Photomicrography with ‘hybrid’ eyepieces

Introduction

When using microscopes with a finite (eg. 160 or 170 mm) mechanical tube length, there are roughly two ways to perform photomicrography:

1. Afocal method. With this method, there is a lens or camera objective between eyepiece and camera sensor. The camera lens acts as a relay optic and captures the image that is corrected by the eyepiece.

2. Projection by means of a special projective or photo-eyepiece. Here, there is no (camera) lens between the eyepiece and sensor and the image is projected onto the sensor by the respective eyepiece or projective.

For a long time I have used the afocal method, but after a lot of experimenting with eyepieces that can serve as projection eyepieces, I have become convinced that the second method produces better images. With the afocal method, there is extra glass between the eyepiece and the sensor. It is certain that this will never improve the image in the center of the microscope field. Any additional optical element in the optical path can potentially degrade the image. Projectives are special eyepieces that correct the image formed by the objective and project it onto the sensor. For photography with DSLR cameras, projectives with low magnifications are particularly suitable. A highly wanted projective is for example the NFK 1.67x, to be used with the Olympus BH2 microscope system. However, the price for this projective on the second-hand market is often absurd.

Not all microscope manufacturers have produced useful projectives in the past. Carl Zeiss, for example, went the afocal path at one point and because of this, photography with Zeiss microscopes with 160 mm mechanical tubelength was and is mainly done with a relay lens between eyepiece and sensor. If you want to photograph with for example a Zeiss Standard microscope without any relay optics, an ordinary observation eyepiece (e.g. a Kpl10x) can be used as a projective when the position of this eyepiece in the photo tube is raised a few mm. However, the results with this are variable and there is often a clear chromatic aberration at the edges of the image when photography is done this way.

Hybrid eyepieces

I own a fairly large collection of eyepieces and at one point I wondered what would happen if I would combine two different Zeiss eyepieces and used them as a projection eyepiece for photography. So, I exchanged the eye lens of a Zeiss Kpl8x eyepiece with the eye lens of a Kpl10x eyepiece. I had only expected a bad image, but the results were surprising. Not only did the image on the camera appear parfocal with the visual image, there was also little chromatic aberration at the edges. The image was significantly better than when using a raised Kpl10x eyepiece. I had the best experience using both lenses from a Kpl10x eyepiece on a Kpl8x eyepiece body. The fact that it works better this way than raising a normal eyepiece is probably caused by the increased distance between field lens and eye lens. Apparently, the eyepiece is more functioning like a photo-eyepiece this way. With some photo-eyepieces, like for example the Carl Zeiss FK10x, it's also possible to

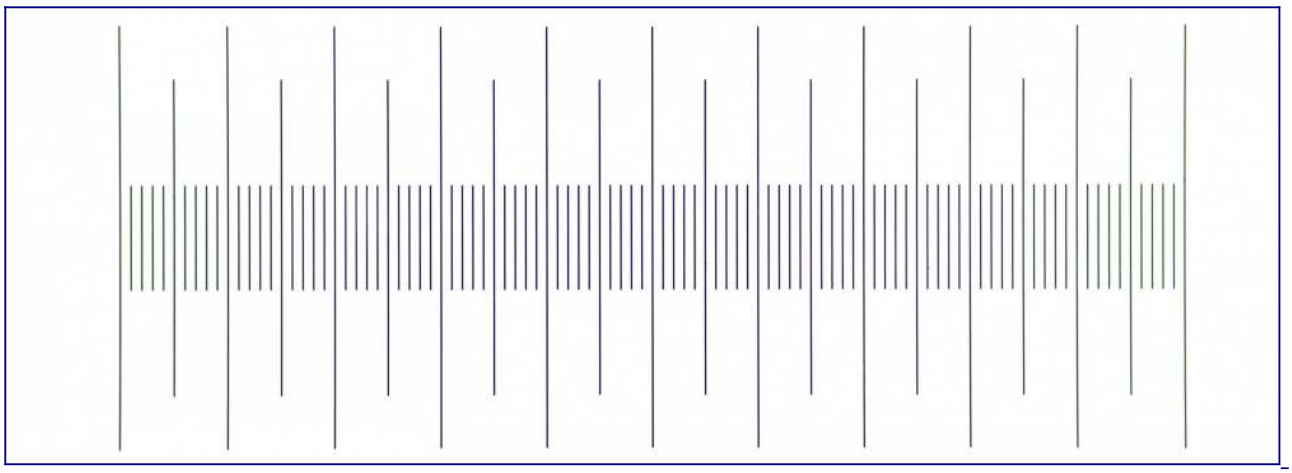
change the distance between the two lenses. In any case, the chromatic aberration is largely cancelled using the hybrid eyepiece. I also experimented with Leitz and Olympus eyepieces and some results are shown below.

