



中国科学技术大学

第六章 像差理论

2015/11/11

§ 6.1 概述

由理想光学系统到实际光学系统

● 理想光学系统

- 近轴
- 细光束

$$\sin \theta = \theta; \cos \theta = 1$$

● 实际光学系统

- 大孔径
- 大视场

$$\sin \theta = \theta - \frac{\theta^3}{3!} + \frac{\theta^5}{5!} - \frac{\theta^7}{7!} + \dots$$

像差来源

像差种类

- 单色光（单色像差）

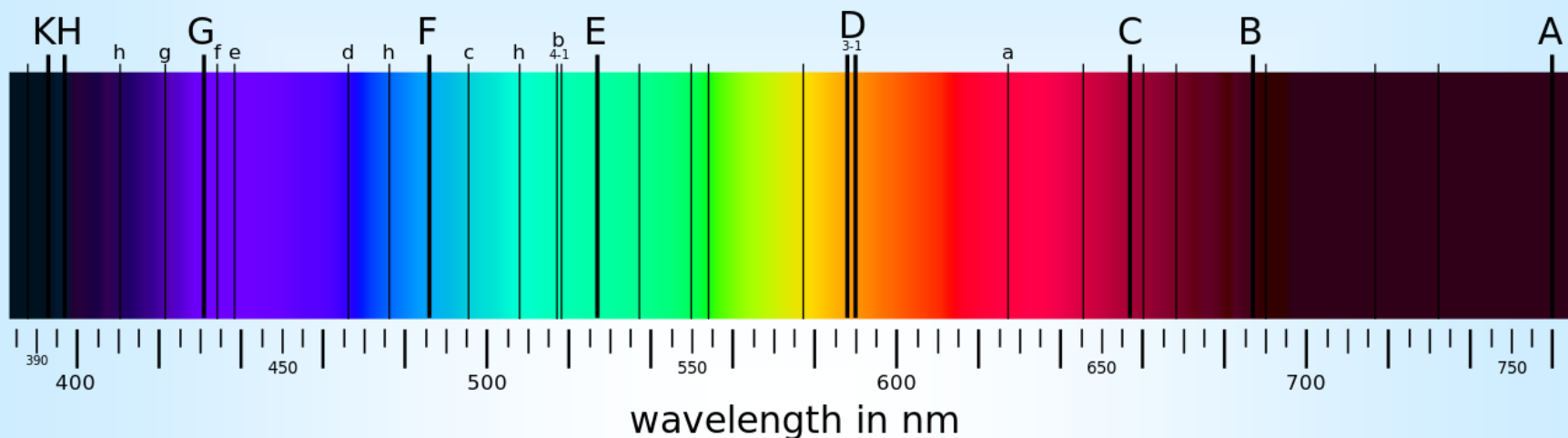
- 球差、彗差、像散、场曲、畸变

- 白光（色差）

- 位置色差、倍率色差

} 几何像差

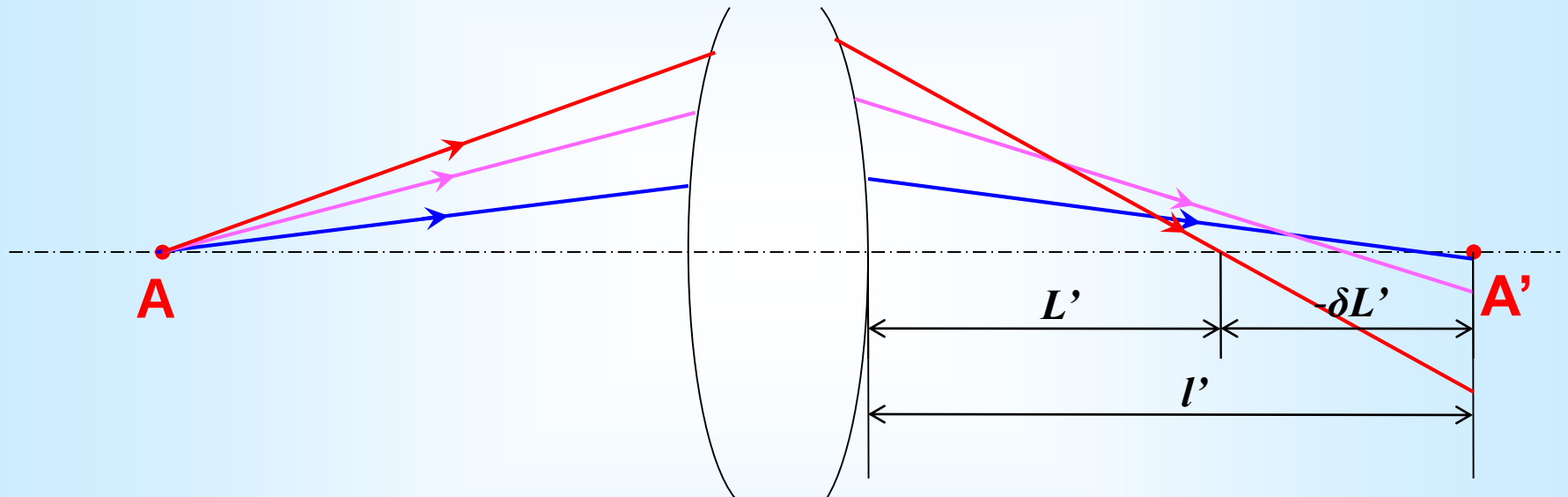
夫琅和费谱线



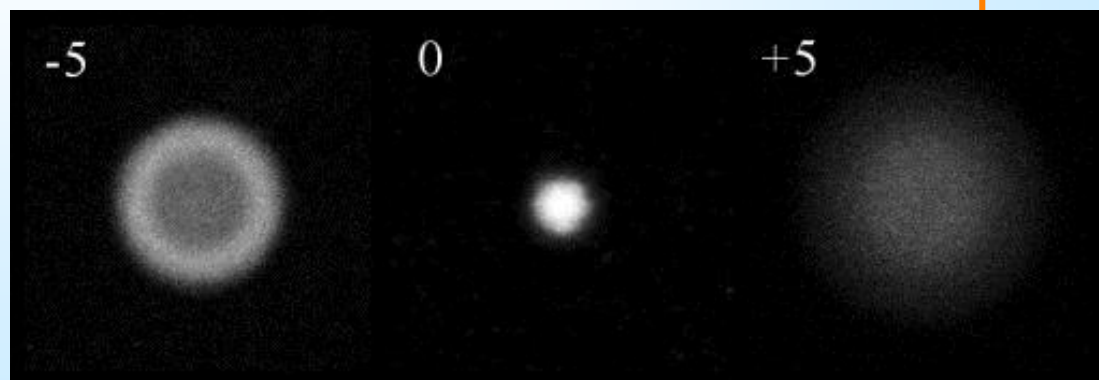
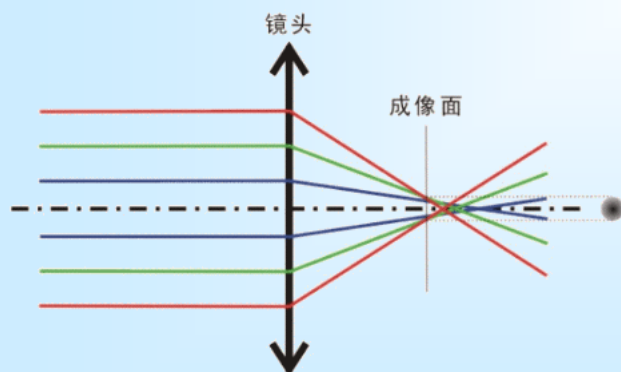
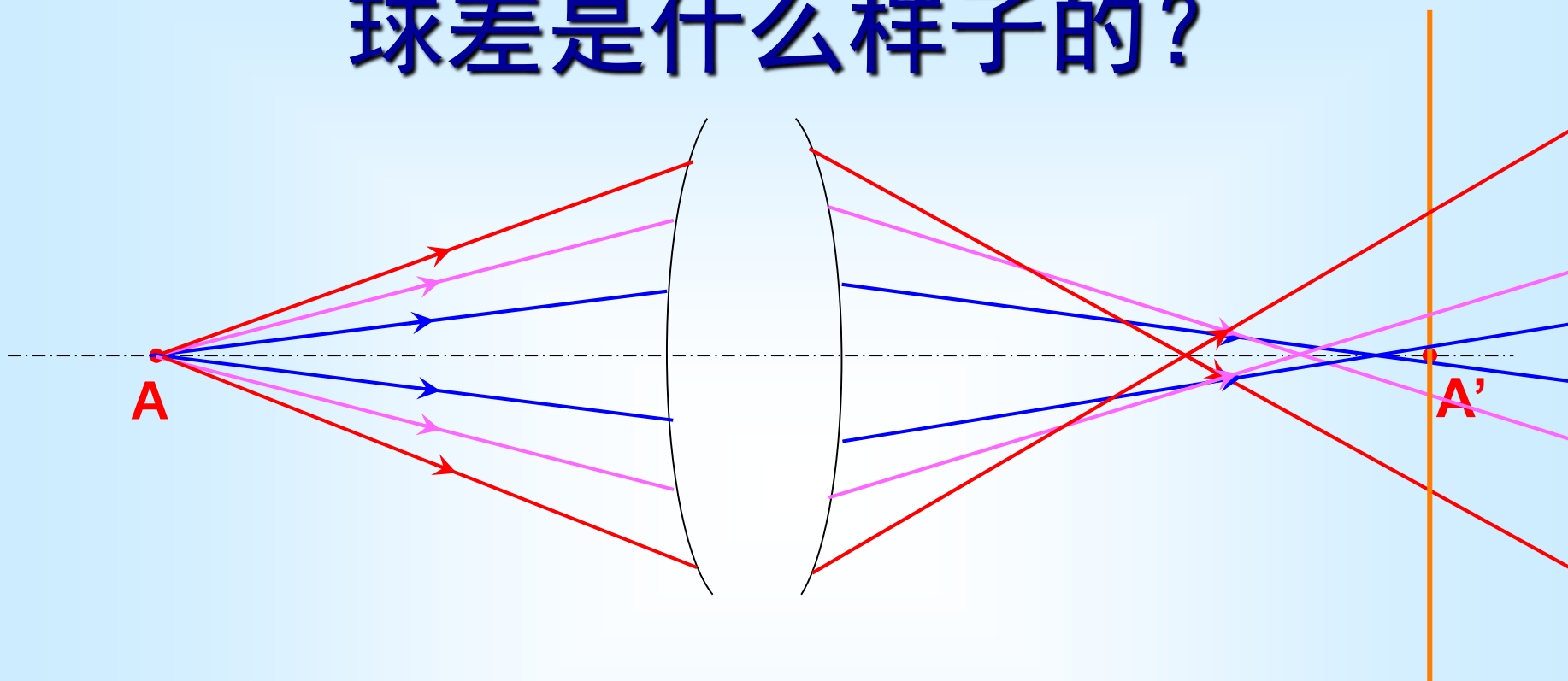
名称	元素	波长 (nm)		名称	元素	波长 (nm)		名称	元素	波长 (nm)
y	氧 (O ₂)	898.765		b ₁	镁 (Mg)	518.362		G	钙 (Ca)	430.774
Z	氧 (O ₂)	822.696		b ₂	镁 (Mg)	517.270		h	H δ	410.175
A	氧 (O ₂)	759.370		b ₃	铁 (Fe)	516.891		H	钙 (Ca ⁺)	396.847
B	氧 (O ₂)	686.719		b ₄	铁 (Fe)	516.751		K	Ca ⁺	393.368
C	H α	656.281		b ₄	镁 (Mg)	516.733		L	铁 (Fe)	382.044
a	氧 (O ₂)	627.661		c	铁 (Fe)	495.761		N	铁 (Fe)	358.121
D ₁	钠 (Na)	589.592		F	H β	486.134		P	钛 (Ti) ⁺	336.112
D ₂	钠 (Na)	588.995		d	铁 (Fe)	466.814		T	铁 (Fe)	302.108
D ₃ (or d)	氦 (He)	587.5618		e	铁 (Fe)	438.355		t	镍 (Ni)	299.444
e	汞 (Hg)	546.073		G'	H γ	434.047				
E2	铁 (Fe)	527.039		G	铁 (Fe)	430.790				

