

INVESTIGATION OF TOP QUALITY TELESCOPES.

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INTRODUCTION.

Recently some new telescopes were introduced: the Leica Apo-Televid 82 (objective diameter 82 mm) and the Kowa Prominar 883 (objective diameter 88 mm), while the Swarovski ATM80HD was introduced as the successor of the Swarovski ATS80HD (both with 80 mm objective). Although the Zeiss Diascope 85 (with 85 mm objective) is on the market for a number of years, I have tested this telescope as well. All four telescopes are available in a straight version and in an angled version. Investigated are the instruments with angled eyepiece. The eyepieces of the telescopes can be changed so the telescopes are suited for different observation purposes.

APPROACH.

With different methods various aspects of the optical quality and of the user comfort are investigated. For a quick and convenient overview the results of the investigations are listed in a number of tables.

MEASURES AND WEIGHTS

The telescopes with their zoom eyepieces are all of almost the same length (39-40 cm). The weight differences are larger. Weight is an important factor for user comfort certainly when the telescope with tripod has to be carried around for a long time. As can be read in the table the telescope weights differ quite a bit. Telescopes, which do not have a rubber armouring (Kowa, Zeiss) need (certainly at temperatures below zero Celsius) an ever-ready-case, the weight of which has to be added to the weight of the telescope. Quick coupling or decoupling of the telescope from a tripod requires a tripod platform, which fits into the fast-coupling device of the tripod. The tripod platforms of Kowa and Zeiss are not suited for that purpose, so in that case they have to be supplied with a fast coupling device (approx. 40 grams in weight).

Telescope	Weight telescope	Weight telescope plus ever-ready-case	Weight telescope plus ever-ready-case plus tripod fast coupling device	Score
Kowa Prominar 883 with 20-60x eyepiece	1846 grams	2081 grams	2121 grams	3
Leica Apo-Televid 82 with 25-50x eyepiece	1910 grams	2222 grams (ever-ready-case not necessary)	2222 grams (ever-ready-case not necessary)	4
Swarovski ATM 80 HD with 25-50x eyepiece	1594 grams	1824 grams (ever-ready-case not necessary)	1824 grams (ever-ready-case not necessary)	1
Zeiss Diascope 85 T* FL with 20-60x eyepiece	1730 grams	1965 grams	2005 grams	2

USER COMFORT

The telescope tube.

The telescope tubes of the Swarovski ATM80HD and the Leica APO-Televid 82 are covered with a hard rubber armouring (Swarovski green, Leica black), which protects the telescopes against bumps and which prevents the telescope from generating noise. The rubber armouring protects the telescope well so an ever-ready-case is not required for protection. The Kowa and Zeiss telescopes have a bare metal housing: Kowa with light-green colour, Zeiss with a green or with a silver colour. A bare metal housing without armouring can be very annoying: it is a potential source of noise if an object hits the telescope and especially at freezing temperatures a metal housing is not something to be handled without gloves. In those circumstances an ever-ready-case helps with its advantages and disadvantages like an increase in price and an increase in weight. When the ever-ready-case is used only for transport of the telescope in a

backpack, than a simple nylon bag (as offered in many outdoor shops) is lighter and cheaper. In full sunshine a silver metal housing does not collect as much heat as a coloured housing with or without armouring (every disadvantage has its advantage according to a famous Dutch soccer philosopher).

The focussing device

The focussing device of the Kowa, Leica and Zeiss telescopes is incorporated in a bulge on top of the prism housing. The focussing wheel consists of two parts: a fast focussing wheel and a slower focussing one for very accurate focussing. The smooth turning focussing wheel of the Swarovski telescope is an integral part of the telescope tube. That makes the Swarovski telescope slimmer and more tightly shaped than the other telescopes. Both focussing systems have their own supporters, but in my opinion they both work well. When one uses the telescope for photography purposes I myself prefer the Swarovski focussing system, but others will undoubtedly favour with similar arguments the other focussing system. At temperatures below zero Celsius the focussing wheels of the Leica and Zeiss telescopes are more difficult to handle when carrying gloves. The focussing wheel of the Kowa telescope has some margin. Time will learn how that works out after heavy use. There is a big difference in focussing speed ranging from 2 to 6 revolutions from close focus to infinity, see the table. Kowa and Swarovski are the fastest ones with approximately 2 revolutions from close focus to infinity. The focussing speed was measured with a stopwatch and Kowa and Swarovski were two times faster (2-3 seconds versus 5-6 seconds). Focussing speed certainly is an important point to keep in mind especially with fast moving objects. A slow focussing speed is in that case very frustrating. Score focussing speed: Kowa 1, Swarovski 1, Leica 2, Zeiss 2.

