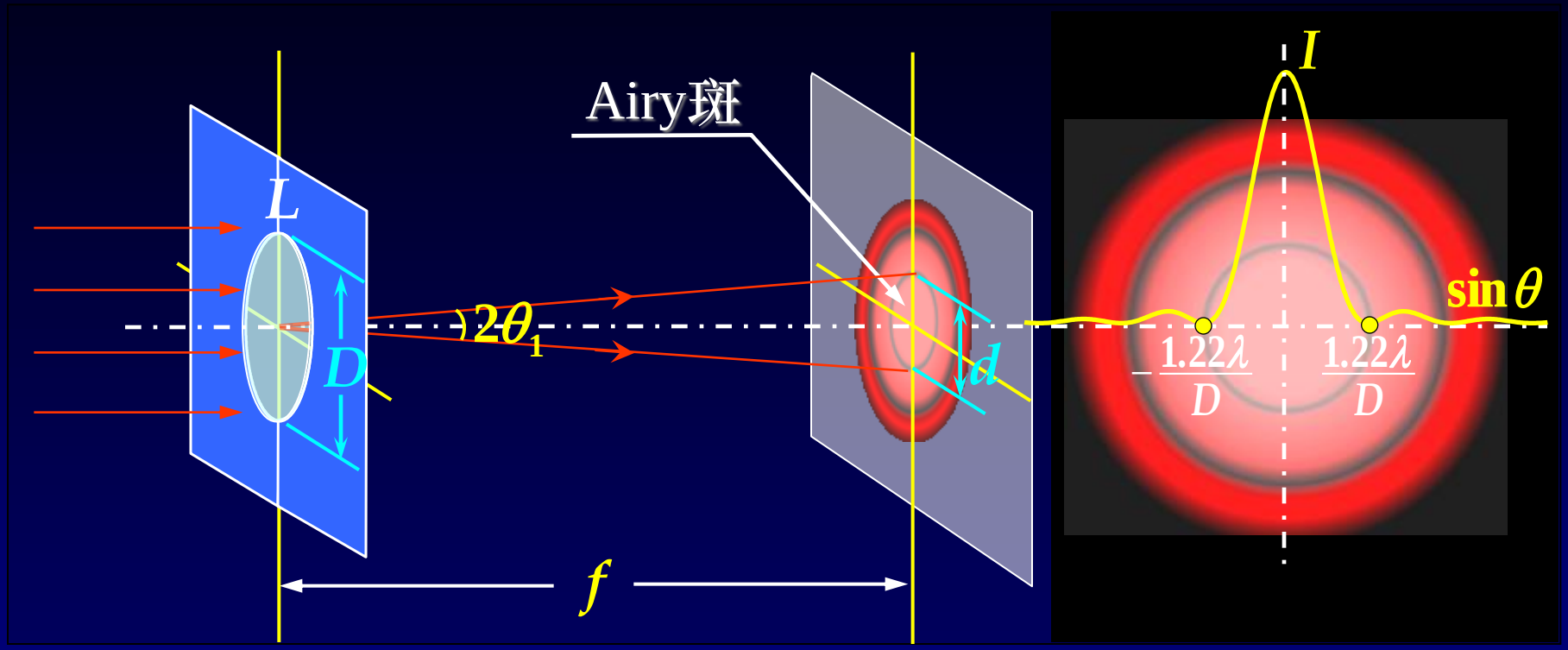
§ 11.7　圆孔衍射

光学仪器的分辨本领

一、圆孔*Fraunhofer*衍射

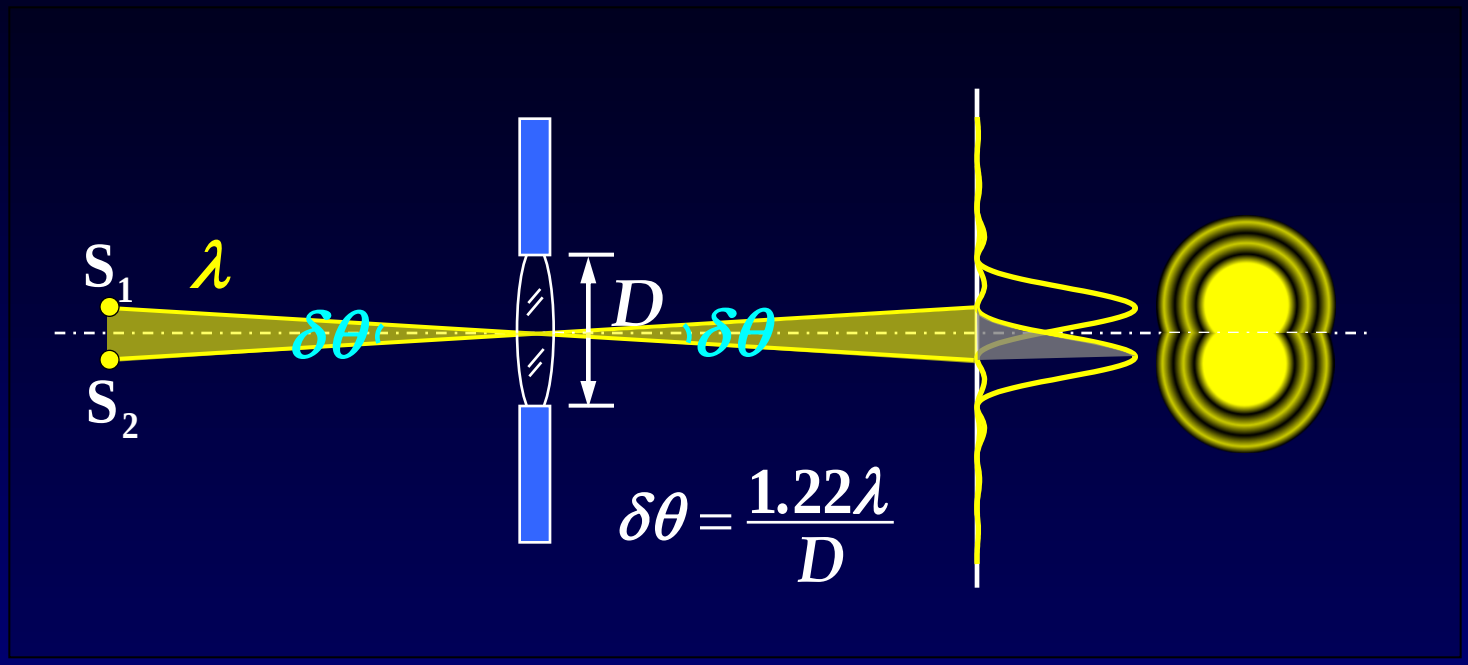


Airy 斑