If you want to experiment with this method, it is important that an adapter is used with which the distance between camera sensor and eyepiece can be varied.

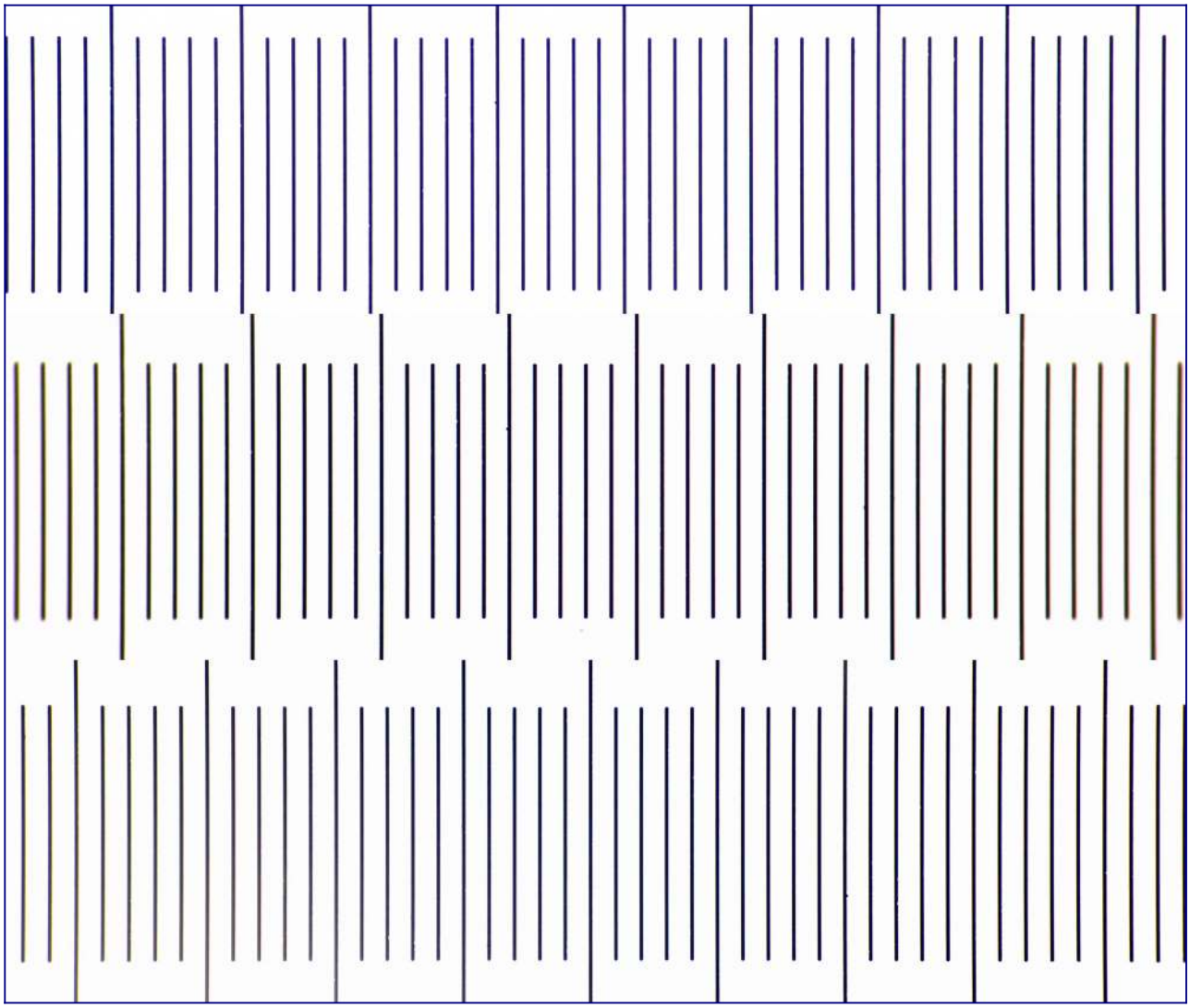
Zeiss

I tested the combination of a Kpl8x and Kpl10x eyepiece with a stage micrometer on a number of different Zeiss objectives. Both lenses of a Kpl10x eyepiece were screwed onto a Kpl8x body. This ‘hybrid’ eyepiece gives considerably less chromatic aberration than when a normal Kpl10x or Kpl W10x is used at an elevated position. There is a slight pincushion distortion, but this is within an acceptable range. Satisfactory results were achieved with all Zeiss objectives