Tripod platform

A vibration free arrangement is an absolute requirement for a steady and razor sharp telescope image. That asks for a sturdy tripod platform of sufficient size. The Kowa, Leica and Swarovski telescopes have a tripod platform of approximately four by four centimetres. The tripod platform of the Zeiss telescope is smaller, see the table. Kowa, Swarovski and Zeiss have supplied their tripod platforms with the two common threads to fix the telescope to a tripod (1/4 inch English thread and 3/8 inch German), Leica has only the English thread, which is the most common one. All four telescopes have their tripod platform attached to a ring around the telescope tube in which the tube can turn around its axis. The rings are supplied with a stopper system to choose specific angles of the telescope tube. That allows quick finding of desired positions of the telescope tube.

Above the comfort of a fast coupling device to a tripod has been mentioned. Only the tripod platforms of Leica and Swarovski fit by itself directly into the fast coupling device of a Manfrotto tripod or in tripods of own brand (Swarovski).

For fast coupling of the Kowa and Zeiss telescopes on a tripod a fast coupling device of, for example Manfrotto, has to be attached to the tripod platform of the telescope. That increases the weight (+ 40 grams) and the price (+15 to 30 euros) of these telescopes.

Lenshood, aiming device, optical filters.

All the investigated telescopes have a retractable lens hood. From the telescopes of Kowa, Swarovski and Zeiss the lens hood can be extracted and it also can turn around the telescope tube, the hood of the Leica telescope hood can only be extracted and pushed back. The lens hood of the Kowa telescope moves slightly loose on the telescope tube.

Telescopes have a relatively small field of view certainly at higher magnifications. That makes it difficult to find the object quickly especially when that object is moving fast from left to right (or the other way) in the field of view. Therefore all telescopes have an aiming device for quick finding of the object. The aiming device of the Kowa, Leica and Zeiss telescopes is positioned on top of the lens hood; the Swarovski telescope uses a small tube as aiming device, which is located under the eyepiece. It can be removed from the telescope. All objective mounts are supplied with a thread mount for inserting optical filters; their sizes are listed in the table. Such large size optical filters are rather expensive.

The eyepieces

Each telescope has its own supply of eyepieces. They are listed in the table together with their field of view. The 20-60x zoom eyepiece is a favourite choice for birders. In practice a magnification of 60x is not always useful either because the available light does not have too low a level to distinguish details as a result of the very small exit pupil at 60x, or because the optical quality is insufficient or because air turbulence hampers the observations. Moreover the field of view becomes rather small at 60x magnification. Leica and

Swarovski have now also introduced a 25-50x eyepiece, which seems to have a more universal applicability also because of the larger field of view. The Leica and Swarovski engineers deserve compliments for the splendid optical performances of these wide angle zoom eyepieces: it is a real asset for birders. It is not sure whether Leica will offer a 20-60x eyepiece for the new Leica Apo-Televid, that is still under investigation.

All the investigated telescopes have a bayonet fitting with a locking device for fast exchange of the eyepieces. Kowa, Leica and Swarovski use a springy catch as a locking device, which is released by pushing a small button. The small rubber armoured button of the Leica telescope gives some trouble to uncouple the eyepiece. It goes smoothly and all right with the Kowa and Swarovski telescopes. Zeiss uses a springy locking device with snaps into position and is then locked. That works also fine, it is even quicker than the button locks.

All eyepieces have twist-up or extractable (Zeiss) eyecups to accommodate spectacle users. The eyecups of Kowa and Swarovski have a thread mount while Leica uses a bayonet, which is kept in place with ball bearings. It takes quite a bit of force to remove the Leica eyecups and it is not easy to put them back into their original position. A thread mount is more comfortable. The eyecups of the Zeiss Diascope can not be removed by the user of the telescope and when they are damaged the telescope has to be brought to a repairperson.

The eye relief is sufficient for all telescopes to give spectacle users full access to the whole field of view. Surprisingly the Swarovski eyepieces with an eye relief of 17 mm even give access to the whole field of view when using ski goggles, whereas the other telescopes with larger eye relief do not (ski goggles have a larger distance to the eye than normal spectacles).