§ 6.2 球差 (Spherical Aberration)

球差产生原理



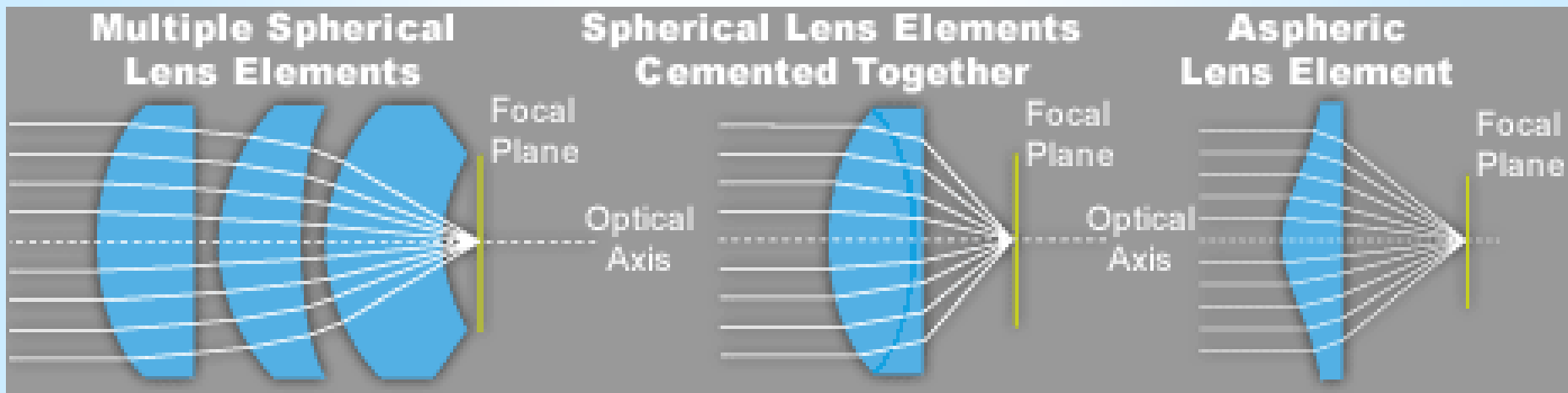
球差是什么样子的？



球差的校正

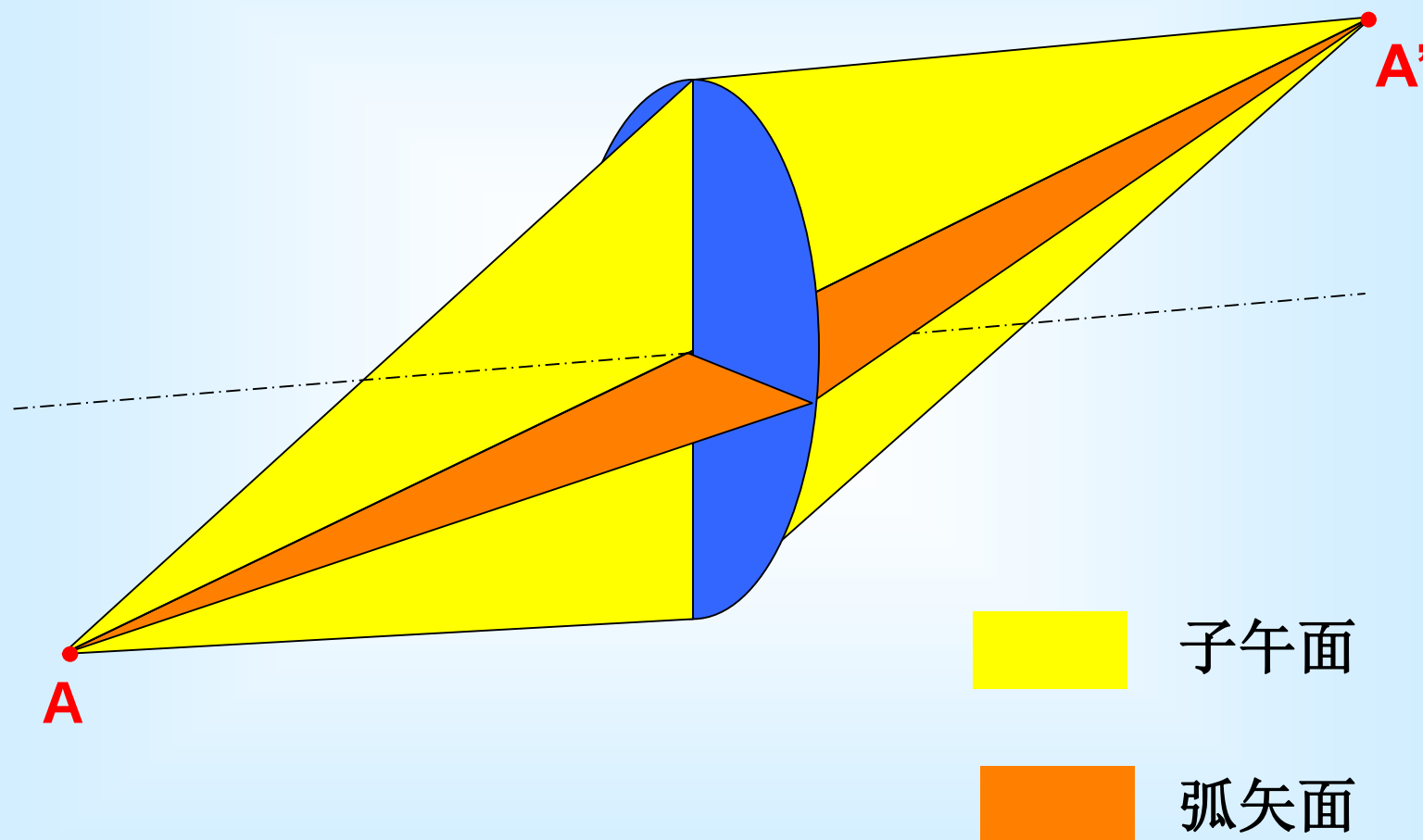
● 单透镜：

- 球面：正透镜→负球差；负透镜→正球差
- 单球面透镜一定有球差，要校正球差可使用正负透镜组合
- 非球面单透镜可以做到无球差

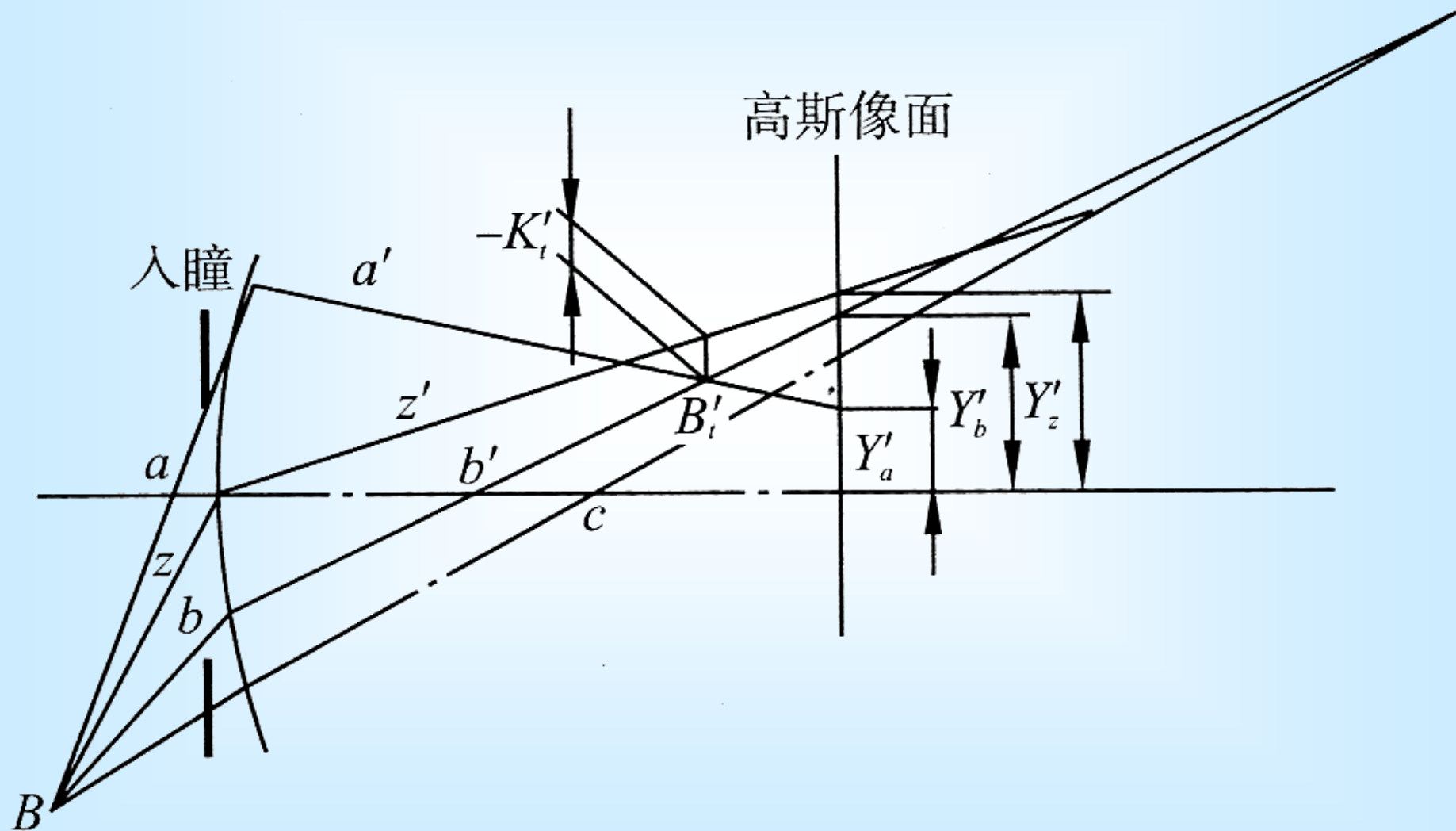


§ 6.3 彗差 (Coma)