that I tested, including various (plan) achromats, Neofluars and (plan) apochromats. The tests were done on a Zeiss Standard 16 with trinocular tube. The hybrid eyepiece was not raised and the distance between camera sensor and eyepiece was adjusted until the image on the camera was parfocal with the visual image. Satisfactory results were obtained with both an Olympus PEN E-PL1 and a Canon 600D camera.

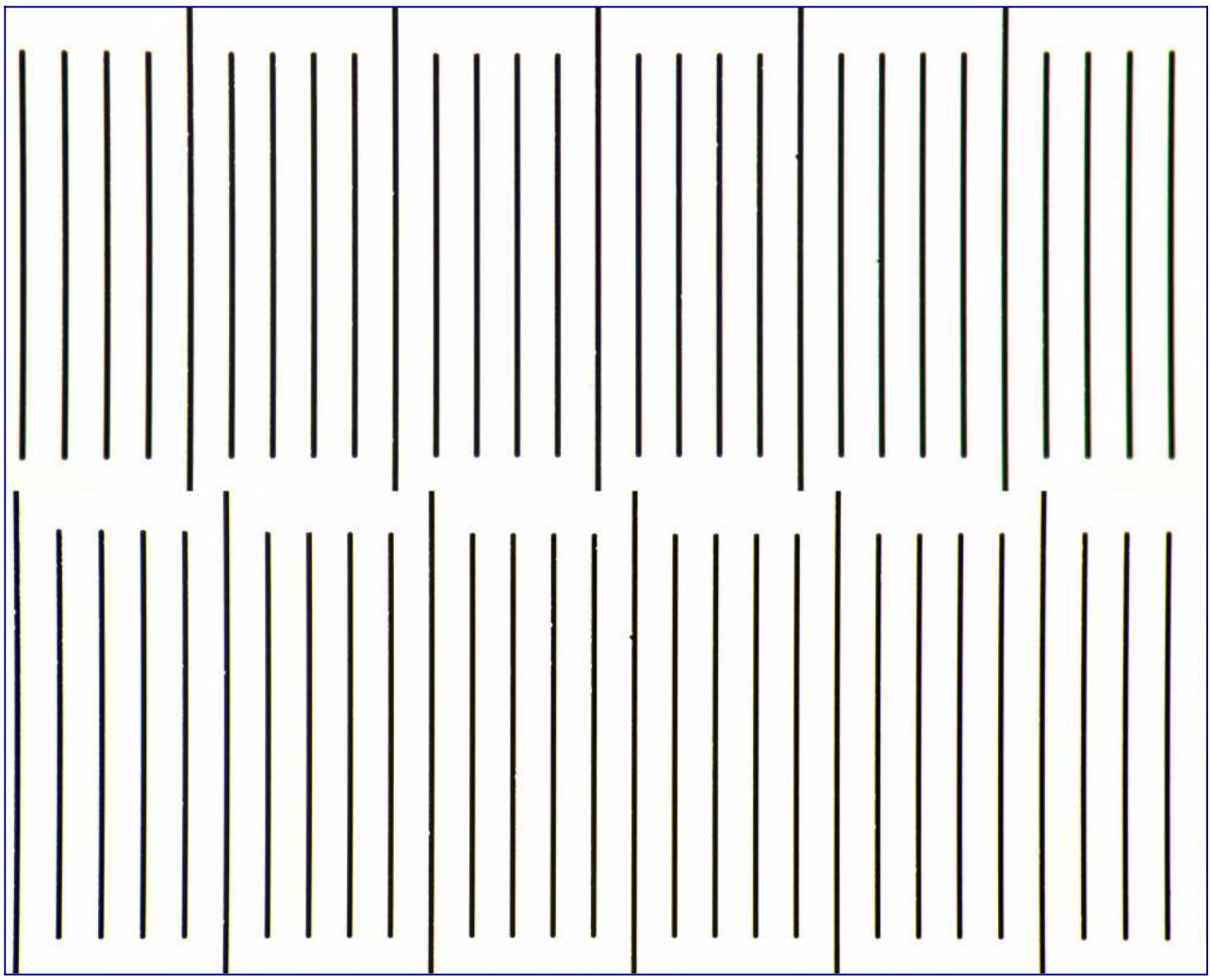
Combination of a Zeiss Kpl8x and Kpl10x eyepiece in use as a projection eyepiece with the Zeiss Standard and a Canon 600D camera. The field lens and the eye lens of a Kpl10x eyepiece were screwed onto a Kpl8x body.