OPTICAL QUALITY.

Optical quality of a telescope is the key element for top level telescopes. Important parameters of the optical quality are image brightness, sharpness of the full image, perfect colour reproduction and good correction of optical aberrations like colour dispersion, spherical aberration, curvature of field, astigmatism, coma etc.

(a) luminosity- image brightness.

The luminosity of a telescope or binocular is fully determined by the size of the exit pupil and the light transmission of the optical system. High luminosity is a very important basis for optimal image brightness. To make things more complicated: colour reproduction of the optical system also plays a role for the establishment of image brightness observed with the human eye.

The **exit pupil P** is defined as the objective diameter (**O**) divided by the magnification (**M**): $P=O/M$. It means that a larger objective diameter yields a larger exit pupil at the same magnification. This yields in principle a higher luminosity unless the light transmission of the optical system is low. Often objective diameter, magnification and exit pupil do not have the exact values as printed on the telescopes or binoculars. Therefore the values of these properties were measured and the results are listed in the tables below.

The exit pupil is related to the size of the pupil of the human eye, which is small in full daylight (2 mm) and grows larger at low light levels (8-10 mm at a young age and 4-5 mm when you are over 45 years of age). A telescope with its exit pupil of 4,4 to 1,5 mm is therefore not very well suited as a night observation instrument. With these restrictions in mind it is understandable that for an optimal performance at low light levels a high light transmission is of importance.

The light transmission is the percentage of the incoming light, which is transmitted by the optical system of a telescope or binocular. Part of the light that enters the telescope is namely lost for image formation by (a) absorption of light by lenses and prisms of the telescope (this is a small amount with modern optical glass) and (b) through reflection of light on glass-air surfaces. High quality coatings reduce reflection losses to a large extent. Nevertheless even with top telescopes 10-20% of the incoming light is lost for image formation.

Light transmission is measured with special equipment. The obtained transmission spectra yield the following information:

- High light transmission over a broad spectral area (blue- green-red) is an important basis for a bright image.

-The shape of the transmission spectrum gives information about the colour reproduction of the optical system: a low transmission in the blue part of the spectrum (500nm) and a much higher transmission in the green-yellow region (550-620 nm) results in a yellow bias of the colour reproduction. A flat transmission

spectrum over a broad spectral area of 500-560 nm yields a good colour reproduction. The spectral area of 500-560 nm has to do with the light detecting pigment system in the human eye. That consists at daylight of colour sensitive cones with optimum sensitivity around 555 nm. At low light levels the cone system does not work anymore and light detection is taken over by the very sensitive rods in the eye, which have their optimal sensitivity around 500-505 nm.

As written above the luminosity of a telescope is determined by the combination of the size of the exit pupil and the amount of light transmitted by the optical system. The Kowa and Zeiss telescopes are expected to have in principle with their objective diameters of respectively 88 and 85 mm a higher luminosity at magnifications for which the exit pupils amount 44,-3,2 mm (approximately 20-27x) as compared with the Leica and Swarovski telescopes (which have maximum exit pupils of approximately 3,2 mm). In reality the situation is more complicated because of the differences in light transmission between the telescopes. The transmission measurements show that the light transmissions of the Kowa and Zeiss telescopes at 500 nm, the spectral area of optimum sensitivity of the human eye at low light levels are considerably lower than the light transmission of for example the Swarovski ATM80HD telescope. The result is that the performance at low light levels of the Kowa and Zeiss telescopes is less than one would expect in comparison with the Swarovski telescope.

One can illustrate the combined effect of exit pupil and light transmission as the effective luminosity with measurement data of the light output of the different telescopes under standardized conditions with a light meter, which has the same spectral response curve as the human eye. The results of such measurements are listed in an attachment, but they are not used as parameters for this test, since the interpretation is not straightforward, since one has to take into account the differences in field of view as the basis of the amount of light entering the telescope. Nevertheless the data may be interesting as "brain gymnastics" for smart readers who like puzzles.

(b) colour reproduction

The colour reproduction of the Swarovski ATM80HD telescope is perfect. For an explanation see the flat transmission curve in the wavelength range 500-560 nm. The Leica Apo-Televid scores second followed by the Kowa Prominar 883 and the Zeiss Diascope 85. The colour reproduction of the two latter ones moves slightly to the yellow part of the spectrum, but it is much stronger for the Zeiss telescope than it is for the Kowa telescope. In photography such a yellow bias is indicated as "warm" but birders need a perfect colour reproduction. The differences in colour reproduction are clearly visible by eye.

