Leica R-Lenses

by Erwin Puts

January 2005

Chapter 9: 180 mm lens

__ LEICA APO-SUMMICRON-R 180 mm f/2

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__General considerations

This lens was introduced in 1994 and was generally recognized as a lens with superior qualities. It is indeed a lens that redefines the famous Summicron quality and places it on a much higher level than had been seen before. The focal length of 180mm has been the acid test for optical manufacturers since the days of the Berlin Olympiad of 1936 when Zeiss showed the impressive Olympia-Sonnar 180 mm f/2.8. Since that day the performance of lenses has improved significantly, not gradually, but with period jumps. The LEICA APO-TELYT-R 180 mm f/3.4 set the pace in 1975 with an, for that time, excellent image quality. The task to reduce the chromatic aberrations in telephoto-lenses to very slight proportions is a never ending story. It is well known that the major problem for this type of lenses is the presence of chromatic aberrations (longitudinal, that is, along the optical axis and lateral, that is, vertically across the image plane). The phenomenon of chromatic or colour aberrations has been explained in previous chapters. These optical errors are best seen at the edges of dark subject details against a bright background as coloured bands or fringes. Most often this halo is purplish, but other colours are possible. With a telephoto-lens the object is enlarged, but these aberrations are magnified as well. The classical approach is to correct the lens by making the focus points of two different wavelengths to coincide. Such a lens is called an 'achromat'. If we accomplish this feat for three different wavelengths, then the lens is claimed to be apochromatically corrected. Such a lens is close to the ideal state of correction. We must accept however that for the other wavelengths there is still a different focus and the sum of these aberrations is called the residual aberration or the secondary spectrum.

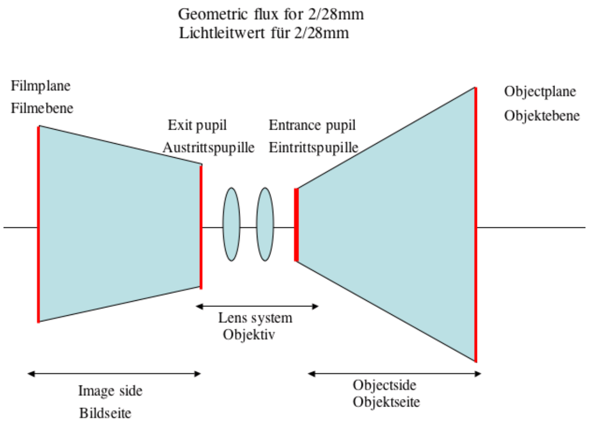
What we do not often realise is the fact that this correction is exact only for one specific zonal area of the lens. Let us return for a moment to the spherical aberration: we know that rays that fall on the lens at the outer zones of the lens are bent more strongly than the rays entering the lens in the centre. The rays from the outer zones are in focus in front of the image plane, and the rays from the centre (the axis) are in focus in the image plane itself. You may see the problem: if we want rays with two or three wavelengths to focus on the same location, we must choose one of several possible locations and by implication one specific zone of the lens (or image height). In other words: we have the 'simple' spherical aberration for monochromatic light, but the same phenomenon occurs for every wavelength. This more troublesome chromatic aberration is never discussed in the popular literature, but is very bad. It is called spherochromatism, but is also known as the variation of chromatic aberration with ray height and as the variation of chromatic aberration with wavelength. All three descriptions refer to the same phenomenon. Every wavelength corresponds to a different colour sensation. It is customary however to use seven well defined wavelengths (or colours) as the base for optical design and error correction.
The wider the aperture, the more troublesome the correction of spherochromatism becomes. The designer of the LEICA APO-SUMMICRON-R 180 mm f/2 had to face these challenges and needed to reduce the secondary spectrum to a small amount over the whole range of wavelengths in the visual band and for a very wide aperture.
The result is very impressive: at the widest aperture of f/2, the LEICA APO-SUMMICRON-R 180 mm f/2 is better than the LEICA APO-TELYT-R at f/3.4. The LEICA APO-SUMMICRON-R 180 mm f/2 does not improve on stopping down: the MTF values for the 5 to 20 lp/mm range do hardly change from aperture f/2 to f/8. At smaller apertures we see the usual drop in quality due to diffraction effects.