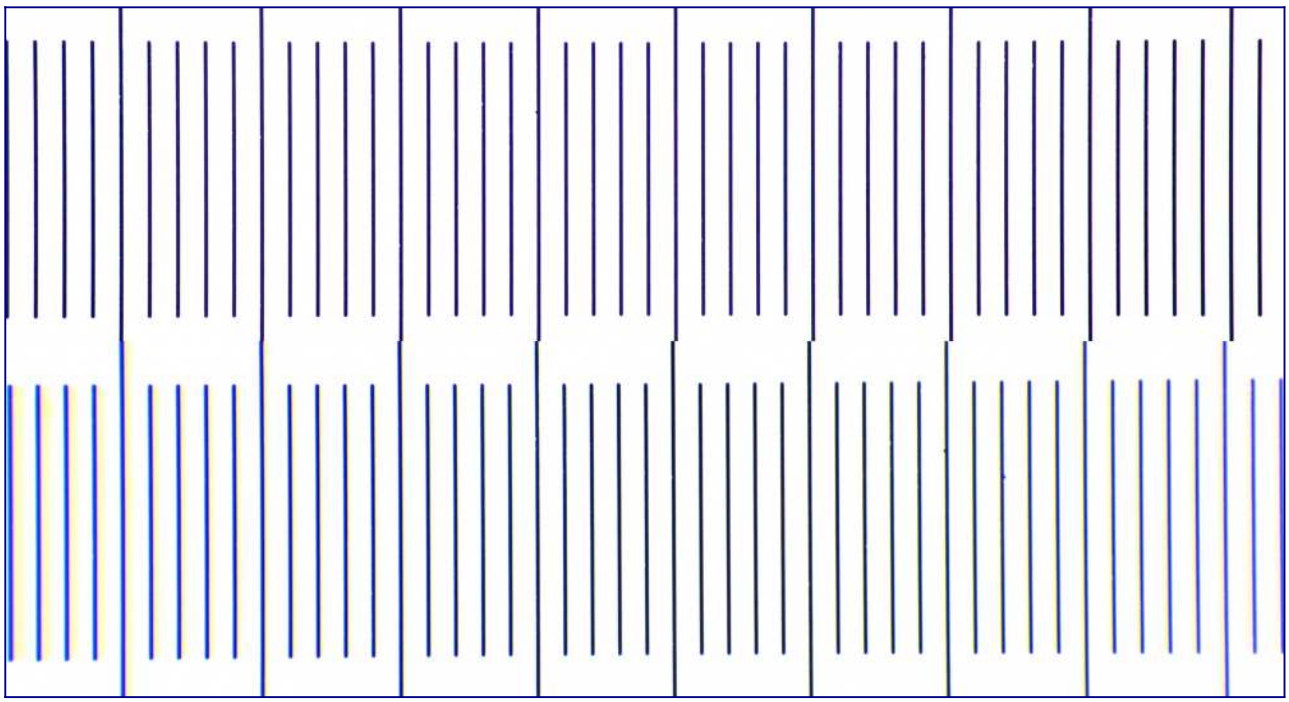
Stage micrometer photographed with a Zeiss Plan 10/0.25. Eyepiece projection with a hybrid Kpl8x-Kpl10x eyepiece.