Score colour reproduction: Swarovski 1, Leica 2, Kowa 3, Zeiss 4

(c) colour aberrations c.q. colour dispersion

The four investigated telescopes all have colour correction lenses. That means that they contain optical elements with minimal colour dispersion. For that purpose Kowa has incorporated in the optical system of its objective a lens element consisting of calcium fluoride, a mineral with very low colour dispersion. Calcium fluoride has also some disadvantages: it withers quickly when exposed to humid air. That problem can be solved efficiently with a good coating. Furthermore calcium fluoride is sensitive to sudden temperature jumps with the risk of cracking. Kowa has solved the calcium fluoride vulnerability problem by incorporating the calcium fluoride element between other less vulnerable glass elements in the five lens objective. Zeiss also uses a fluoride containing element in its objective with the same vulnerability problem and Zeiss has solved that problem in an identical way as Kowa.. Leica and Swarovski have also used lenses with low colour dispersion cf. the indications APO (Leica) and High Definition (Swarovski). Remnants of colour dispersion can be found at the very edges of the field, it is very small at the Kowa, Swarovski and Zeiss telescopes and a little more at the Leica telescope, but the differences are very small.

(d) field curvature/edge sharpness

The sharpness at the edges of the image of the Swarovski ATM80HD is excellent. Kowa and Leica are also performing well in this respect, although it is a tiny bit less than that of the Swarovski telescope. The Zeiss Diascope 85 clearly has an area of blur at the edge of the image and that is not pleasant, considering the relative small fields of view of telescopes.

Performance at low temperatures

At temperatures of minus 10 to minus 20 degrees Celsius, the focussing system, zoom mechanism and twist-up eye cups of the Leica, Swarovski and Zeiss telescopes perform excellent. With the Kowa Prominar the friction of all these systems is slightly increased at these low temperatures, but is not a problem for their

performance, they still can be turned well. With gloves the broad focussing ring of the Swarovski telescope is easy to use, both rings of the Kowa telescope can also be used well with gloves, but the user comfort of the focussing rings of the Leica and Zeiss telescopes is less since the rings are more difficult to use with gloves.

WARRANTY AND SERVICE

The service of Kowa goes through its dealer Benel in Hoogeveen, The Netherlands, who has a repair person available in The Netherlands who performs the majority of the repairs. If the repair person can not solve the problem, the telescope is sent to Kowa. The appointment is that the customer receives on request a written statement about the expected duration of the repair and about the costs of the repair.

In The Netherlands Leica had acquired a not so good reputation with regard to repairs: expensive and long waiting times. Leica dealer Transcontinenta has handled that problem drastically and starting Januari 1, 2009 repairs are handled under courtesy that means: with no or with very low costs (unless the damage is caused by carelessness of the client) and repairs are performed as fast as possible.

Quite a few shopkeepers report that Swarovski has an unrivalled service, fast and without costs unless the client has caused the damage himself.

Zeiss has a good service through its dealer Technolyt in Wormerveer, The Netherlands, who does most of the repairs by its own repair person. When repair problems are too complicated the telescope is sent to Zeiss, who has an excellent repair department in Germany. Technolyt has so much confidence in the quality of the Zeiss telescopes that it has increased the warranty term of the Zeiss telescopes and binoculars with 20 years on top of the ten years warranty by Zeiss.

CONCLUSION

Score list of performances. A score of 1 means that the telescope scores highest on a particular point etc. As a consequence of the application of that method the telescope with the smallest number of points has the best overall performance.