半角宽度：$\theta_1 = \dfrac{1.22\lambda}{D}$

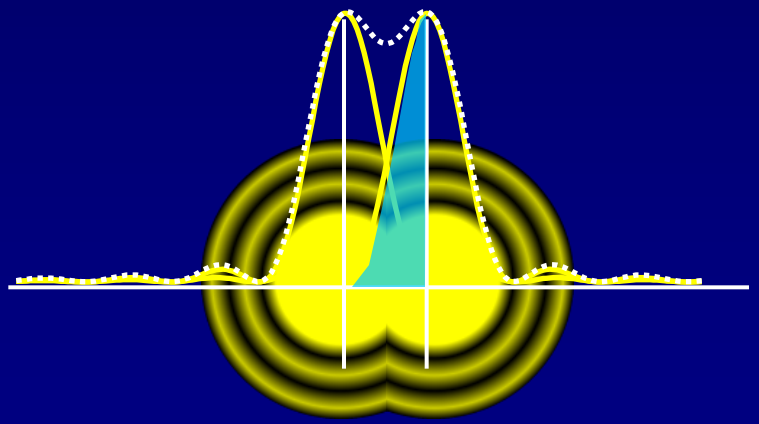
线 宽 度：$f \cdot 2\theta_1 = \dfrac{2.44\lambda}{D} f$