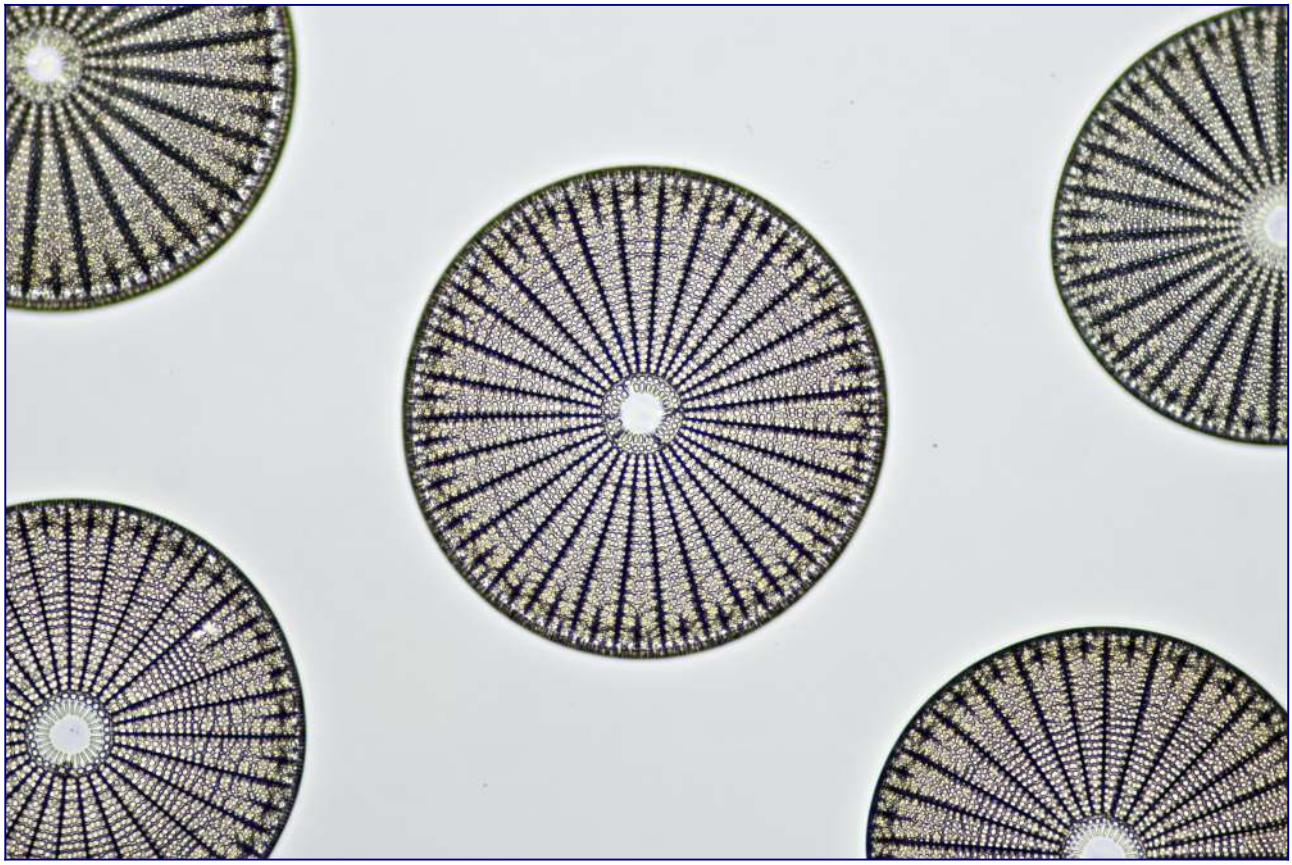
Stage micrometer photographed, from top to bottom, with Carl Zeiss Plan 25/0.45, Neofluar 25/0.60 and Planapo 25/0.65. Projection with hybrid Kpl8x-Kpl10x eyepiece.