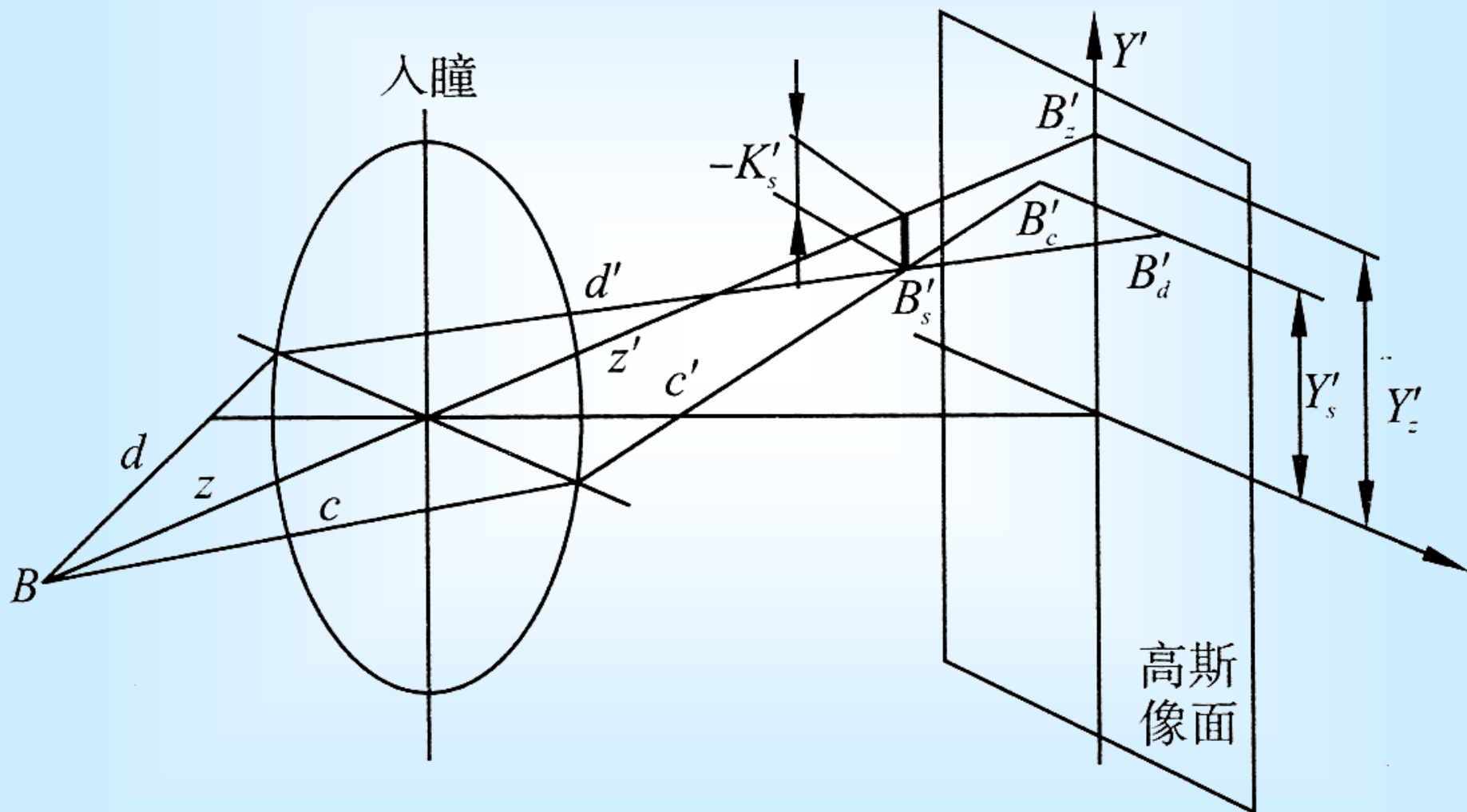
子午面与弧矢面



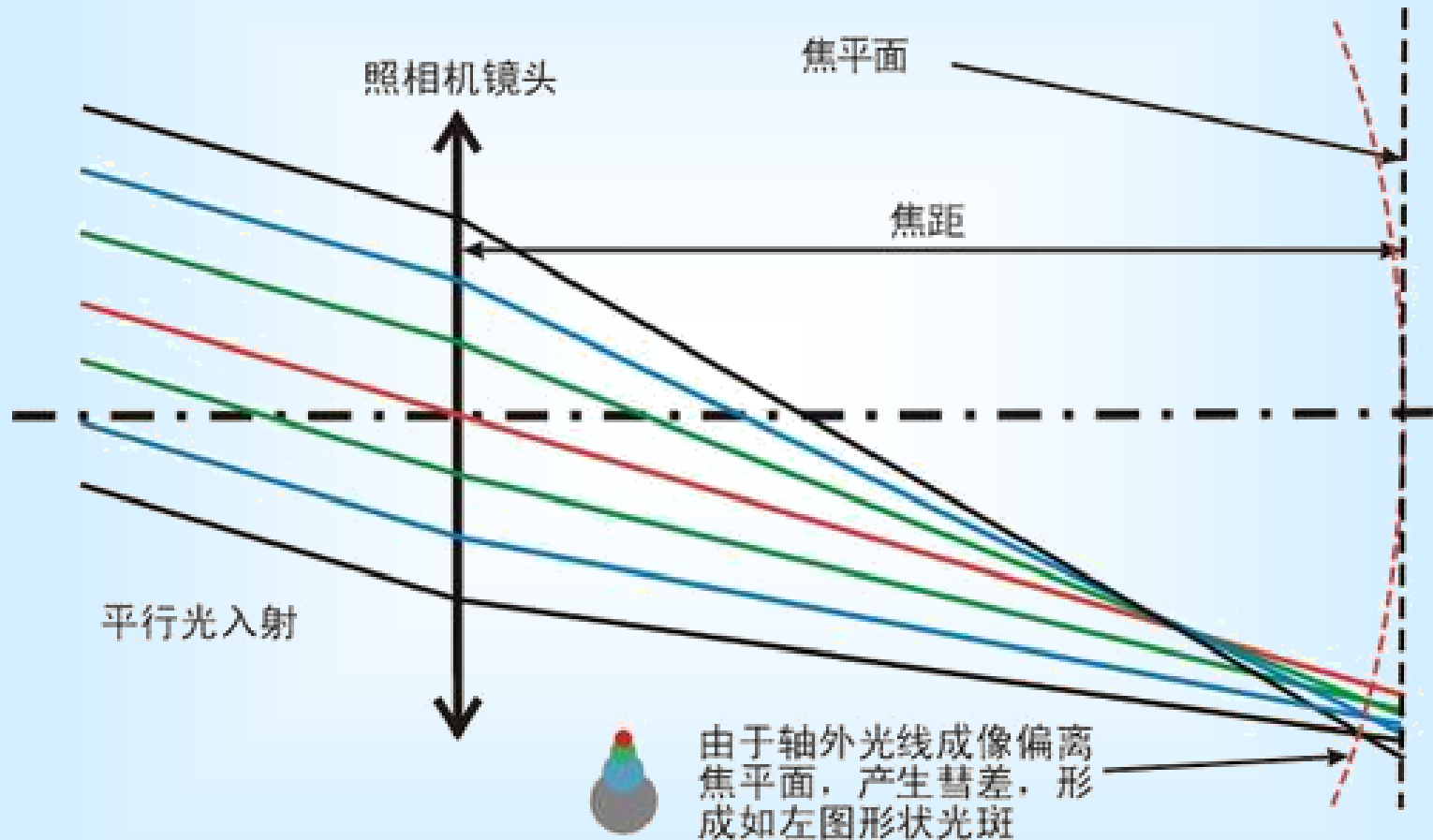
子午面彗差



弧矢面彗差

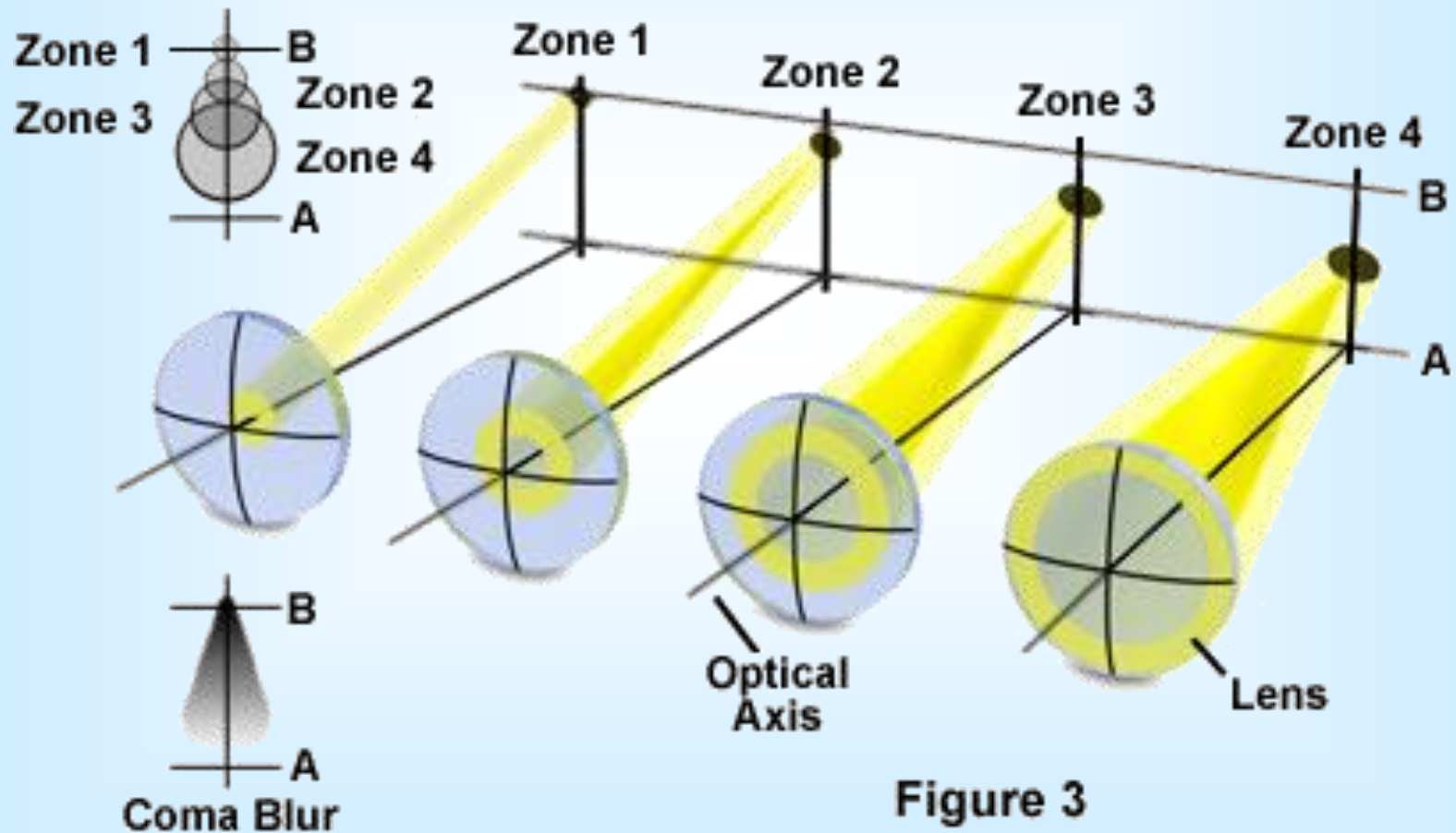


彗差 (Coma)



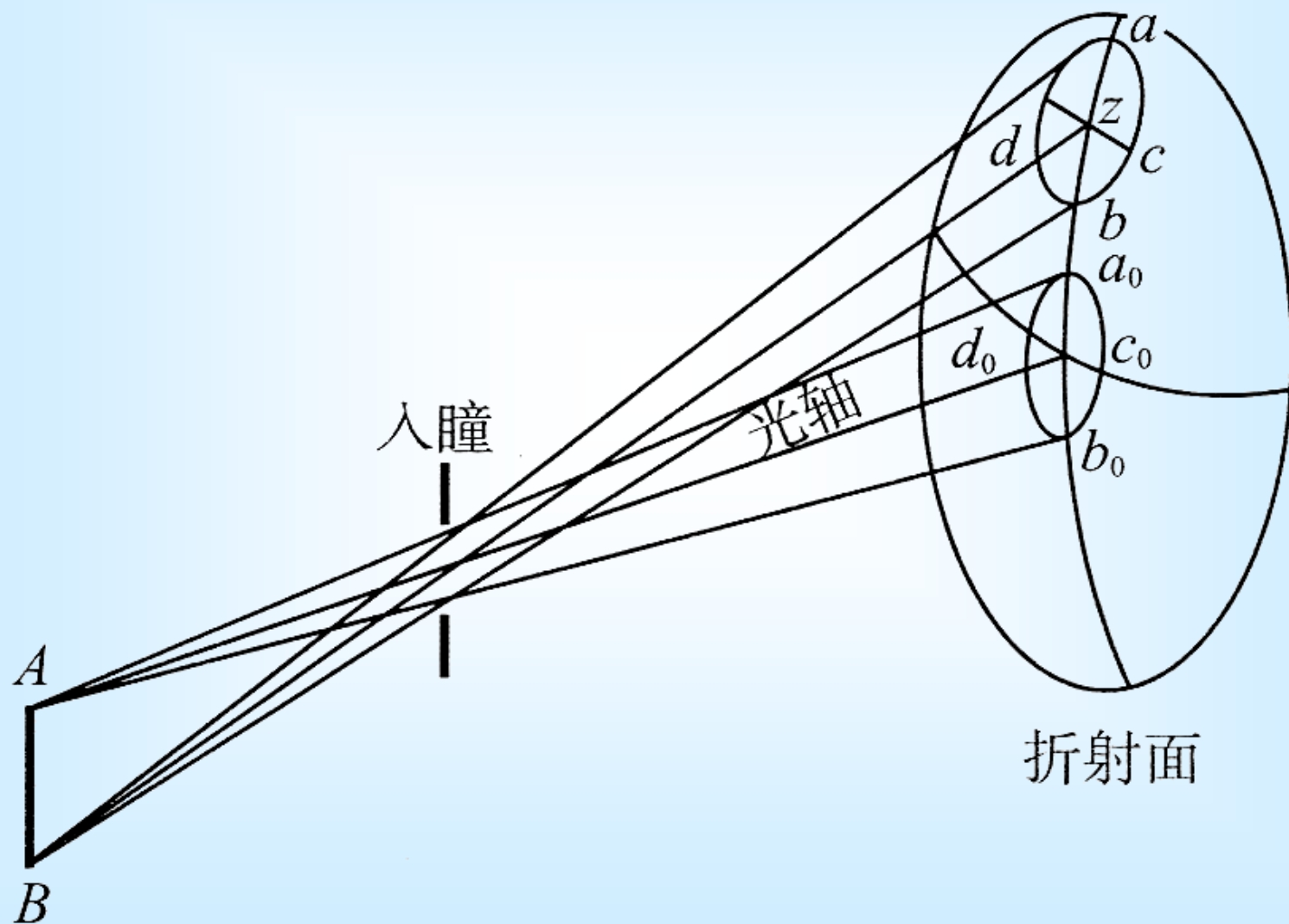
彗差 (Coma)