二、光学仪器的分辨本领



Rayleigh判据：

$\theta = \delta\theta = \dfrac{1.22\lambda}{D}$ 时，恰可分辨！

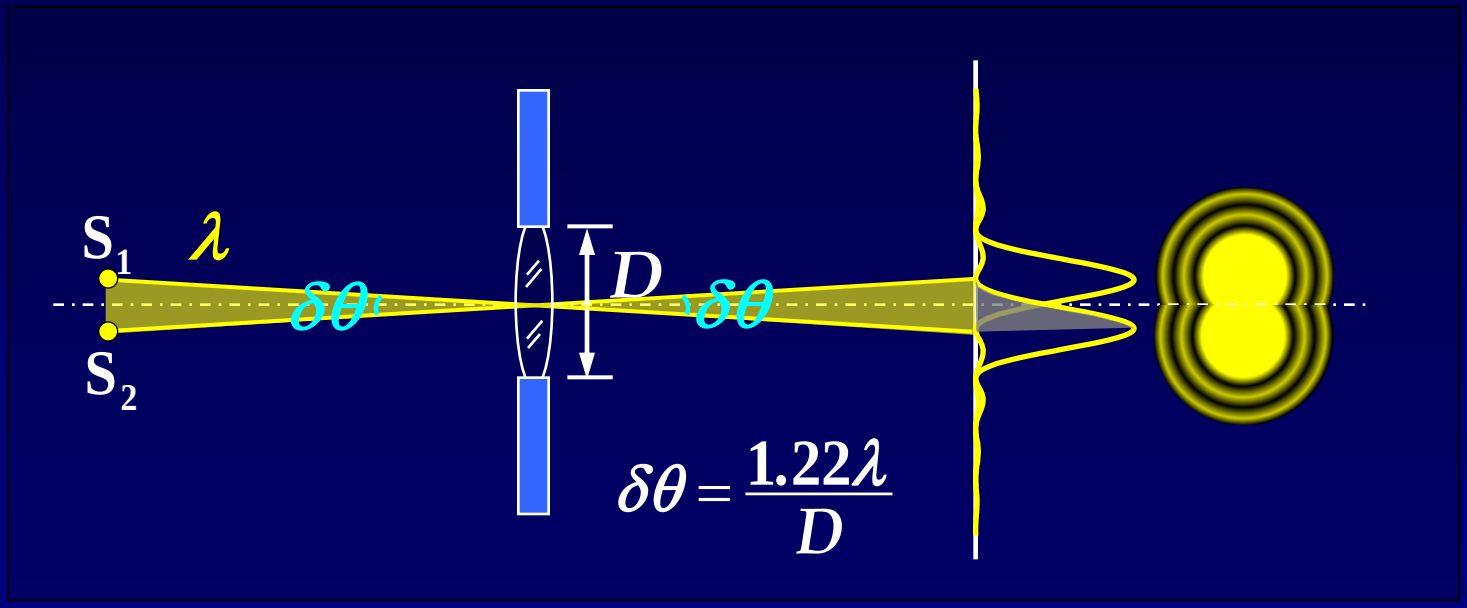


最小分辨角：$\delta\theta = \dfrac{1.22\lambda}{D}$

可分辨：$\theta \geq \delta\theta$

可分辨的高度：$h \approx l \cdot \theta \geq l \cdot \delta\theta$

可分辨的距离：$l \approx \dfrac{h}{\theta} \leq \dfrac{h}{\delta\theta}$



最小分辨角：$\delta\theta = \dfrac{1.22\lambda}{D}$　　可分辨：$\theta \geq \delta\theta$

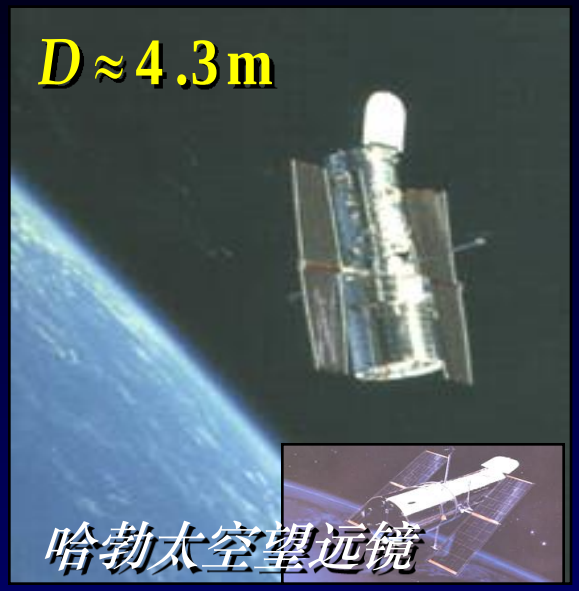
可分辨的高度：$h \approx l \cdot \theta \geq l \cdot \delta\theta$