__Size of the lens

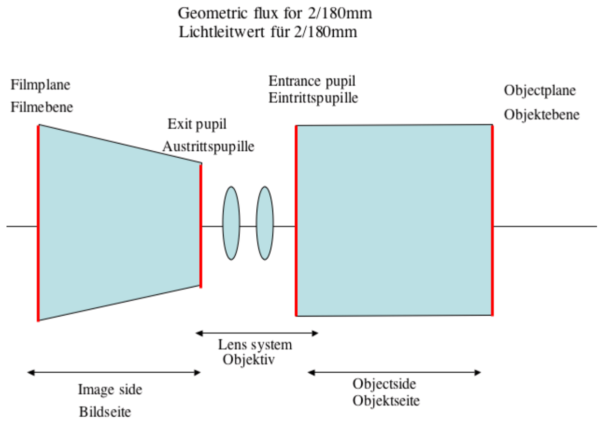
The optical performance is indeed quite impressive, but so is the size of the lens. The lens can certainly be used without a tripod and the ergonomically design does support this use. With 2500 grams the lens is not suited for prolonged handheld use. The lens is 176 mm long and has a diameter of 116 mm. That is only slightly wider than the diameter of the front lens. This diameter is 90 mm, that is focal length divided by aperture or 180/2.
In comparison to others with the same specifications, the lens is not a large one. The Canon EF 200 mm f/1.8 weights 3000 grams and has dimensions of 208 mm (length) and 130 mm (diameter). The slightly larger aperture explains the bigger dimensions. Note the shorter length of the Summicron, indicating a true telephoto design. We may note here that a physically shorter lens is more difficult to correct than a physically longer lens with the same focal length.

Would it be possible to design a more compact lens? To answer this question I have to introduce another new concept: the geometrical flux or in German; 'Lichtleitwert'. Photography is physically speaking nothing more than capturing the light energy that is radiating from the object. The lens has a certain angle of view with which the object is seen and isolated. The object radiates energy in all directions and the lens does capture a small part of this total energy flux, restricted to the angle of view of the lens. From the object to the camera lens we may imagine a cone of light or a light pipe through which the light energy streams from the object to the camera lens and through this one to the film. We can calculate the amount of energy by finding the size of the cone: the formula is quite complicated, and involves the length of the cone, the solid angle (the three dimensional version of the angle of view), the size of the entrance pupil and much more.
An optical system is among others characterized by its entrance and exit pupils. The entrance pupil accepts the light that is coming from the object and the exit pupil is the pupil where the light energy leaves the lens to be captured on the film plane. From the exit pupil to the film plane we see another cone of light with dimensions equal to the diameter of the film plane and the size of the exit pupil.
These relationships are graphically represented in figure 1 for a hypothetical 28 mm lens.

The shaded area on the image ***(see image 1 on next page)*** side represents the light pipe (geometric flux) from the film plane to the exit pupil of the lens. The shaded area on the object side represents the light pipe from object plane to the entrance pupil of the lens. These areas are almost equal in size, but that is only for purposes of clarity. If we were to calculate the exact amount of light energy we would note that the amount of light energy in both light pipes is the same. Here we disregard the effect of vignetting and transmission losses.



(image 1)



(image 2)

The important point is to understand that this relationship of equal energy holds for all lenses with the same aperture but of different focal length.
A moment's thought will show that we are here saying that a lens with the same aperture transmits the same amount of light whatever the focal length.
The size of the cone of light on the image side is always the same. The diameter of the film plane is always the same too. On the object side we must have the same amount of light energy, but now we can have different shapes of the light pipe. Size of the entrance pupil (or maximum aperture of the lens) and angle of view may be changed in relation to each other. For a 2/28 mm lens we have a small entrance pupil diameter (2.8 mm in fact) and a large angle of view (76). For a 2/180 mm lens we have a smaller angle of view (14), and must have a larger entrance pupil, in this case 90 mm.
(see image 2).