Off-Axis Coma Aberration

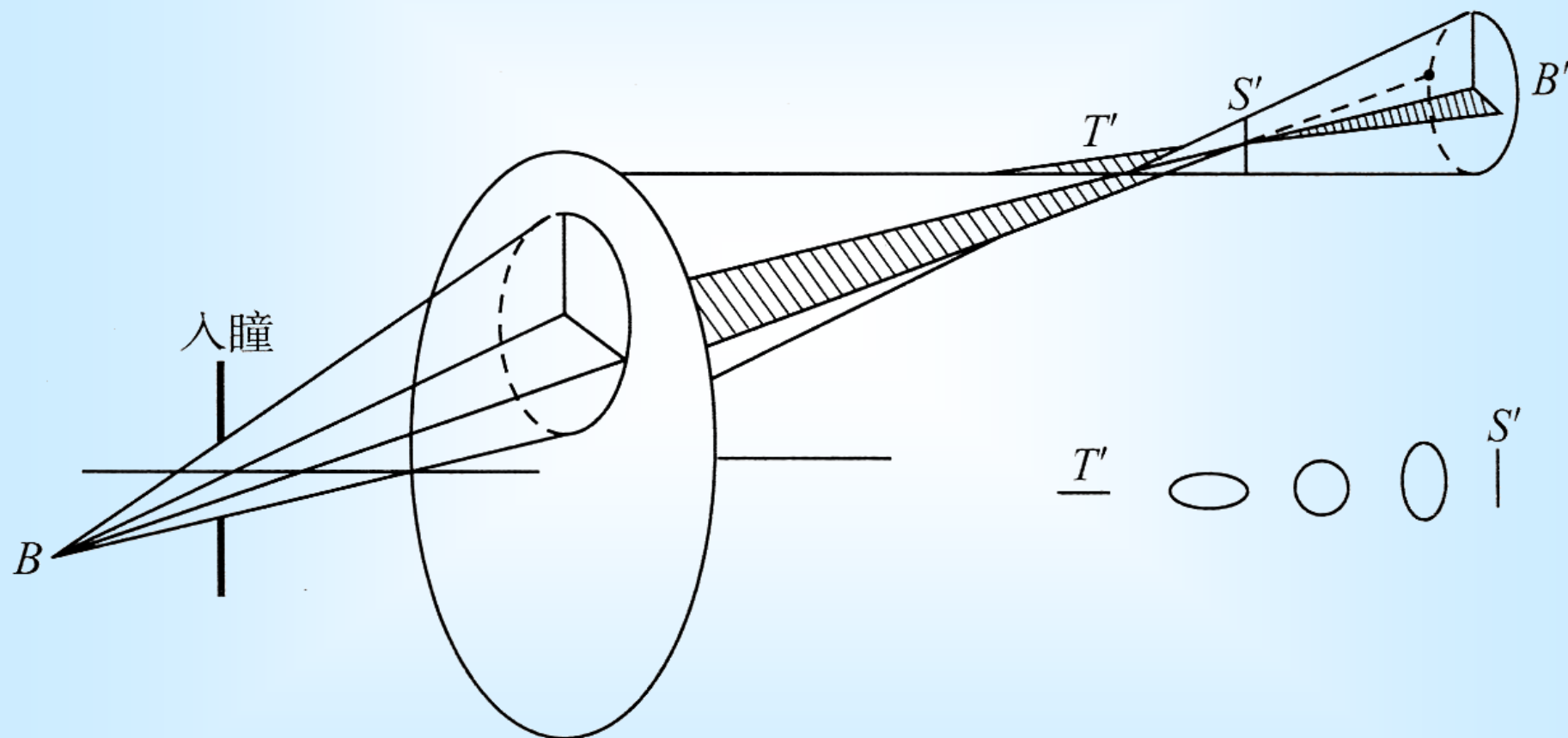


§ 6.4 像散和场曲

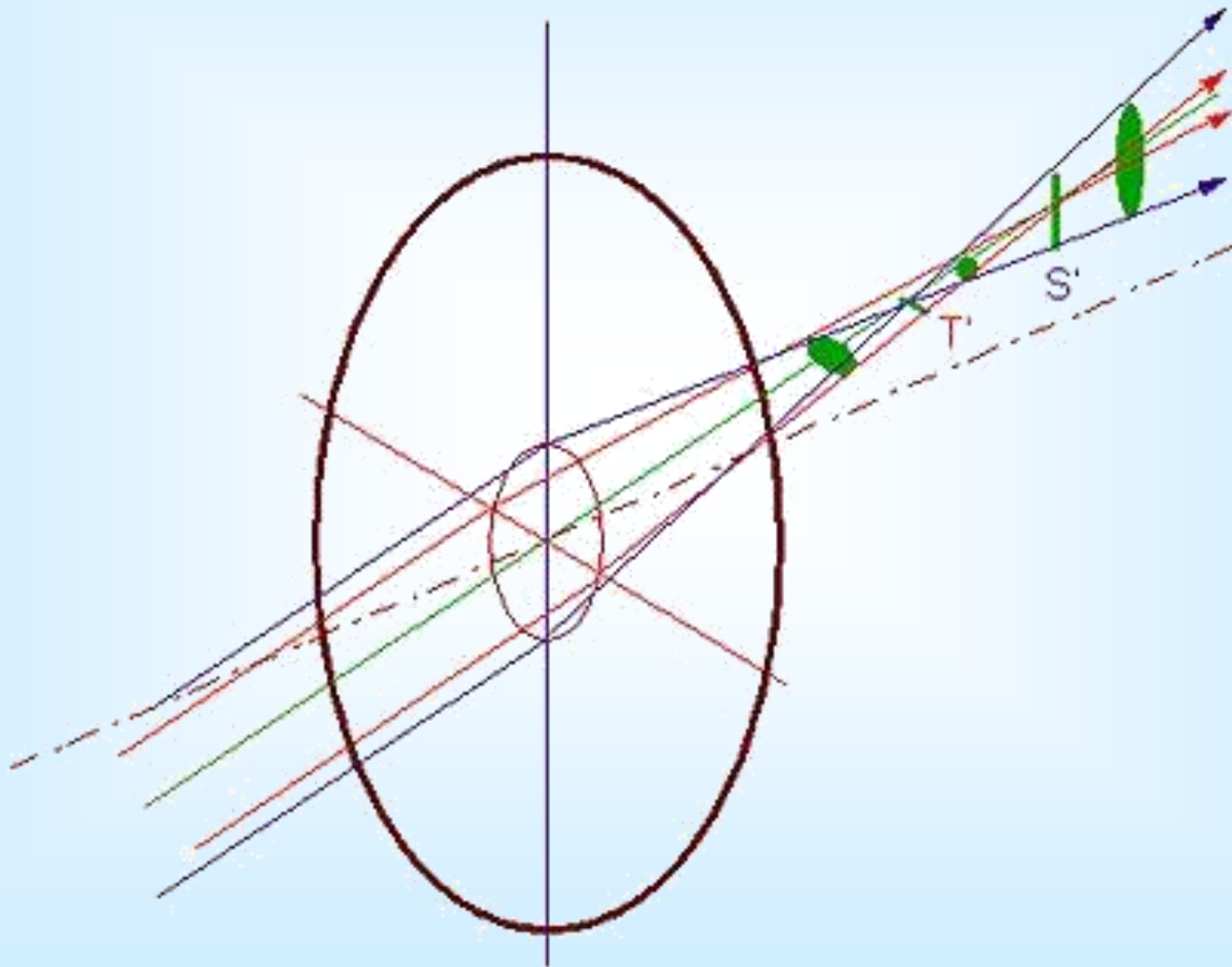
细光束



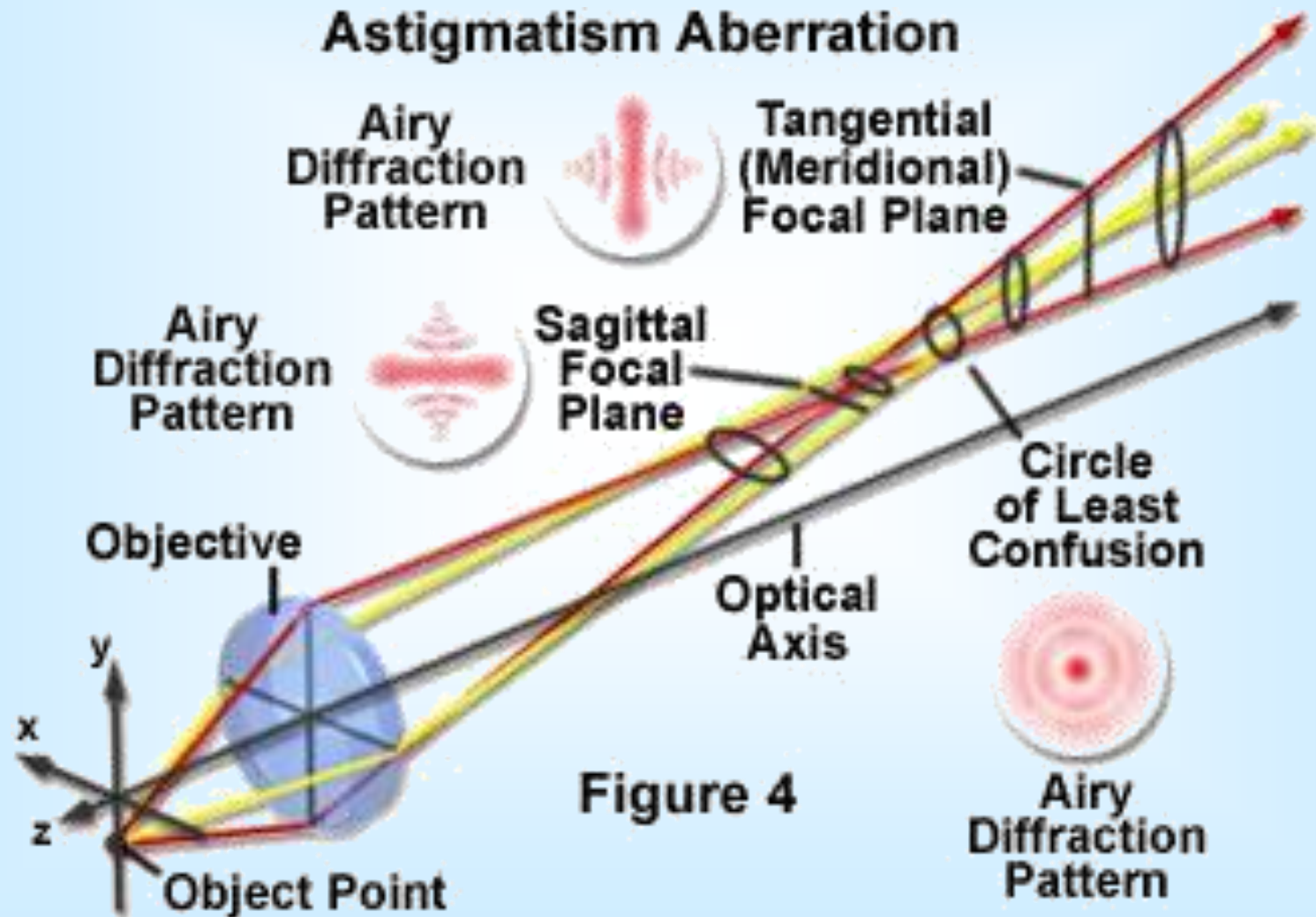
像散 (Astigmatism)



像散 (Astigmatism)



像散 (Astigmatism)



像散作用下的成像情况

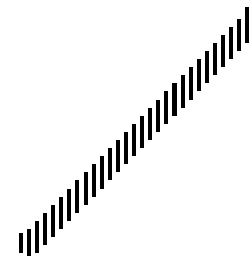
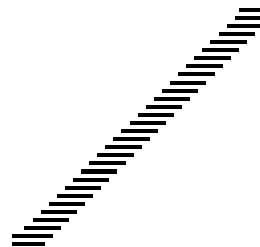
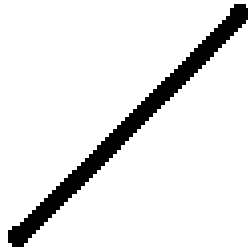
物



