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Design and Correction of Optical Systems – Part 5

Exercise 5-1: Galilei Telescope

A Galilean telescope consists of an afocal combination of a positive and a negative lens. The system transforms the diameter of a collimated incoming beam by a magnification factor Γ. The magnification can be expressed by the focal lengths of the lenses as

$$\Gamma = -\frac{f'_+}{f'_-}$$

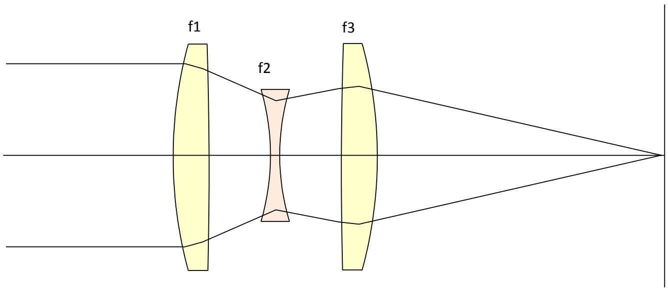
What is the Petzval condition for a flattened field of view for this system ? Derive the formula for the magnification for a Galilei telescope with flat field. If the available glass materials have refractive indices in the range n = 1.45...2.0, what is the achievable range of magnifications ?

Exercise 5-2: Aplanatic Meniscus Lens

Consider a focussing objectiv lens with F-number F' = 1.0 and a back focal length of s' = 80 mm. The numerical aperture of the system should be increased by adding of an aplanatic lens made of BK7. The refractive index can be approximated by n = 1.5. The diameter of the entrance pupil is D = 100 mm.
Calculate the focal length of the system. Determine the radii of the aplanatic lens. Calculate the back focal length and the aperture of the new system, if the thickness and the distance of the aplanatic menuscus can be neglected.
Re-calculate the results, if the lens is made of the high refracting material SFL6 with n = 1.8.

Exercise 5-3: Triplet System

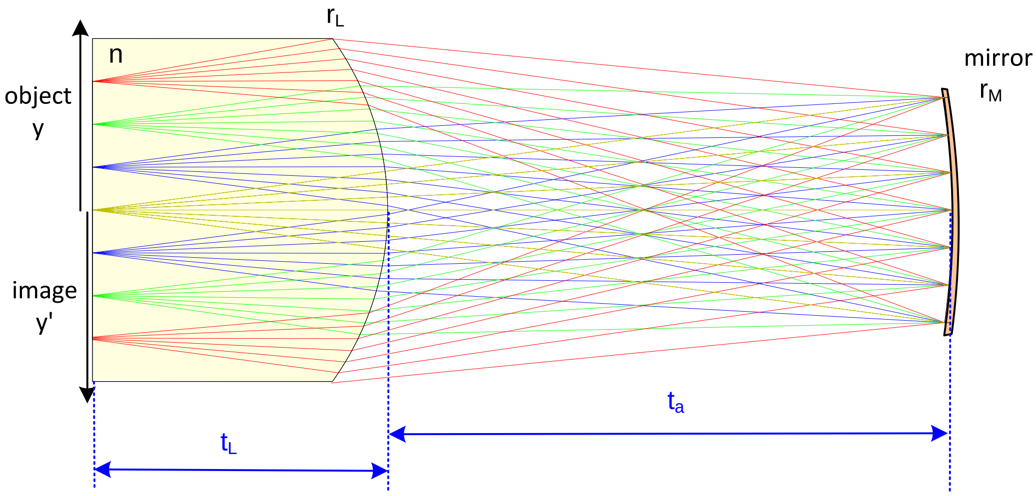
A classical triplet system consists of two positive lenses L1, L3 and one negative lens L2 in the sequence (+) (-) (+) as shown in the figure.



It is assumed, that the lenses are thin and can be considered as close together. The outer positive lenses are identical and of reversed orientation. They are made of a glass with high index $n_1 = n_3 = 1.8$ and the negative lens is made of a low index glass with $n_2 = 1.5$. Calculate the individual focal lengths of the lenses, if the total focal length of the system is f' = 100 mm and the field of view is flattened according to the Petzval theorem.
What can be done to control and correct the spherical aberration of the system ? If the negative lens is exactly in the middle position between the positive lenses, why can be seen coma and distortion, although the setup is symmetrical ? Why is the spherical aberration contribution of the identical outer surfaces not equal ?

Exercise 5-4: Dyson System

The so called Dyson system is a very clever setup, which can be used for some imaging applications with a quit good correction. A typical layout is shown in the following figure. All the curved surfaces are of spherical shape, the surface in the object and image plane respectively is plane.



a) What are the remaining aberrations of the system in the general case of arbitrary parameters ? Sketch the system, if the mirror is unfolded and considered it as a positive thin lens.
b) If the parameters are chosen as $t_L = -r_L$ and $t_L+t_a = -r_M$, what is the consequence for the aberrations ?
c) What is in addition the necessary condition for the parameters to correct the Petzval field curvature in 3rd order ? What should therefore be the radius r_L of the lens, if the glass index is $n = 1.5$ and the mirror has the radius $r_M = 100$ mm ?
d) What is now the only remaining primary aberration of the system ?