可分辨的距离：$l \approx \dfrac{h}{\theta} \leq \dfrac{h}{\delta\theta}$

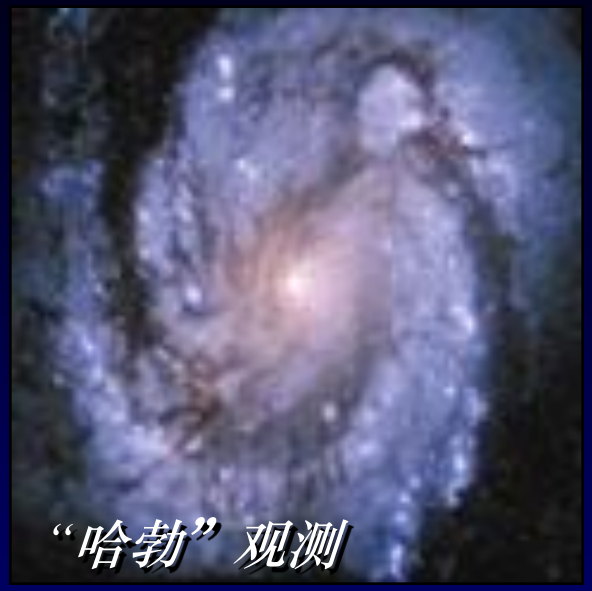
光学仪器的分辨本领：$R = \dfrac{1}{\delta\theta} = \dfrac{D}{1.22\lambda}$

提高分辨本领的两个途径：使 $D\uparrow$ 或 $\lambda\downarrow$!