Telescope	Kowa Prominar 883	Leica Apo-Televid 82	Swarovski ATM80HD	Zeiss Diascope 85 FL
Weight	3	4	1	2
Focussing speed	1	2	1	2
Colour reproduction	3	2	1	4
Rubber armouring of the telescope body	2	1	1	2
Light transmission: 555nm (daylight viewing)	4	2	1	2
500nm (night viewing)	3	2	1	3
Sharpness at the edges	2	2	1	3
Remnants of colour dispersion	1	1	1	1
Eyecups	1	2	1	3
Fast coupling on tripod	4	1	1	4
Price	1	3	4	2
Total score	4x1 2x2 3x3 2x4	1x1 8x2 2x3 2x4	12x1 1x2 1x4	2x1 5x2 4x3 2x4
Final score	25	22	14	28

The final score is clear: the Swarovski ATM80HD wins by a mile as the best, but it is also the most expensive telescope. The Leica Apo-Televid 82 scores second and has almost the same price as the Swarovski ATM80HD telescope. The Kowa Prominar 883 and the ZeissDiascope 85 close the row. The differences in the final scores of the Kowa, Leica and Zeiss telescopes are small, there are however differences on specific points, which may be of importance for birders (weight, tripod coupling, field of view, image brightness/transmission, colour reproduction). The price most certainly will play an important role when one considers to buy a telescope and the Kowa Prominar 883 telescope has in that respect an attractive master card, followed by Zeiss, who also offers digiscopers the very user friendly DC4 digital photo eyepiece.

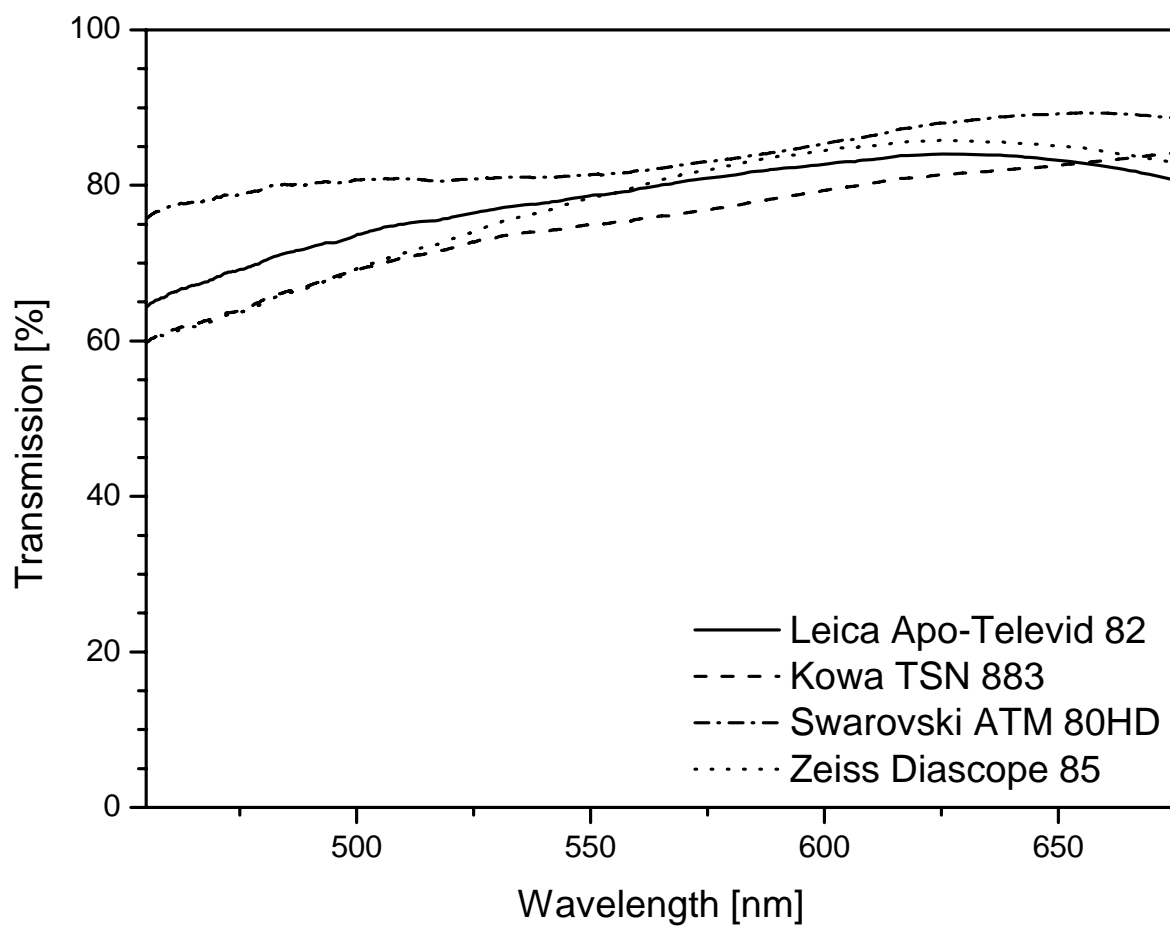
Before the reader buys a telescope in this price segment it is advisable to investigate the properties of the different telescopes carefully and compare their performances in accordance with your own demands. Perhaps you can use the score list above and write your own observations in it to construct your own score list before you cut the expensive Gordian knot.

