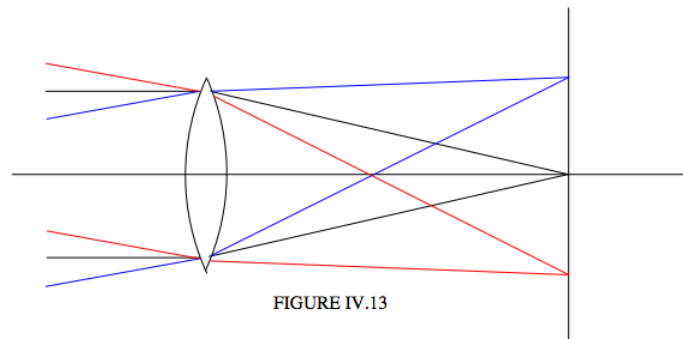
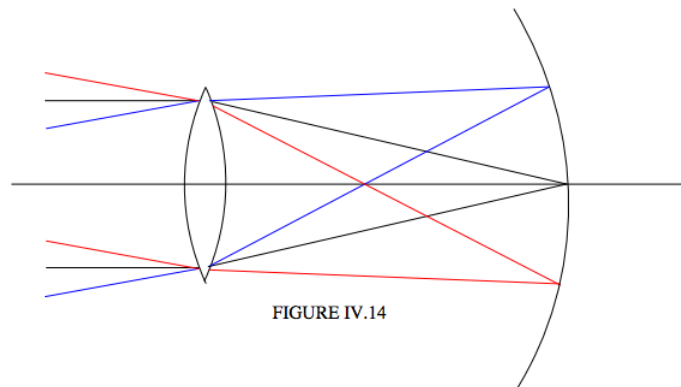


4.5: Curvature of Field

Suppose we have a lens that we have managed to correct for (or at least to minimize) spherical aberration, astigmatism and coma, say by a combination of choosing the right shape of the lens and not going too far off-axis. (I.e. we might close the lens to an aperture of $f/11$ rather than opening it up to $f/5.6$.) Nothing that we know about refraction and lenses and mirrors tells us that that light coming in at different angles to the axis forms point images conveniently situated in a plane, as illustrated hopefully in Figure IV.13.



Alas, life is not as simple as that, and light doesn't generally come to a focus in a focal plane, but rather in a curved focal surface (sometimes called the *Petzval surface*), as in Figure IV.14.



This doesn't matter a great deal in a telescope designed merely for looking through, since the eye can rapidly accommodate for slightly different image distance, but it obviously matters in a photographic telescope. One effective way of dealing with this problem, particularly if your detector is a flexible film, is to shape the filmholder so that the film fits along the Petzval surface. This is often done, for example, with Schmidt astronomical telescopes.

In designing a lens or lens system, the problems of astigmatism and curvature of field are often closely related. For example a meniscus lens tends to suffer from astigmatism, and there is a focal surface for the tangential image, and a focal surface for the sagittal image, and the tangential and sagittal surfaces curve in opposite senses. With luck, or more likely with some careful design, the surface (C) for the loci of the circles of least confusion is between the tangential (T) and sagittal (S) surfaces and is approximately planar (Figure IV.15).

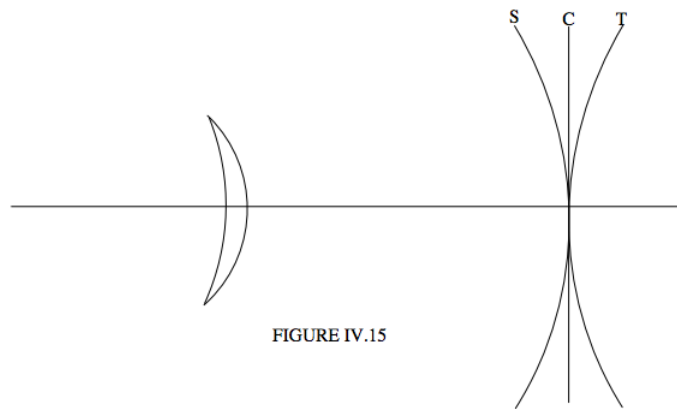


FIGURE IV.15

It has been shown that, if you have a doublet lens, made of two lenses, one a converging lens of focal length f_1 and refractive index n_1 , and the other a diverging lens of focal length f_2 and refractive index n_2 , curvature of field will be least if $\frac{1}{n_1 f_1} + \frac{1}{n_2 f_2} = 0$. For example if you have two glasses, of refractive indices $n_1 = 1.51$ and the other of refractive index $n_2 = 1.67$, and you want to make a doublet lens of focal length 100 cm, what should be the focal lengths of the two components of the doublet if you want to minimize curvature of field?

Answer: The lenses need to satisfy $\frac{1}{n_1 f_1} + \frac{1}{n_2 f_2} = 0$ and $\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{f}$. It's probably easier to work in terms of powers rather than focal lengths, so we have to solve $1.67P_1 + 1.51P_2 = 0$ and $P_1 + P_2 = 0.01$. This gives $P_1 = -0.094375 \text{ cm}^{-1}$ and $P_2 = +0.104375 \text{ cm}^{-1}$, or $f_1 = 10.60 \text{ cm}$ and $f_2 = 9.58 \text{ cm}$. You will then have to design the lenses so that the faces of the two lenses that are in contact have the same radius of curvature, and we leave that to the reader.

For a similar problem concerning a doublet with minimum chromatic aberration, see Chapter 2, [Section 2.10](#).

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