大型现代天文望远镜

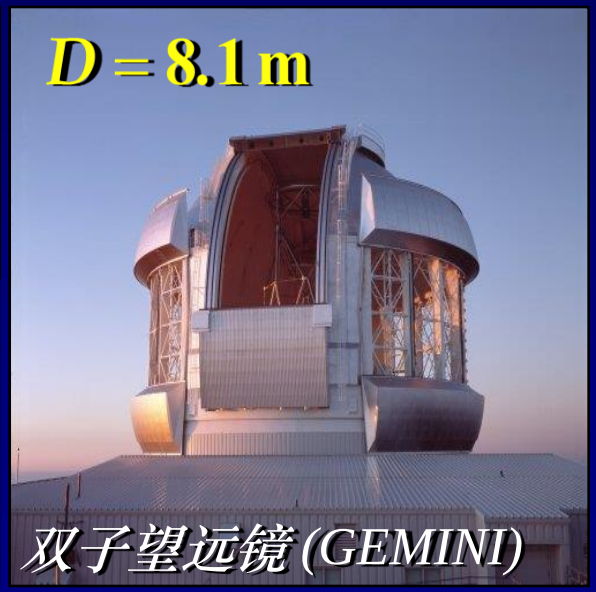

D ≈ 4.3 m
哈勃太空望远镜


地面观测

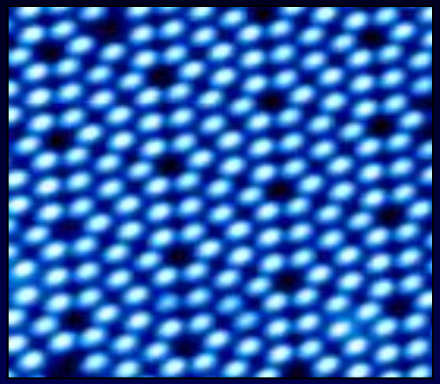

“哈勃”观测

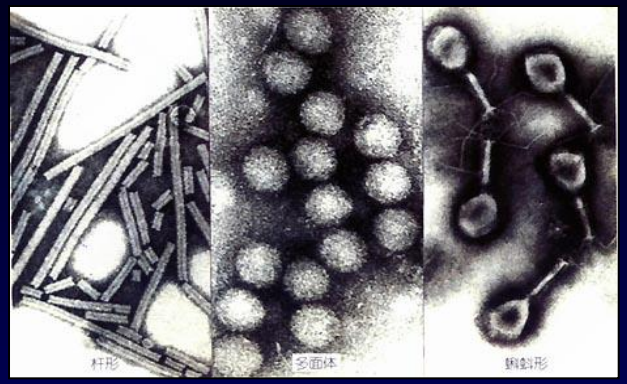

D = 16 m
欧洲南方天文台甚大望远镜(VLT)

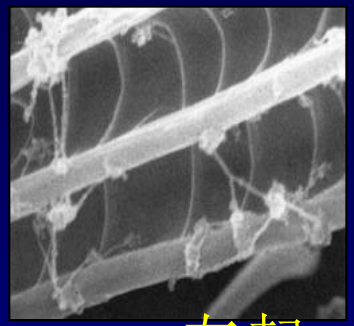
VLT结构


D = 8.1 m
双子望远镜(GEMINI)

电子显微镜 (减小波长)