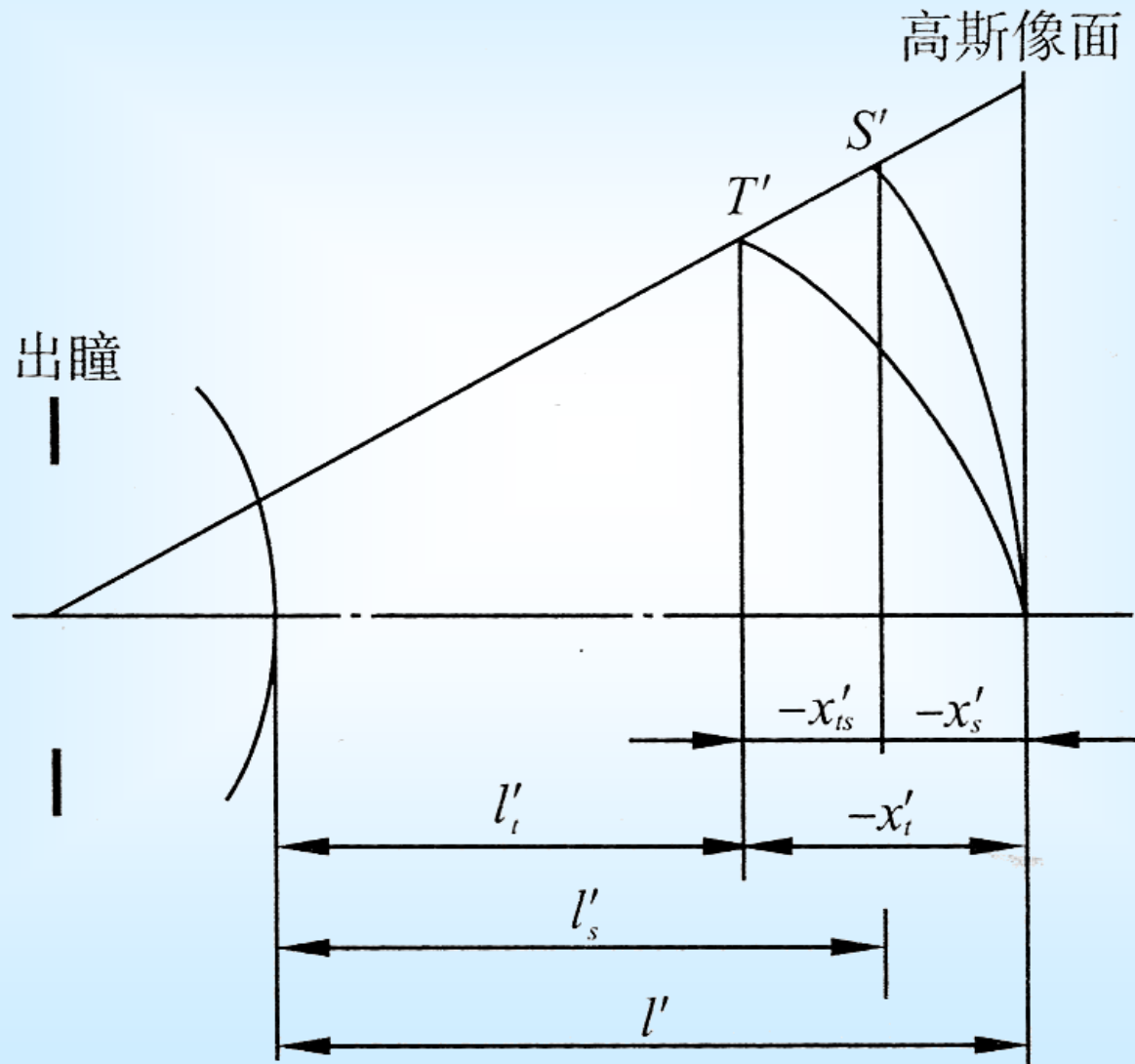
子午像



弧矢像

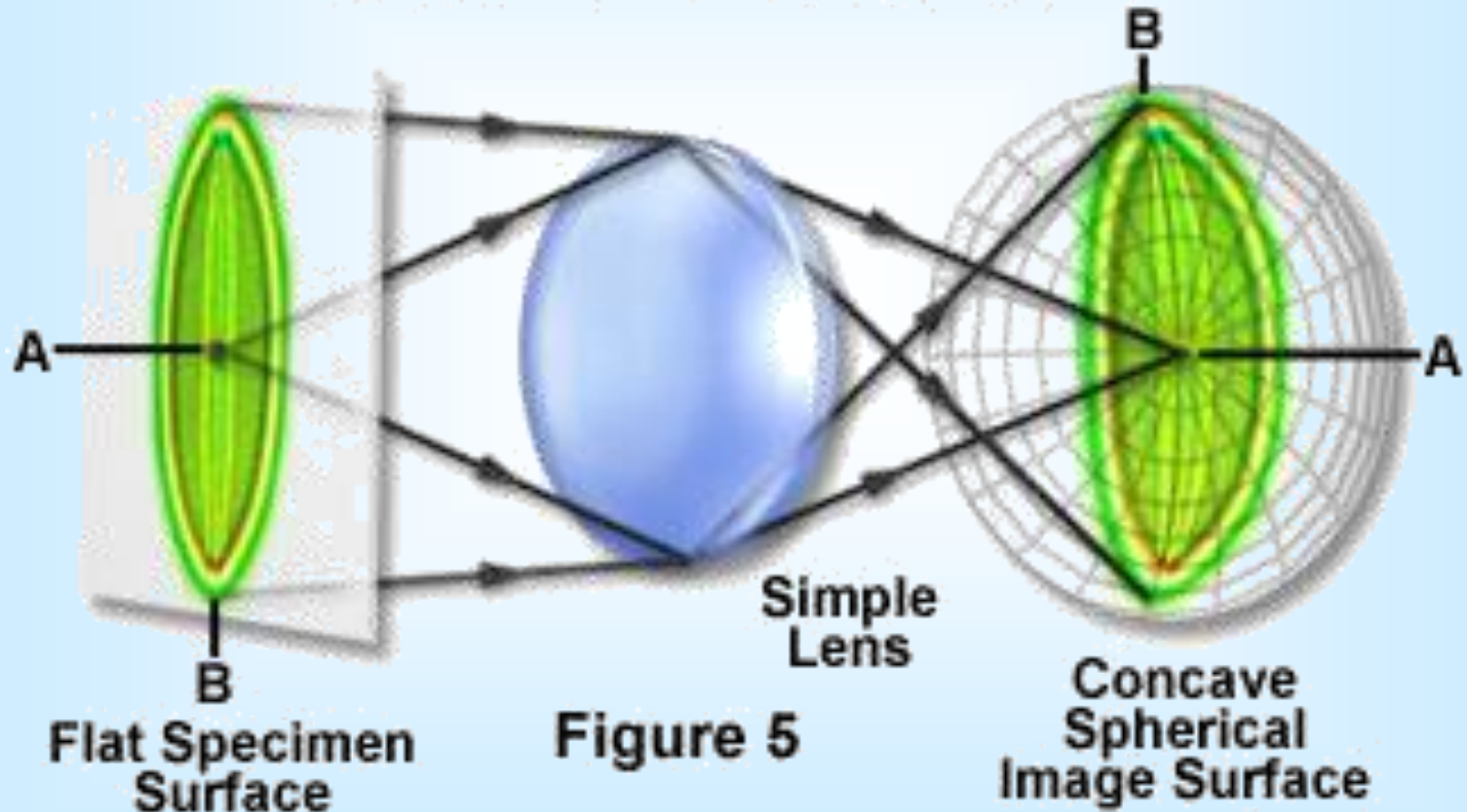


场曲 (Field Curvature)