It is not possible to design a 2/180 mm lens with a smaller entrance pupil to reduce the physical dimensions. The upshot is this: if you need a large aperture telephoto-lens, you have to accept the physical dimensions that are required by the geometric flux equation.

__Diffraction limited

The LEICA APO-SUMMICRON-R 180 mm f/2 has an exceptionally good performance and is quite close to being diffraction limited. There is much misunderstanding when interpreting this claim. Officially a diffraction limited lens is a lens where the optical aberrations are reduced to zero and the image of a point has the diameter of the calculated Airy-disk diameter. The formula is R= 2.44 x wavelength x f/number (in radians). For the standard wavelength (yellow) and an aperture of f/2 the diameter is 2.68 micron or 375 linepairs/mm. Note that the diameter of the spot size depends on the wavelength. With other wavelengths (colours) the size of the spot is different. We should distinguish between a monochromatically diffraction limit and a limit that is composed of all colours.
Theoretically the use of colour filters in black and white photography can boost the resolution of the lens as we can block the colours that are spoiling the resolution. Most optical errors are reduced when stopping down the lens and performance of the lens improves simply by using a smaller aperture. If a lens has optical errors, we see the classical pattern : the lens improves when stopping down to the optimum aperture and then the image quality is degraded again but now as the result of diffraction: the bending of light at the edges of the diaphragm blades. A lens that is diffraction limited hardly improves on stopping down

The LEICA APO-SUMMICRON-R 180 mm f/2 can be classified as being monochromatically diffraction limited at aperture 5.6. At this aperture 270 lp/mm can be resolved, if we have a film that can handle this. Such a film does not exist and my own experiments indicate that a practical resolution of about 150 lp/mm is the best we can expect. In the case that some readers may be disappointed, I wish to note that this resolution implies a spot size of 0.0033 mm on the film!

You will have to enlarge the negative by a factor of at least 30 times to be able to detect this spot size.
But resolution is not all there is: contrast is evenmore important and here we can say that at 5.6 contrast is very high for the 40 lp/mm: around 80%! Stopping down from this aperture to 1:16 will reduce the resolution to 90 lp/mm and the contrast for the 40 lp/mm to about 55%.
The negative effects of stopping down too much can be clearly seen in these figures. The upshot is that you should adapt the choice of your film to the situation in order to avoid having to select too small an aperture! With the R8/9 and shutter speeds to 1/8000 you have ample choices!

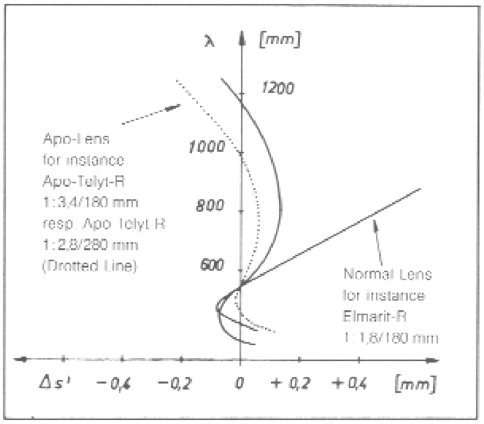
__MTF values

Resolution is dependent on wavelength, but the MTF curves too are related to wavelength. Most manufacturers and several magazines now publish MTF graphs. It is hardly possible to compare these graphs in a direct manner.
There is a difference between calculated and measured graphs and between graphs based on a different spectral composition of white light. And you must know the optimum value of the linepairs used to calibrate the equipment. When calculating the MTF values you can use the geometrical or the diffraction limited MTF.

The first ones allow for larger spot sizes and give more favourable results. The spectral composition of the white light is also very important: if your lens is very good in the yellow region of the spectrum and bad in the deep blue part of the spectrum, you might use an MTF that disregards the deep blue section of the spectrum and you get better results than when you use the whole spectrum.
In most cases this information is not known and then the direct comparison is very tricky. It is best to compare only lens ranges within themselves to get a feeling for the relative performance within a range and avoid making comparisons across lens lines of other manufacturers.