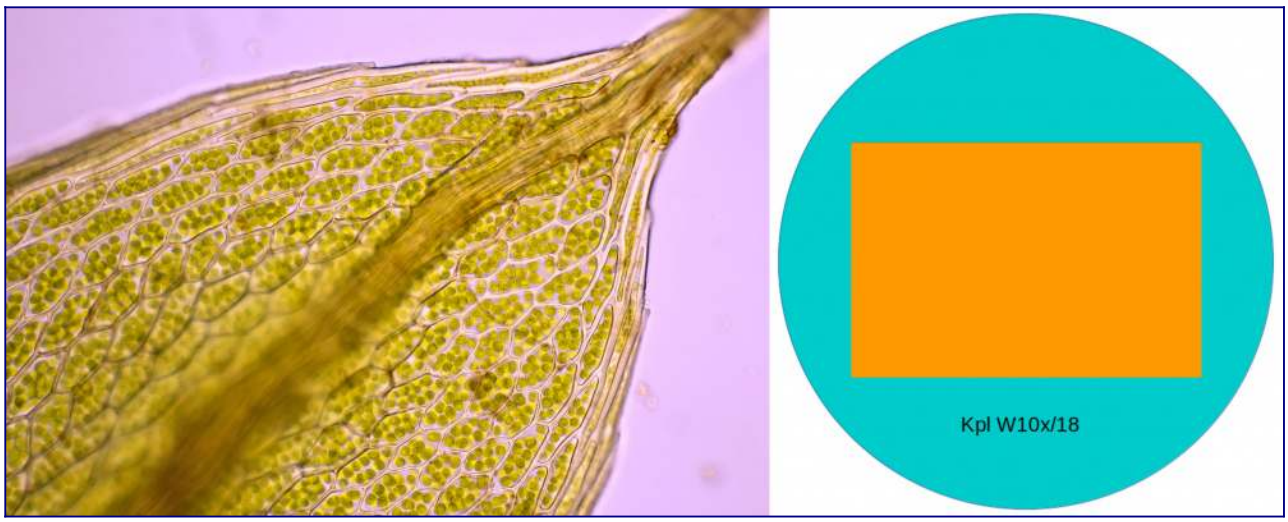
Stage micrometer photographed with Zeiss Plan 40/0.65 (top) and Zeiss Planapo 40/1.0 (bottom). Projection with hybrid Kpl8x-Kpl10x eyepiece.



Comparison between eyepiece projection with a hybrid eyepiece (top) and a raised Kpl W10x eyepiece (bottom). Chromatic aberration is clearly visible with the normal eyepiece. Objective: CZ Plan 25/0.45.



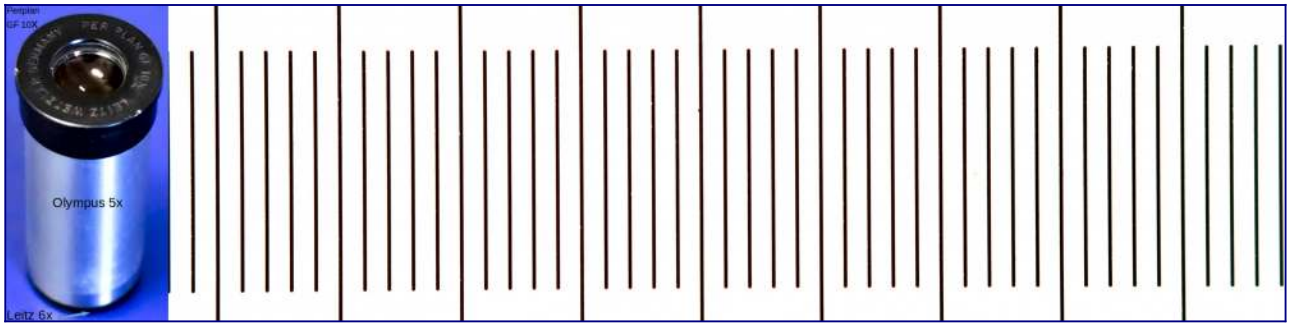
Arachnoidiscus, photographed with a Carl Zeiss Plan 25/0.45 objective and hybrid Kpl8x-Kpl10x eyepiece. This is the complete image as it is captured by the sensor of the Canon 600D camera.



Left: a moss photographed with a Zeiss Planapo 25/0.65 and hybrid Kpl8x-Kpl10x eyepiece. Right: The orange rectangle indicates the part of the microscopic field of view that is photographed using this eyepiece and a Canon 600D camera. The circle refers to an eyepiece with a field number of 18, such as a Zeiss Kpl W10x/18 eyepiece.