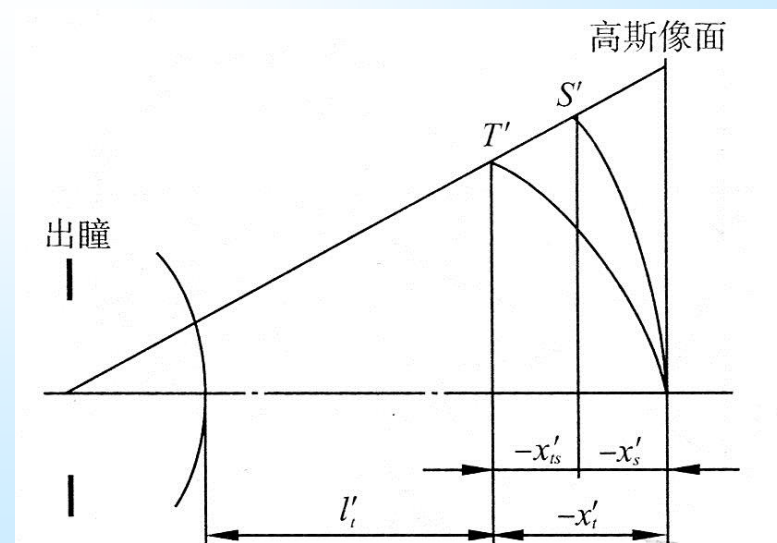
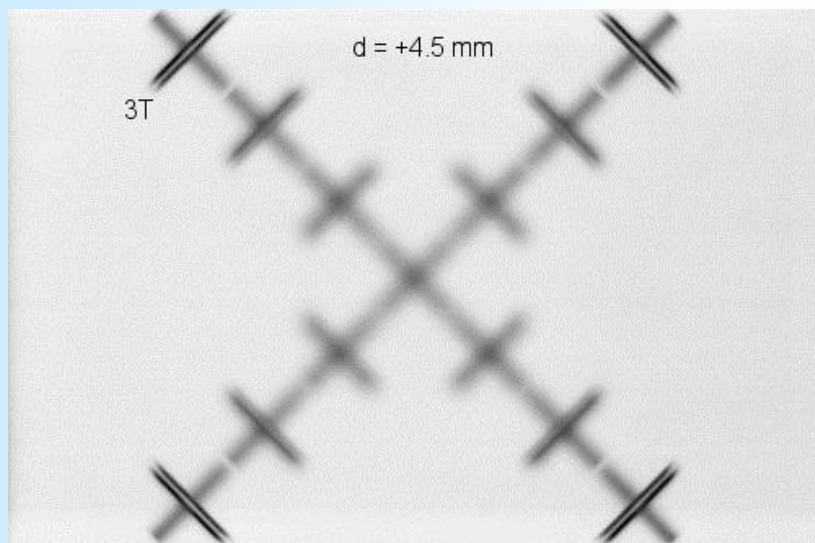
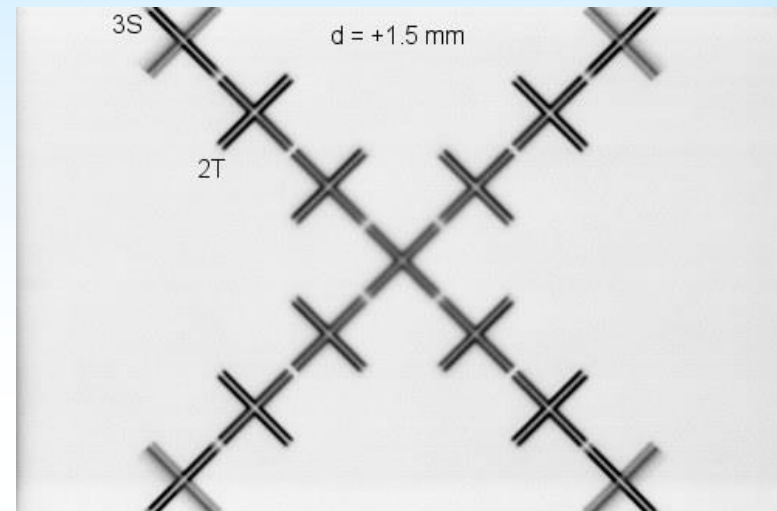
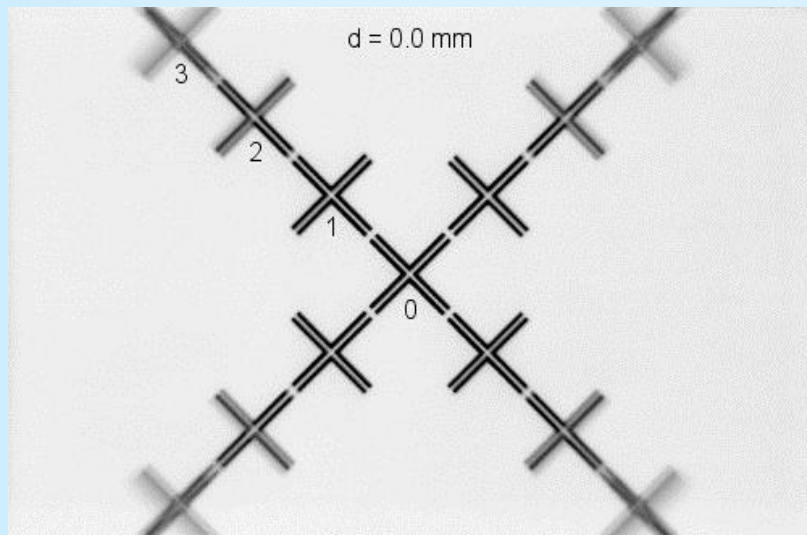


场曲 (Field Curvature)