__Apochromatic correction.

What has been discussed above about the wavelength dependence of diffraction limits and MTF values, can



(image 3)

be transferred to the notion of apochromatically corrected lenses too. The official statement tells you that an apochromatically corrected lens is a lens where three colours have been brought to a common focus. There is no discussion of the level of correction of all the other colours, or the secondary spectrum.

In the picture ***(see image 3)*** we see on the vertical line the different colours from infrared (top) to deep blue (bottom) and on the horizontal line the amount of residual colour aberration.
While it is important that the three colours focus to the common line, we see also that the rest of the colours are diverging from the line. The area under the curve (the dotted line) indicates the amount of residual aberrations or the secondary spectrum.
That is why some lenses, designated as being apo-corrected show a disappointing performance: the residuals are still too large! It is best to reduce the total residual aberrations to a minimum, even if this implies that we have to distract a little from the official definition.

A lens that is corrected for the smallest possible residual chromatic aberration needs very special glass of anomalous dispersion, carefully selected to cancel out all colour errors.

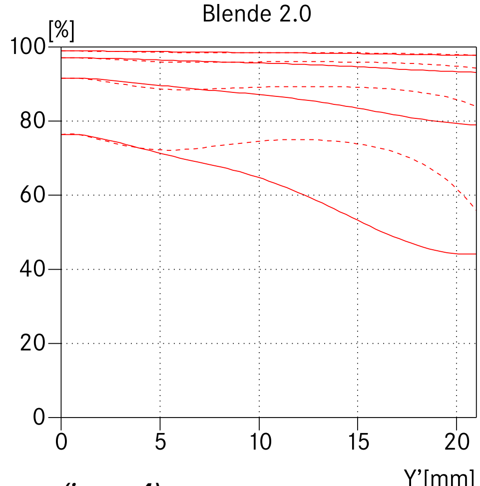
Often these glasses are quite sensitive to environmental influences. In the case of the LEICA APO-SUMMICRON-R 180 mm f/2 the front lens element is a bit sensitive and therefore the filter in front of the lens is really needed. Glasses needed for the apochromatic correction are sometimes sensitive to environmental conditions, but the special characteristics of the selected glass are needed for the high level of correction of this lens. They also add considerably to the weight. The total weight of the glass elements is more than 850 grams or about a third of the total weight of the lens.

__Optical considerations

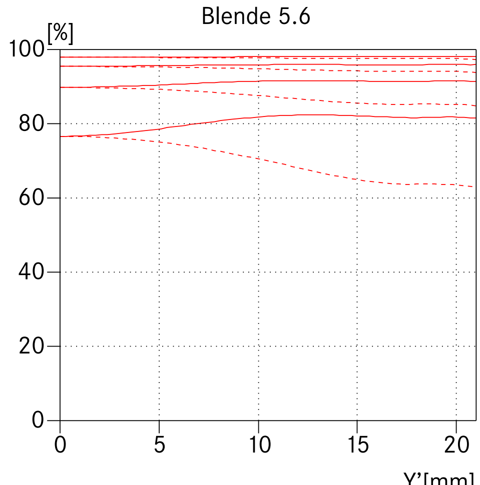
If we accept the Summicron designation as the embodiment of optical performance, we may safely state that this LEICA APO-SUMMICRON-R 180 mm f/2 is the best Summicron ever designed as of this date. Period. It really is the benchmark lens for all Summicron designs and even surpasses the already famous LEICA APO-SUMMICRON-M 90 mm f/2 ASPH. You may with some reason argue that a 180mm has a narrower angle of field, and is therefore easier to design. But on the other hand the enlargement of the chromatic errors more than offsets this 'advantage'. The size of the lens elements requires a very high level of accuracy in machining, quality control and assembly.
At full aperture the image quality is superb as can be seen from the MTF ***(see image 4)***.