Leitz

I tested different eyepiece combinations with the Leitz Dialux-II and Laborlux-12. For example, with Leitz NPL Fluotar objectives on the Laborlux-12, I get good results with an eyepiece that consists of 3 different eyepieces: a Leitz 6x field lens, the body of an Olympus 5x eyepiece and the eye lens of a Periplan 10x eyepiece. Quite exotic, but it works well with NPL-Fluotar objectives. With the the Leitz EF achromats this combination produces slightly more chromatic aberration. The combination of an Olympus 5x body with both lenses of a Leitz Periplan GF10x also works well for both EF achromats and NPL Fluotars but comes at the expense of the size of the image being captured. The experiments were done with a Canon 600D.



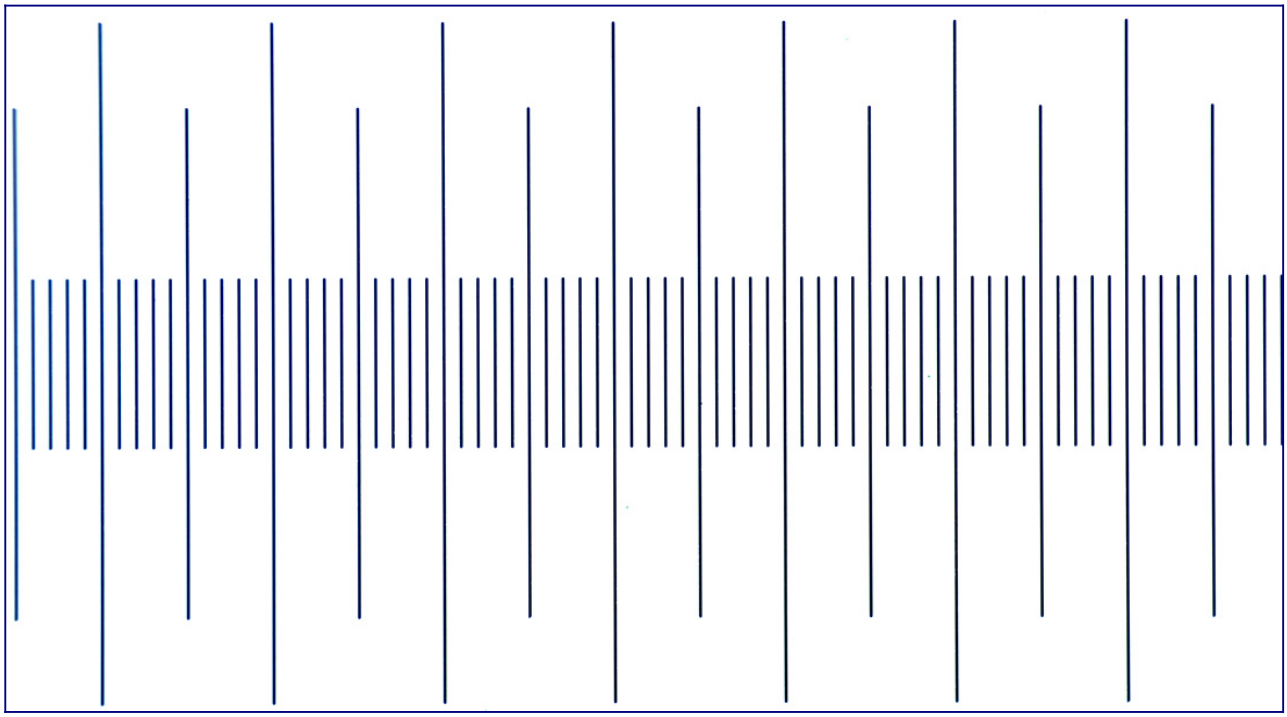
Hybrid eyepiece composed of 3 different eyepieces. Right: Stage micrometer photographed with this eyepiece and a Leitz NPL Fluotar 25/0.55 objective on the Leitz Laborlux-12.

Dracaena epidermis photographed with Leitz Fluotar 25/0.55 and hybrid eyepiece. Microscope: Leitz Laborlux-12.