Field Curvature Aberration

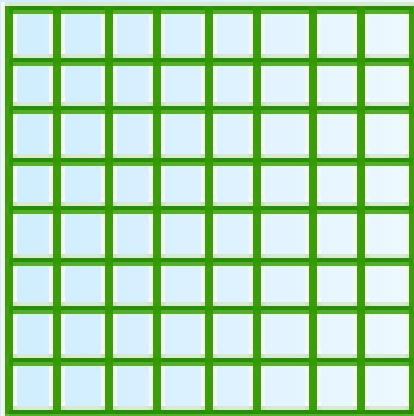


场曲作用下的成像情况

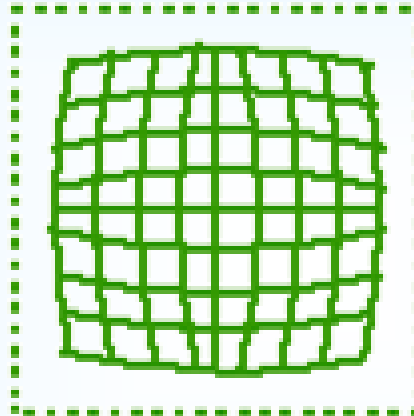


§ 6.5 畸变

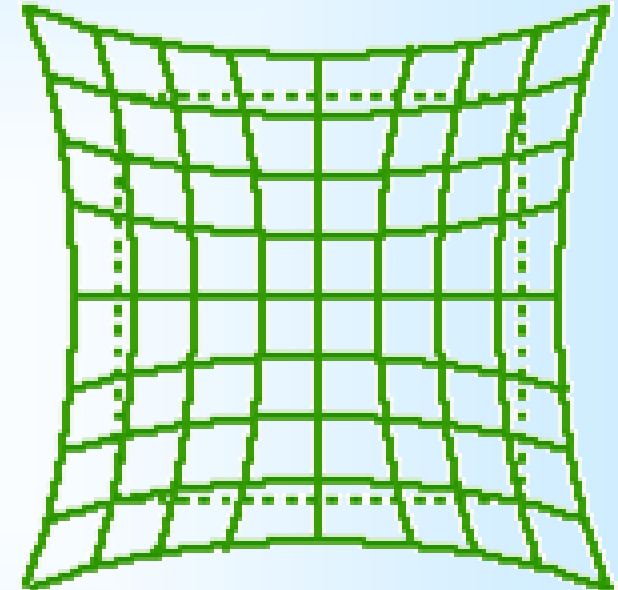
畸变



理想像



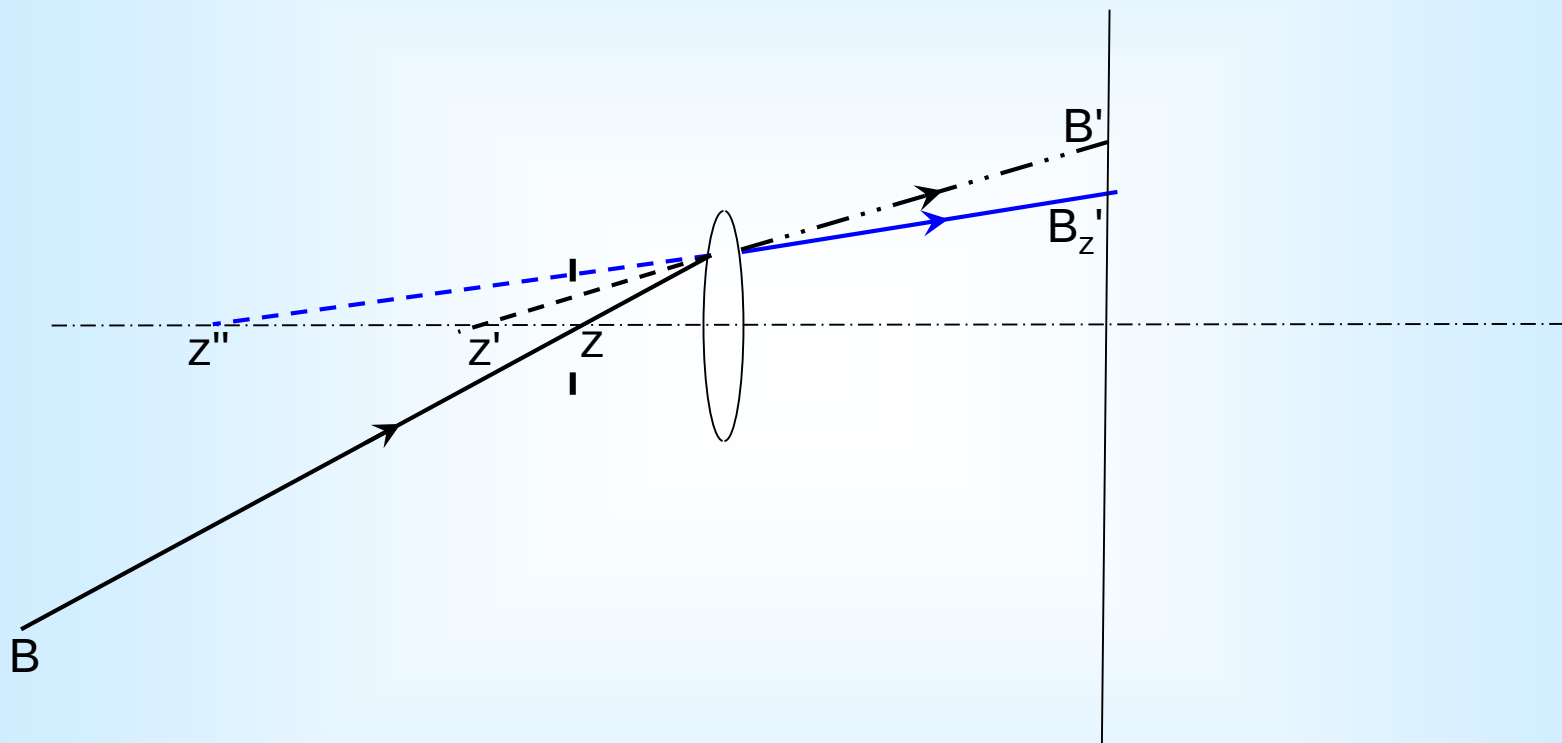
桶形畸变



枕形畸变

畸变仅由主光线的光路决定，它只引起像的变形，对像的清晰度并无影响

畸变的成因