The graph for the 40 linepairs/mm indicates a very crisp rendition of very fine detail over the whole image field. The contrast values seem to drop when going from centre to corner. This is a bit deceptive as in the extreme corner the values is as high as that of the Summicron 50 mm in the centre of the image! This comparison gives a clue as to what quality you can expect in the central portion of the Summicron 180 mm lens. At full aperture there is some tendency to secondary reflections, even if the light source is not directly shining into the lens. Here the use of the shade is very important. From f/2.8 the corners improve and are on the same level as the centre and a very uniform image quality can be expected. A careful comparison with the MTF graph for aperture 5.6 ***(see image 5)*** indicates the drop in contrast that is a characteristic of the influence of the diffraction effects.

The distortion is acceptably low with 1%, but for very critical work and big enlargements, it may be visible, depending on the subject matter. ***(see image 6)***



(image 4)



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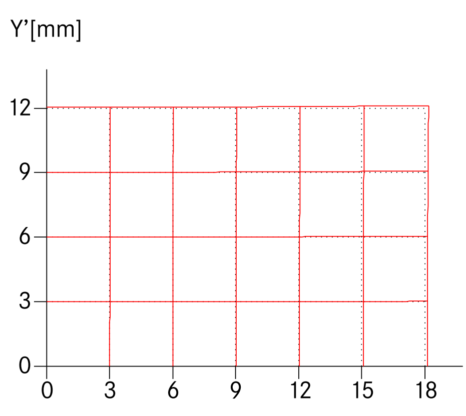


(image 6)

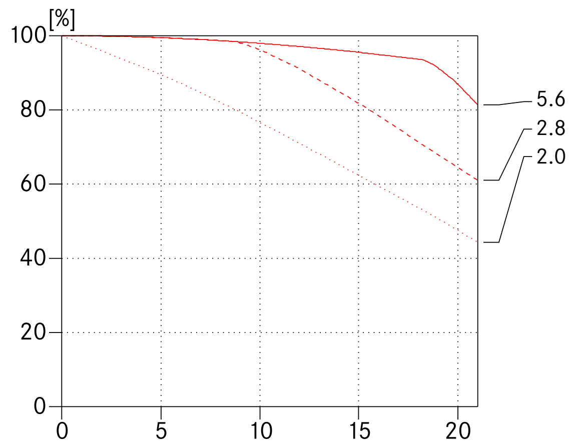
Vignetting is wide open visible with about one stop. Here we must carefully differentiate between the natural vignetting and the mechanical vignetting. The combined effects of the shape of the film gate and the bayonet mount add some vignetting at the upper and under sides of the film area. From 2.8 we see only the natural vignetting. The amount of vignetting is less when one focuses in the near range. At infinity the darkening in the corners is a bit more pronounced. Some stopping down will help.
(see image 7)

The 2x Extender can be used with full confidence at full aperture (but there is more vignetting), and the 1.4 Extender should be stopped down two stops for best performance. Imagine the use of the Summicron 180 lens with 2x Extender and the forthcoming Digiback, with a 1.4 focal length extension. Then we should have a high quality f/2/500mm, ideal for many subjects and purposes.

It goes without saying that it is not simple to extract the inherent optical performance from this lens. Only careful focussing, vibration free exposure and the best possible film technique will allow to exploit the quality. A stable tripod, additional weights on the camera body and lens are all helpful. There are no ready-made receipts here. You must and should experiment. Try to avoid the shutterspeed range from 1/60 to 1/125 with the non-R8/9 bodies as at these speeds the camera body has high frequency vibrations.

With 9 elements, the lens has a clean design. The use of special glass not only adds to the weight ***(see image 8)***, but also has a larger amount of thermal expansion. In big temperature changes the bigger glass elements expand and cemented elements are not possible. The second and third elements seem to be cemented in the drawing, but that is not true. There is an air space of about 0.10 mm that cannot be drawn on this scale. The thermal expansion is the argument for the fact that the focus ring can be set beyond infinity. This is not provided to help find the infinity focus, as sometimes is suggested, but to accommodate the thermal expansion. When we talk about substantial temperature differences, we are thinking of a difference of 40 degrees Celsius, which occurs when the lens was in the heavy sun in the car (about 60 degrees) and then is used in open space (20 degrees).