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**Table
Telescope data**

Telescope	Kowa Prominar TSN 883	Leica Apo-Televid 82	Swarovski ATM 80 HD	Zeiss Diascope 85 T* FL
Weight (grams)	1846 g (+ 20-60x eyepiece)	1910 g (+ 25-50x eyepiece)	1594 g (+25-50x eyepiece)	1730 g (+ 20-60x oc.)
Close focus	5,2 m	3,7 m	4,8 m	4,5 m
Watertight	Yes	Yes	Yes	Yes
Nitrogen filled	Yes	Yes	Yes	Yes
Type of prism	Schmidt roof	Schmidt roof	Schmidt roof	Schmidt roof
Phase correction coating	Yes	Yes	Yes	Yes
Available eyepieces and their field of view (m/1000m)	25x: (37 m/1000m) 30x: (42 m/1000m) 20-60x: (38-19m/1000m)	32 x: (40m/1000m) 25-50x: (41-28 m/ 1000m) 20-60x: (34-20 m/ (1000m) (productie hiervan wordt onderzocht)	20x: (60m/1000m) 30x: (42m/1000m) 25-50x: (42-27m/ 1000m 20-60x: (36-20m/ 1000m	40x: (30 m/1000m) 20-60x: (43-20m/1000m) Digitaal camera eyepiece DC4 40x (30m/1000m)
Number of focussing rotations from close focus to infinity	2	5	2,25	6
Measured exit pupil P (mm)	20x: 4,3 mm 60x: 1,5 mm	25x: 3,1 mm 50x: 1,6 mm	25x: 3,2 mm 50x: 1,6 mm	20x: 4,4 mm 60x: 1,45 mm
Measured objective diameter O (mm)	87,6 mm	81,2 mm	80,0 mm	85,0 mm
Calculated magnification M= O/P	20,4x 58,4x	26,2x 50,7x	25x 50x	19,3x 58,6x
Light transmission 500 nm (night vision) 555 nm (day light vision)	69% 75%	74% 79%	81% 82%	69% 79%
Measured light intensity of light leaving the telescope under standardized conditions	20x: 88 P=3 mm: 60 60x: 20	25x: 72 P= 3mm: 70 50x: 35	25x: 98 P= 3mm: 90 50x: 40	20x: 105 P= 3mm: 78 60x: 24
Eyecups	Twist-up, removable	Twist-up, removable	Twist-up, removable	Extractable, not removable
Eye relief (mm)	20x: 17 mm 60x: 16,5 mm	25x: 19 mm 50x: 19 mm	25x: 17 mm 50x: 17 mm	20x: 16 mm 60x: 16 mm
Suited for: Spectacle users: Skigoggle users:	Yes No	Yes No	Yes Yes	Yes No
Colour reproduction	Very small yellow bias	Almost neutral	Perfect	Visible yellow bias
Filter thread Mount	95 mm	E82	M 82x0,75	M 86x1
Tripod platform (mm)	44x49 mm	42x42 mm	42x45 mm	28-32x45 mm
Rubber armouring	No	Yes	Yes	No
Ever-ready-case	Yes, 85 euro, 235 gram	Yes, 180 euro, 312 gram	Yes, 205 euro, 230 gram	Yes, 179 euro, 235 gram
Other available accessories	- Photo and video adapters - Digital camera adapters - Fluid pan head tripod	- Mirror reflex camera adapter - Digital adapter	- 3 tripods, - Tripodhead FH 101, - TLS 800 mirror reflex camera adapter, - digital camera adapter	- Digital camera eyepiece DC4 - Mirror reflex camera adapter - Quick camera adapter (foto en video) - Tripod - Astro adapters
Warranty	5 years	10 years	10 years	10 years Zeiss plus 20 years Technolyt
Price Body Price eyepiece Price complete set	2539 with zoom eyepiece 20-60x 2539 euro	2499 euro 700 (25-50x) euro 3199 euro	2570 euro 710 (25-50x) euro 3280 euro	2289 euro 569 (20-60x) euro 2858 euro
Final test score	3	2	1	4



ATTACHMENT.