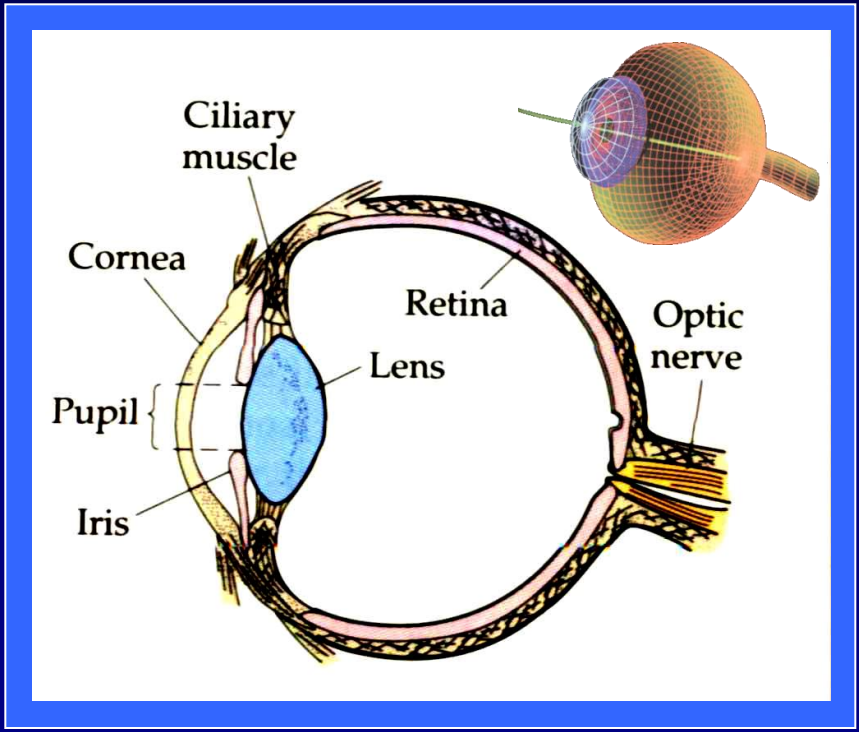
左起：E. Ruska，Gerd Binnig和

Heinrich Rohrer分别因发明电子

显微镜和扫描隧道显微镜而分享1986年诺贝尔物理学奖。

例 在通常亮度下，人眼瞳孔直径约3mm，则人眼的最小分辨角为多大？若要看清相距2mm的两物点，则人与物点间距至多为多少？

解 人眼对黄绿光最敏感：$\lambda = 550\text{nm}$



最小分辨角：

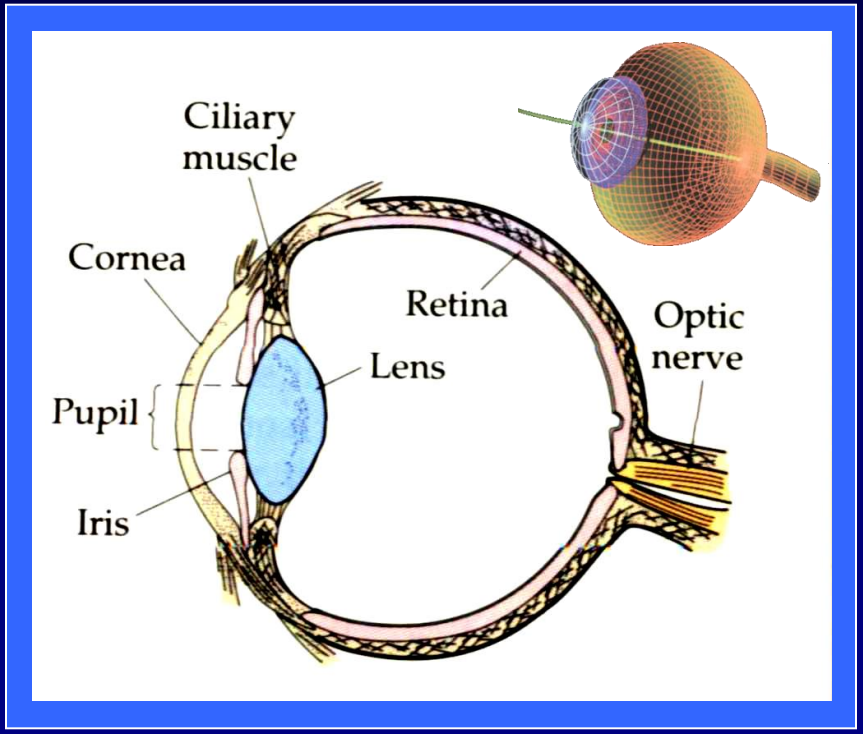
$$\delta\theta = \frac{1.22\lambda}{D}$$

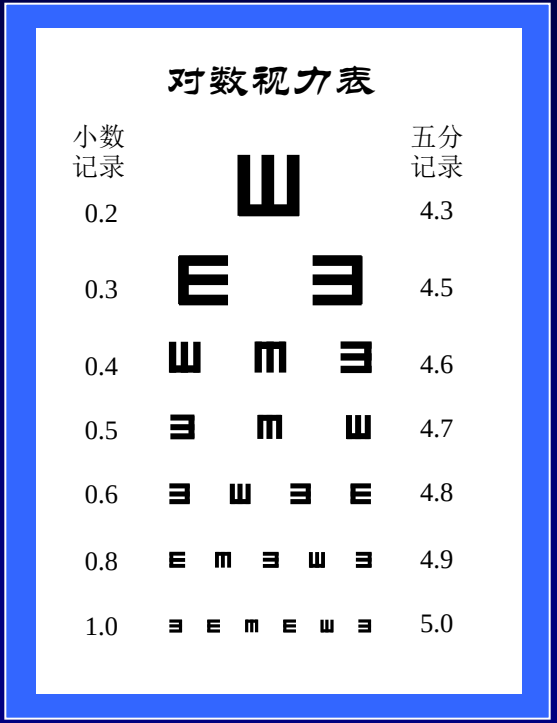
$$= 2.24\times10^{-4}\ \text{rad}$$

$$\approx 1'$$

设：两物点间距为 h，人与两物点间距为 l，则

$$l \approx \frac{h}{\theta} \leq \frac{h}{\delta\theta} = \frac{2\times10^{-3}\ \mathrm{m}}{2.24\times10^{-4}} \approx 8.9\ \mathrm{m}$$





归纳：

1. Rayleigh判据：

$\theta = \delta\theta = \dfrac{1.22\lambda}{D}$ 时，恰可被分辨！

2. 光学仪器最小分辨角：$\delta\theta = \dfrac{1.22\lambda}{D}$

分辨本领：$R = \dfrac{1}{\delta\theta} = \dfrac{D}{1.22\lambda}$

$D\uparrow$ 或 $\lambda\downarrow \longrightarrow R\uparrow$

(The end)