The lens diagram also indicates the mechanism of internal focusing. It makes a big difference if we have to provide internal focussing for a small sized lens or for a big one like the Summicron 180 mm. The movement of the lens group is about 15 mm and this has to be done with great accuracy and smoothness. The focussing movement of the lens is indeed butter smooth. And that is a real mechanical accomplishment.



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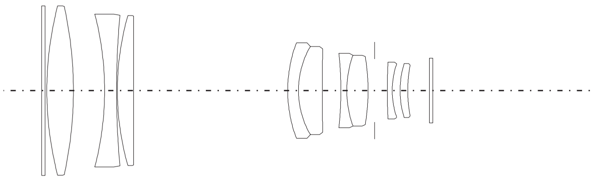

(image 8)

__Artistic considerations.

A look at the depth of field table shows that at full aperture and at close focus the depth of field is less than 1 cm! The sharpness gradient is very smooth and the excellent quality of the sharpness plane provide for a very intriguing representation of the subject matter. The focal length of 180 mm is an outstanding choice for portraiture and spontaneous shoulder length shots. It has been rumoured that the lens was specifically designed to provide fashion photographers with a very creative tool for capturing atmosphere and beauty on the catwalk. The focal length of 180mm is much more useable and versatile than is often assumed. The high contrast wide open and the shallow depth of field do visually guide the eye to the major subject outlines and the excellent reproduction of details adds depth and clarity to the picture. The pictures made with this lens at full aperture show a rarely seen combination of image quality that one expects from a lens stopped down to 5.6 and the depth of field of a lens at aperture 2. With this lens one can play with the depth of field zone and by carefully placing the unsharpness zones in the correct subject planes, one can create startling compositions with great visual impact.
The gradient from sharpness to unsharpness is of course quite abrupt at the wider apertures, as the depth of field is quite limited. With a telelens all subjects are enlarged and the unsharpness blur is also enlarged. Pictures made with the LEICA APO-SUMMICRON-R f/2/180 mm benefit from this characteristic: the unsharpness planes are quite diffuse, and lack the harshness, sometimes associated with highly corrected lenses.
This behaviour produces images that focus the attention of the viewer very forcefully on the main subject without a distracting background or foreground. Especially enchanting are fashion style reportages in urban environments in early evening when the ambient light is mixed with street lights and the fast speed of the lens can be exploited without reserve. The carefully selected distribution of colourful light spots in the background can add immensely to the 'couleur locale' of the scene.

At medium distances the very high resolution and the compressed space add to the impression of being very close to the scene of action and almost being drawn into the scene.

The focal length of 180 mm is often associated with sports photography and landscape photography. In reality this lens is at its best as a portrait and human interest lens in the studio and on location, hand held or on tripod. With the suitable choice of focusing screen, the focus action is very fast and secure and here one does not have any disadvantage compared to the autofocus systems. In fact one is often more accurate!

image: Oliver Richter

__Conclusion

This is one of the best lenses in the R-system and arguably one of the very best lenses of comparable specification in the world. The very smooth handling, outstandingly good optical performance and mechanical stability provide the platform for photographic images of great quality and impact. The focal length is more versatile than is often assumed and the handling is much more convenient than the physical size suggests. This is typically a lens that should be used and experienced. The proof of the pudding is in the eating! It is one the few lenses that can deliver superior imagery wide open. The lens should not be used at very small apertures (beyond 1:8) unless the depth of field requirement asks for this aperture. At apertures from 2 to 5.6 the quality is impeccable and gives the discerning photographer a new tool for creative and high quality images, which go beyond the usual representational photographs. The lens needs some learning, as do all high quality tools and instruments, but the result is worth the effort.

image: Michael Agel