Results of the measurement of the light output of the investigated telescopes at (A) the lowest magnification of the zoom eyepiece, (B) at identical exit pupils and (C) at the highest magnification of the zoom eyepieces.

ILLUSTRATION.

The amount of light entering a telescope is determined by the field of view. For a good understanding of the light intensity ratios: the cone of a field of view of 40m/1000 m is four times larger than a that of the cone of a field of view of 20m/1000m. The luminosity of a telescope is determined by the fraction of the light that is transmitted by the telescope optics (light transmission) and the size of the exit pupil. The light transmission of a telescope with a certain eyepiece is an instrument property. That means with a zoom eyepiece with magnification of 20x and its accompanying relative large field of view a certain fraction of the incoming light is transmitted and that same fraction of light is also transmitted at a magnification of 60x with a much smaller field of view and a much smaller amount of incoming light.

To get an impression of the effective luminosity of the telescopes, the amount of light, which leaves the telescope, is measured with a light meter with a spectral response curve identical to that of the human eye. The results are listed in the tables below.

TABLE A. Light output at the lowest magnification of the zoom eyepiece

Telescope	Magnification	Measured exit pupil (mm)	Field of view (m/1000m)	Surface area of exit pupil (mm ²)	Measured intensity of light leaving the telescope (arbitrary units) (1)
Kowa Prominar 883 with 20-60x zoom	20x	4,3 mm	38	14,5 mm ²	88
Leica Apo-Televid 82 with 25-50x zoom	25x	3,1 mm	41	7,5 mm ²	72
Swarovski ATM 80 HD with 25-50x zoom	25x	3,2 mm	42	8.0 mm ²	98
Zeiss Diascope 85 with 20-60x zoom	20x	4,4 mm	43	15,2 mm ²	105

Sub 1. Measurements were done under standardized conditions using an evenly illuminated white plane as object to look at. The distance of the front lens of the telescopes to the white plane was exactly identical. The detector was put in the position of the human eye. Care was taken that only light leaving the telescope could reach the detector. The detector has a spectral response curve very much identical to that of the human eye. The entrance diaphragm to the detector exceeds the size of the exit pupil. The detector has no surface effect which means that the response is not dependent of the place of the light spot on the surface.

N.B. The measured light intensity values listed in table A can not be read as actual differences in luminosity between the telescopes, since one has to take into account the differences in the size of the field of view (which determines the amount of light entering the telescope) and the differences in the size of the exit pupils and of the light transmission values. The interpretation of the measured light intensity values therefore requires some thinking and some calculations.

TABLE B. Light output at identical exit pupils

Telescope	Calculated magnification	Diameter exit pupil (mm)	Estimated field of view (m/1000m)	Surface area exit pupil (mm ²)	Measured intensity of light leaving the telescope (arbitrary units) (1)
Kowa Prominar 883 with 20-60x zoom	29,2 x	3,0 mm	30m	7,0 mm ²	60
Leica Apo-Televid 82 with 25-50x zoom	27,1 x	3,0 mm	40 m	7,0 mm ²	70
Swarovski ATM 80 HD with 25-50x zoom	26,7 x	3,0 mm	40 m	7.0 mm ²	90
Zeiss Diascope 85 with 20-60x zoom	25,5 x	3,0 mm	32 m	7,0 mm ²	78

In table B the differences in measured light output are caused by the differences in the field of view (amount of incoming light) in combination with the differences in light transmission.

TABLE C. Light output at the highest magnification of the zoom eyepieces

Telescope	Magnification	Measured diameter exit pupil (mm)	Field of view (m/1000m)	Surface area exit pupil (mm ²)	Measured intensity of light leaving the telescope (arbitrary units) (1)
Kowa Prominar 883 with 20-60x zoom	60x	1,5 mm	19 m	1,75 mm ²	20
Leica Apo-Televid 82 with 25-50x zoom	50 x	1,6 mm	28 m	2,0 mm ²	35
Swarovski ATM 80 HD with 25-50x zoom	50 x	1,6 mm	27 m	2.0 mm ²	40
Zeiss Diascope 85 with 20-60x zoom	60 x	1,45 mm	20 m	1,64 mm ²	24

In table C the differences in the values of the measured light output are caused by differences in field of view, differences in the size of the exit pupil and differences in the light transmission.