畸变的成因是由于主光线通过光学系统时存在着球差的缘故

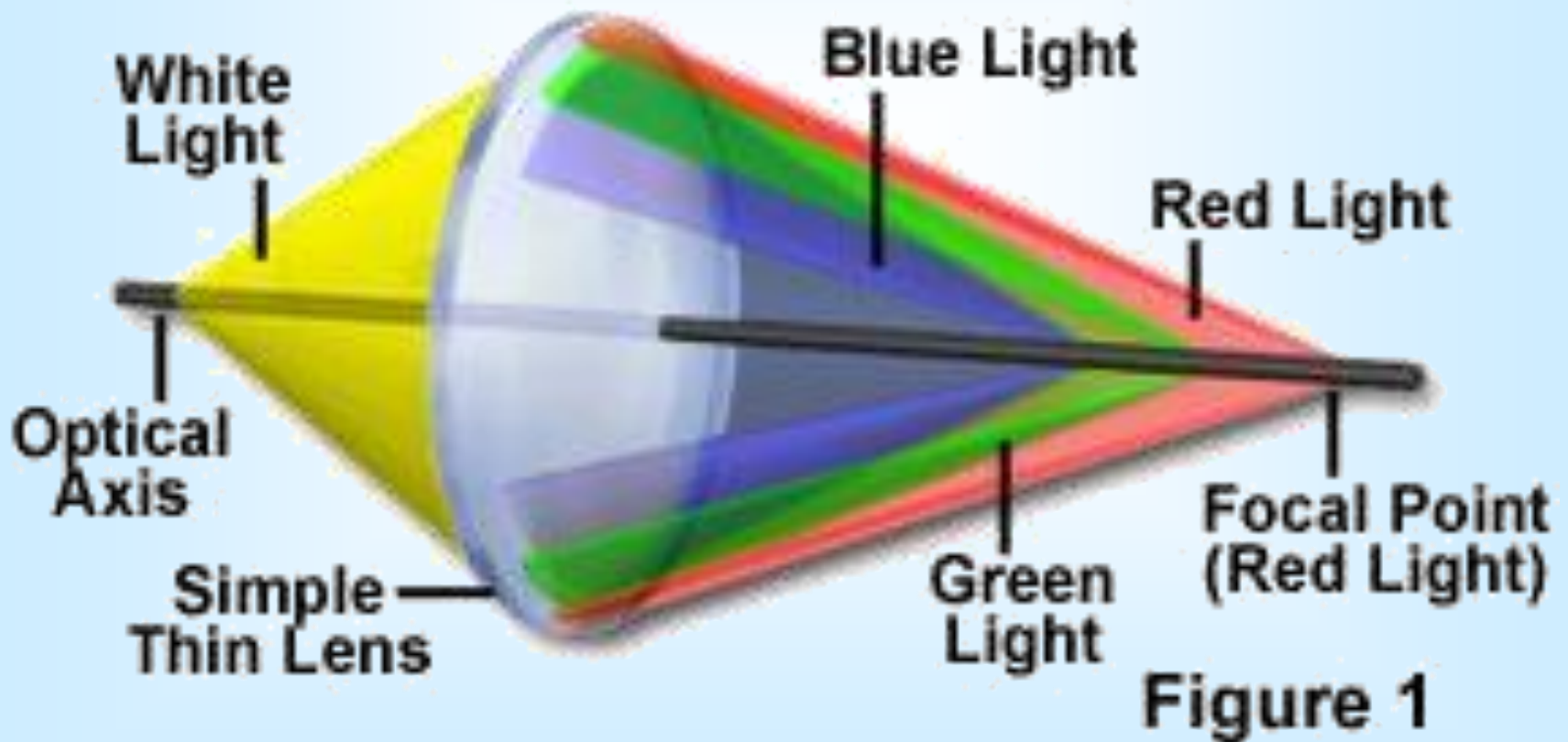
畸变实例



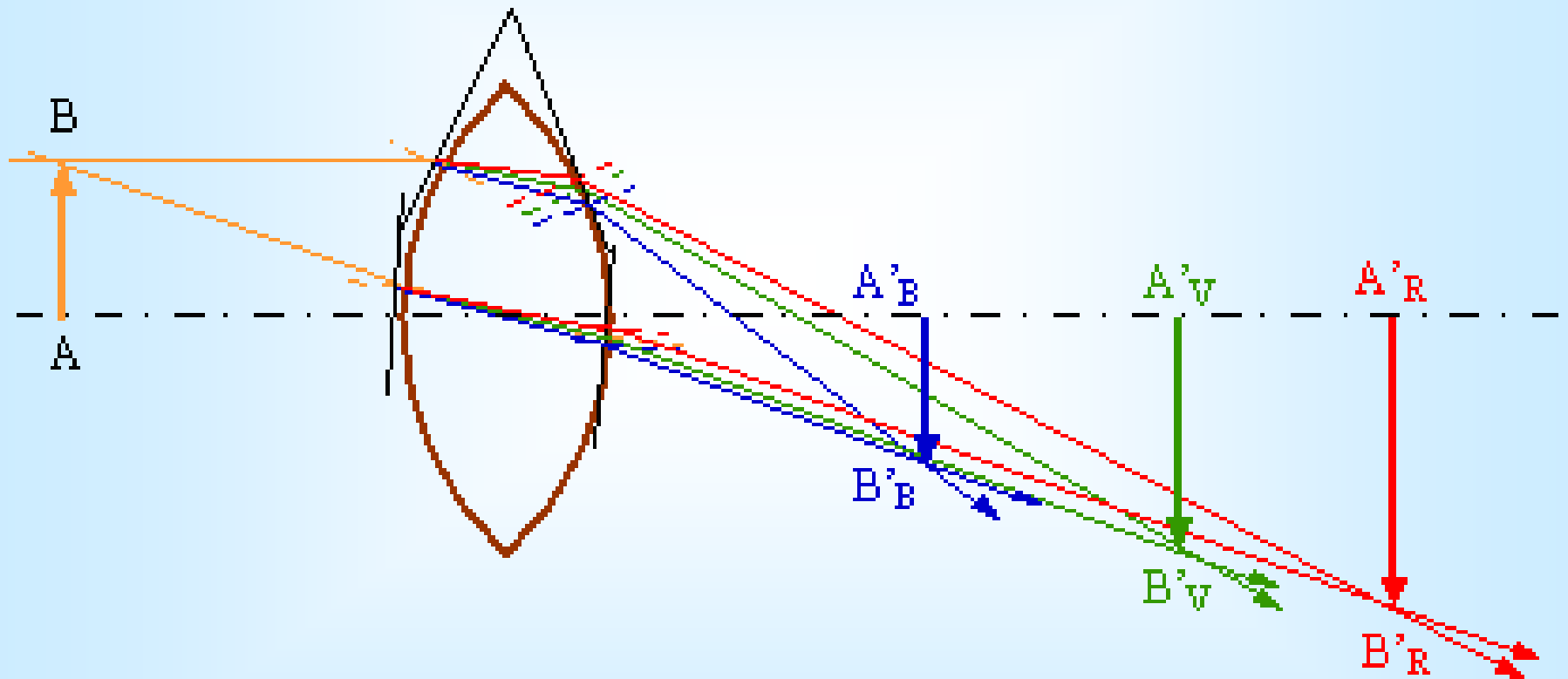
§ 6.6 色差 (Chromatic Aberration)

位置色差

Axial Chromatic Aberration



倍率色差



混合有色差的像差



焦前

焦面

焦后

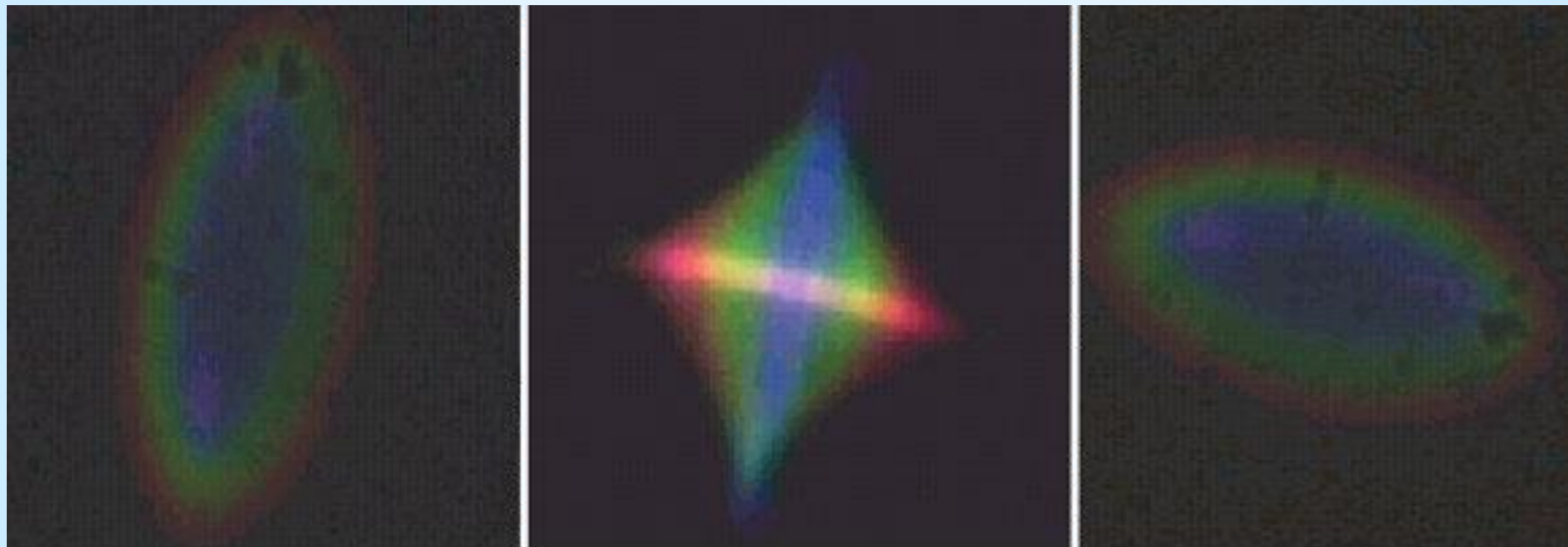
球差

混合有色差的像差



彗差

混合有色差的像差



焦前

焦面

焦后

像散

OK