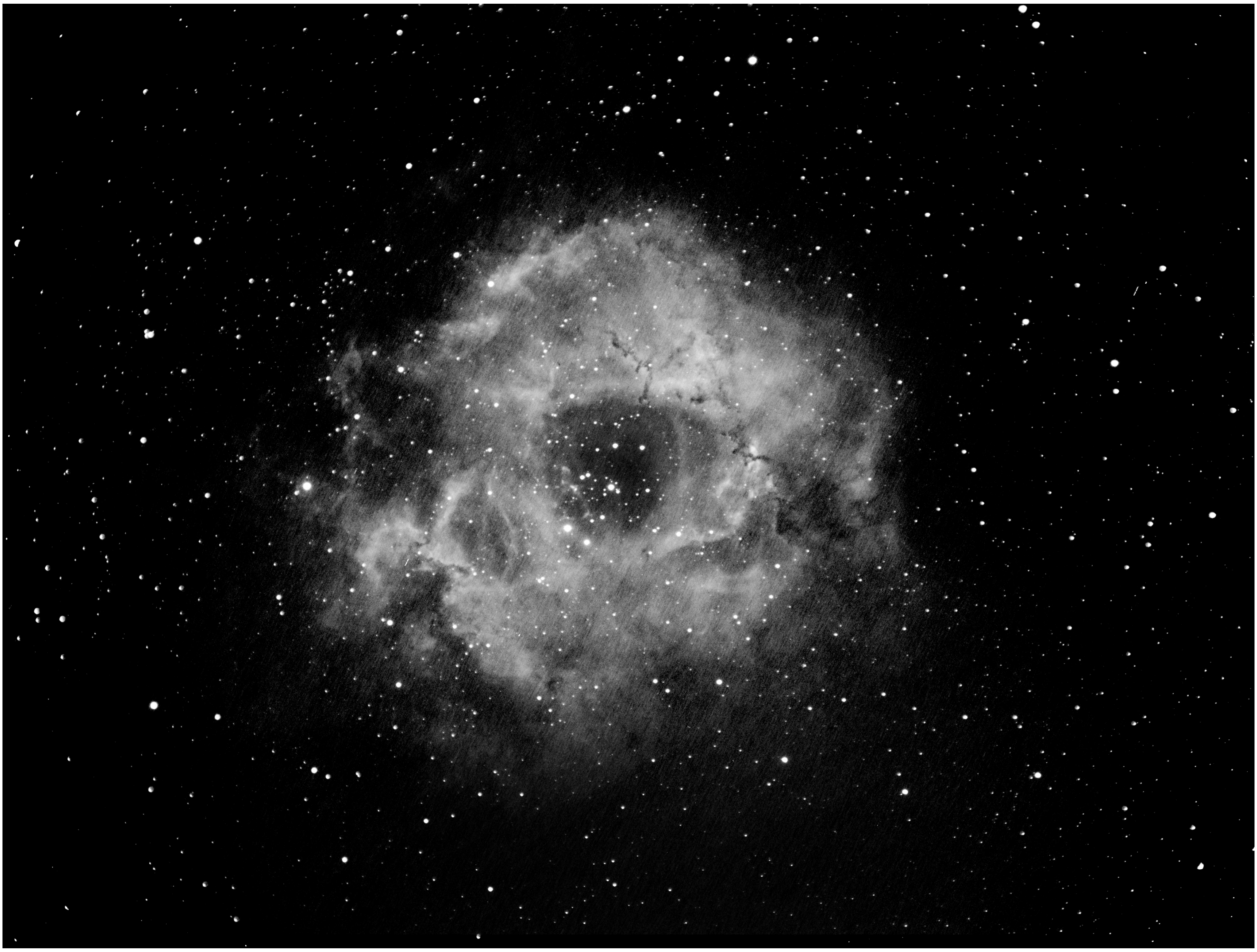
Once again the test, again from my home in Rome, was carried out on the target of the period, NGC 2237, on January 26, 2021, with 60-second frames each without self-guiding with the results of the following images.

It must be said that I purposely carried out the test in the worst possible sky conditions, in order to highlight vignetting and other negative points: in fact, at 19.37 the full moon was only 20 ° from the nebula, as shown by the following screenshot of software The Sky. and that the sky was barely veiled. Of course I was able to allow myself this reckless approach as I used an Astronomik 742 IR pass filter and a 6 nm Halpha filter, which greatly reduced the moonlight making it possible to obtain an image.



Below is a 60 sec raw frame at full resolution: the vignetting is evident, as are the aberrated stars at the extreme edges, but the situation appears to have improved anyway compared to the one without reducer.

In the following image the stacking of 40 frames,60 secs each, between Halpha and IR: insufficient exposure is observed, due to the clear sky background, despite the application of an anti-noise filter, but it was the maximum obtainable in those conditions. Overall performance of the Celestron-Tecnosky 80/560 reducer combination was all in all quite satisfactory, even if, as in the previous case, I don't think it can be on the APS C format, for which the images should definitely be cropped.



Conclusions

In this work, which was not at all easy due to the absence or presence of incomplete or unsatisfactory informations, or in some cases, contradictory on the web and on astronomy texts, I tried to clarify some points of a topic not enough studied in deep,despite the tens of thousands of owners of such accessories on a planetary scale.
I was able to ascertain that the reducers for SC can also be used to flatten and reduce, with all the limitations and precautions of the case, and only after some field tests, even the images obtainable with short focus Apo refractors (f 6 and 7) which today are the most popular, especially for use with CCD or CMOS cameras up to a format immediately lower than APS C, remaining in any case possible, for users of digital SLRs, to partially cut the images, while preserving the usefulness of the reduction of the F/D ratio. I have not tried to use the Meade F 3.3 on refractors as I am sure it would provide unacceptable images on these, but this does not prevent any owners of this accessory from carrying out tests with sensors small, perhaps transforming, if they can, an af 5 refractor in an f 1.6 objective!.