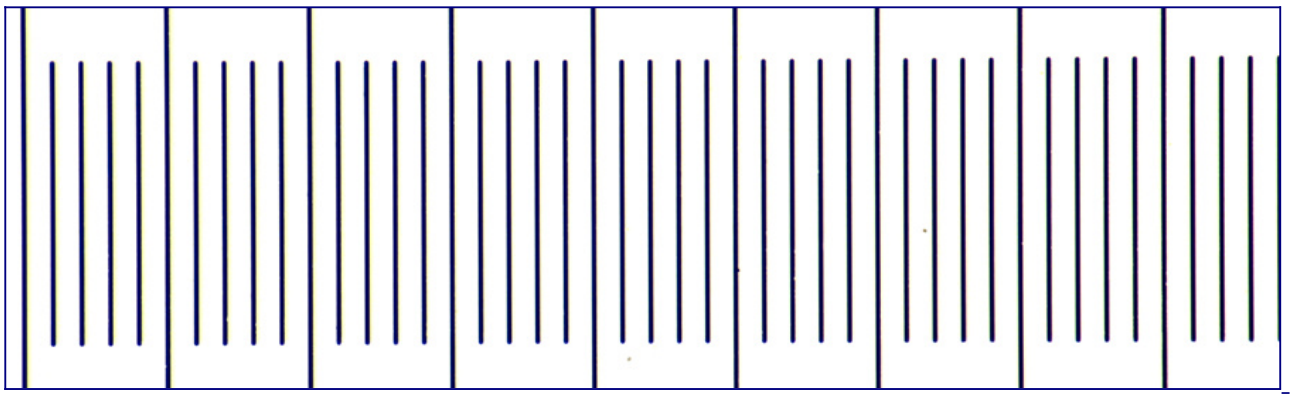
Olympus

I replaced the eye lens of an unbranded 5x eyepiece with an Olympus P7x eye lens. This combination worked well with 37 mm Olympus Plan 20/0.45 and Plan PL40 / 0.65 objectives. Pincushion distortion was absent. Camera: Canon 600D.

Hybrid eyepiece consisting of the lower part of an unbranded 5x eyepiece and the eye lens of an Olympus P7x eyepiece.



Stage micrometer photographed with a 37 mm Olympus Plan 20/0.40 objective and hybrid eyepiece. Camera: Canon 600D.



Stage micrometer photographed with 37 mm Olympus Plan 20/0.40 objective. Here, an Olympus FK2.5x projective was used in combination with the Olympus OM-Mount Photomicro' Adapter L. It is clear that a smaller part of the field of view is captured compared to the hybrid eyepiece. Camera: Canon 600D.

Leaf of a moss taken with a 37 mm Olympus Plan 20/0.40 objective and hybrid eyepiece. Camera: Canon 600D.

Conclusion and comments

Combinations of different eyepieces can give good results as a projection eyepiece. Considerably less chromatic aberration occurs compared to an ordinary eyepiece that is raised. Apparently, by increasing the distance between field lens and eye lens, some of the color artefacts are eliminated. Slight pincushion distortion may occur which will not be visible in normal specimens. The degree

to which chromatic aberration occurs may be slightly more than with the afocal method, but in the vast majority of cases it will be acceptable. It is recommended to try out different combinations of eyepieces. The results were satisfactory with both the Olympus PEN E-Pl1 and the Canon 600D camera. It should also work with other cameras, but it cannot be ruled out that less good results will be achieved with certain cameras. The part of the microscopic field of view that is photographed in this way may be slightly smaller than when the afocal method is used, but personally I do not find that disturbing. I find the size of the part that is photographed with this method acceptable. I have never cared so much about photographing as much of the microscopic field of view as possible. And apart from histological slides, I also don't quite understand why you would want that. The quality of the image will always be best in the center of the field of view. And when objectives without plan-correction are used, there is no reason to capture the entire field of view in many specimens. Moreover, my reasoning is always: what you want to photograph is usually located in the middle and not at the edge of the microscope field. If the entire sensor area is used for a smaller part of the microscope image, the photographic resolution of that part is also better.

The advantage of this method compared to the afocal method is the simple and compact camera setup and the lack of extra glass between eyepiece and sensor. Moreover, there is no need to invest in a camera lens or an expensive projective or photo-eyepiece. For those who want to photograph a larger part of the microscopic field of view, the method may be less suitable.

Sometimes it is good to do some crazy experiments instead of sticking to the usual 'rules'. I can recommend it to everyone.

It would be great receiving feedback from people who are going to try this method. Please refer to my website when the method is going to be mentioned elsewhere:

https://microscopyofnature.com/photography-hybrid-eyepieces

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