

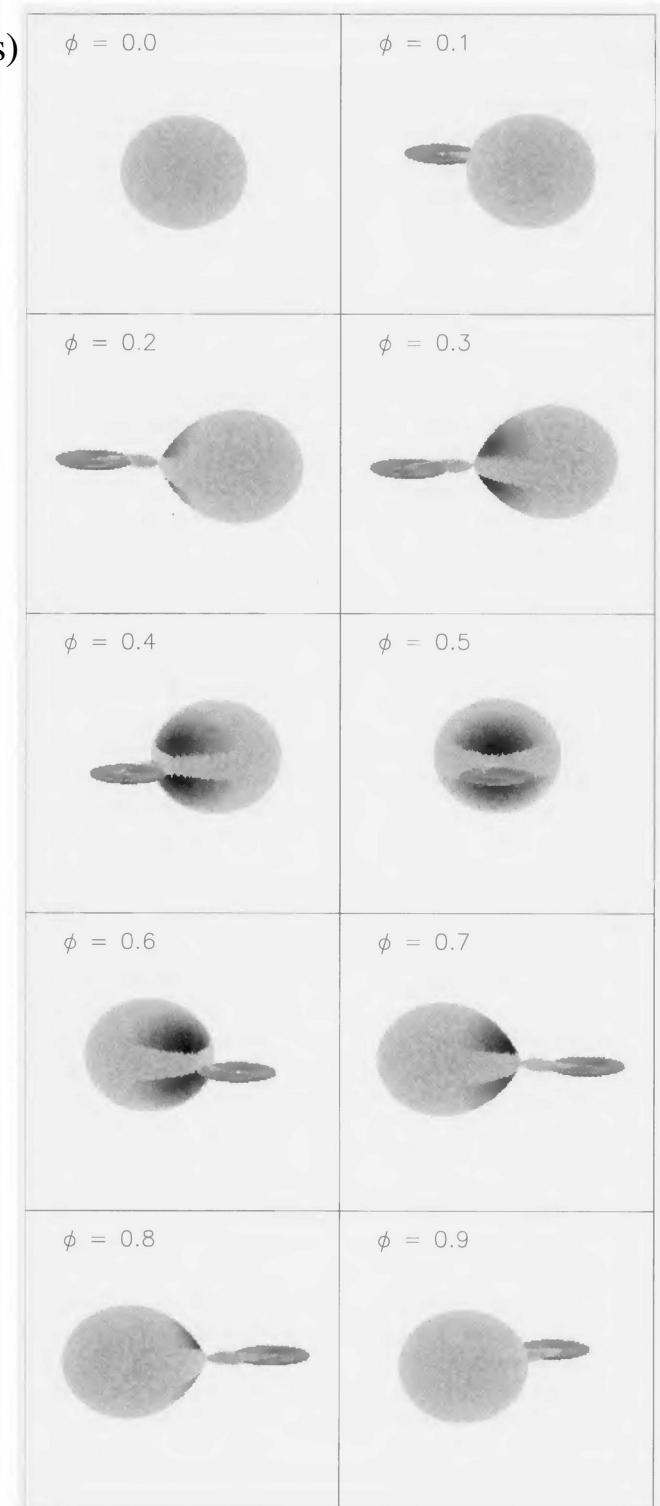
Lecture 16

Stellar Atmospheres
prof. Marcos Diaz

treasure map:

H&M: pg. 627

Frank, King and Raine 2002
“Accretion Power in Astrophysics”
pg. 84



Irradiated atmospheres

formal solution's $I(\tau_2)$

External irradiation changes the atmosphere structure and emission

can be observed as:

- Continuum contribution
- Line Veiling
- Line reversals – emission lines

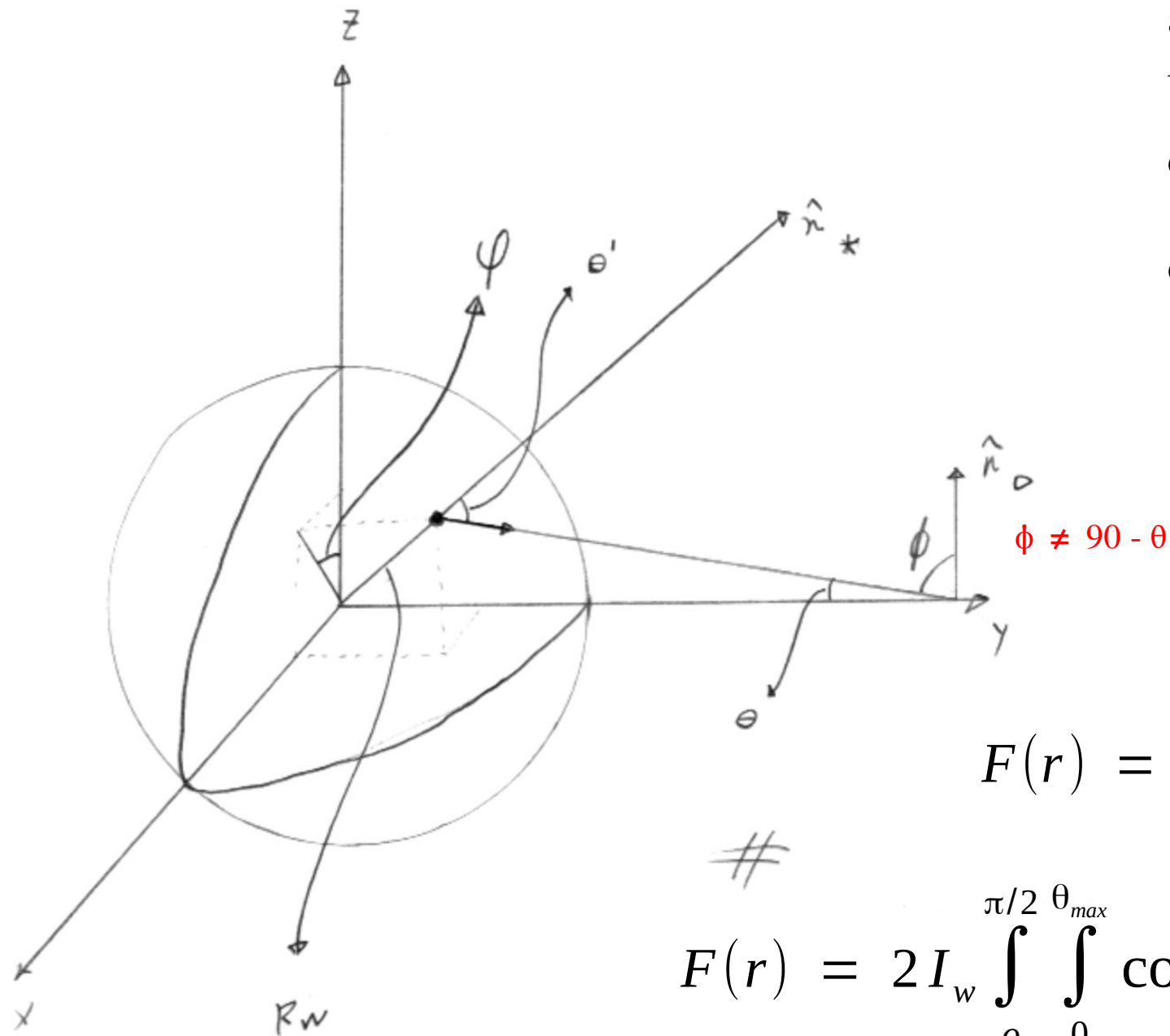
may be associated to:

- chromospheres
- mass loss
- photoionization
- comptonization

Simple model: photospheric bolometric thermalization approximation

$$\sigma T_{eff}^4 = \sigma T_{eff*}^4 + \phi; \quad \phi = F(\vec{r})(1-A); \quad A = \text{bol. albedo}$$

application: temperature profile of irradiated disks

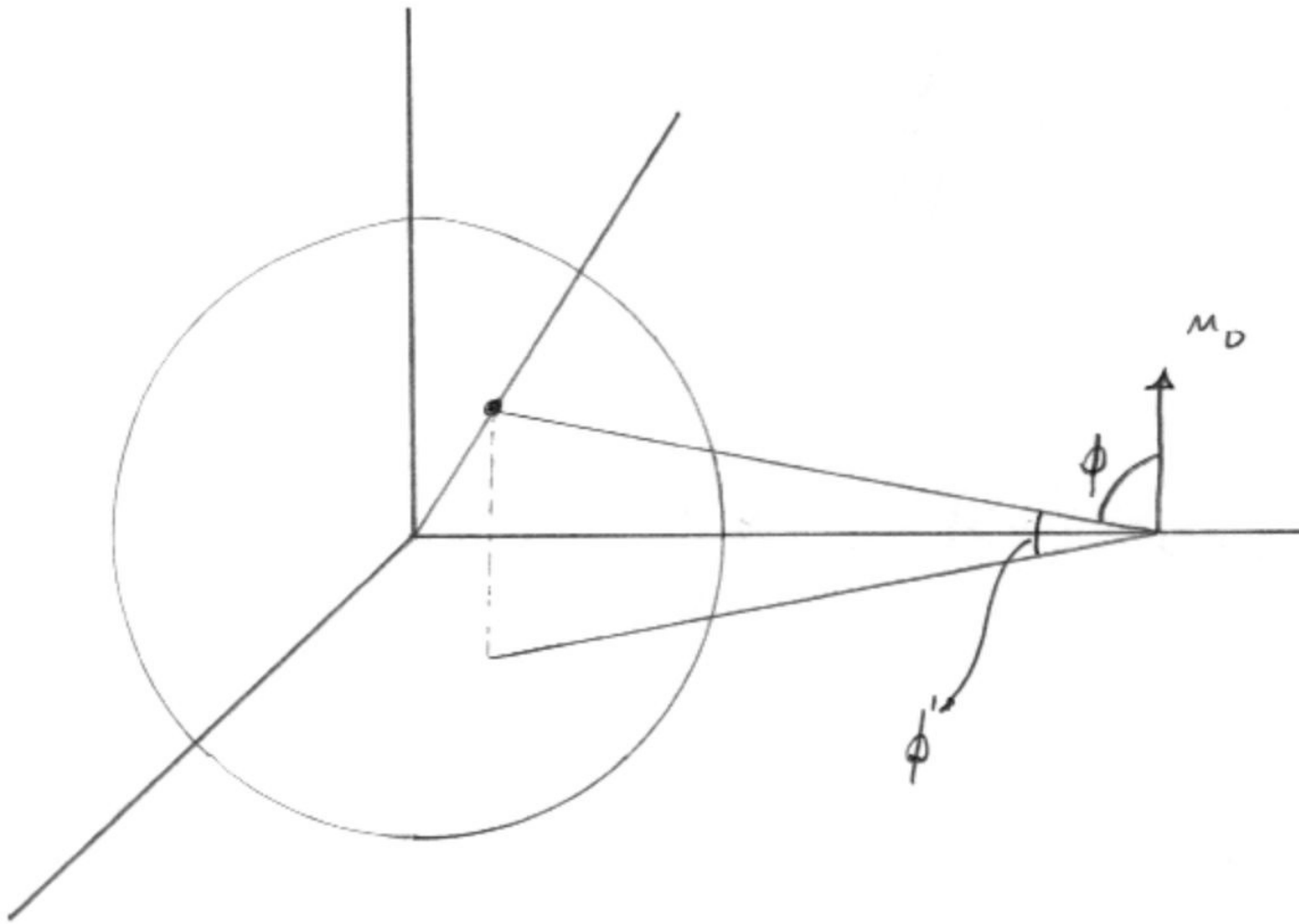


- $I_w(\theta) = \text{constant}$
- $\theta_{\max} = \arcsin(R_w/r)$
- $-\pi/2 < \varphi < \pi/2$
(optically thick disk)
- disk flare angle = 0
(optically thin disk)

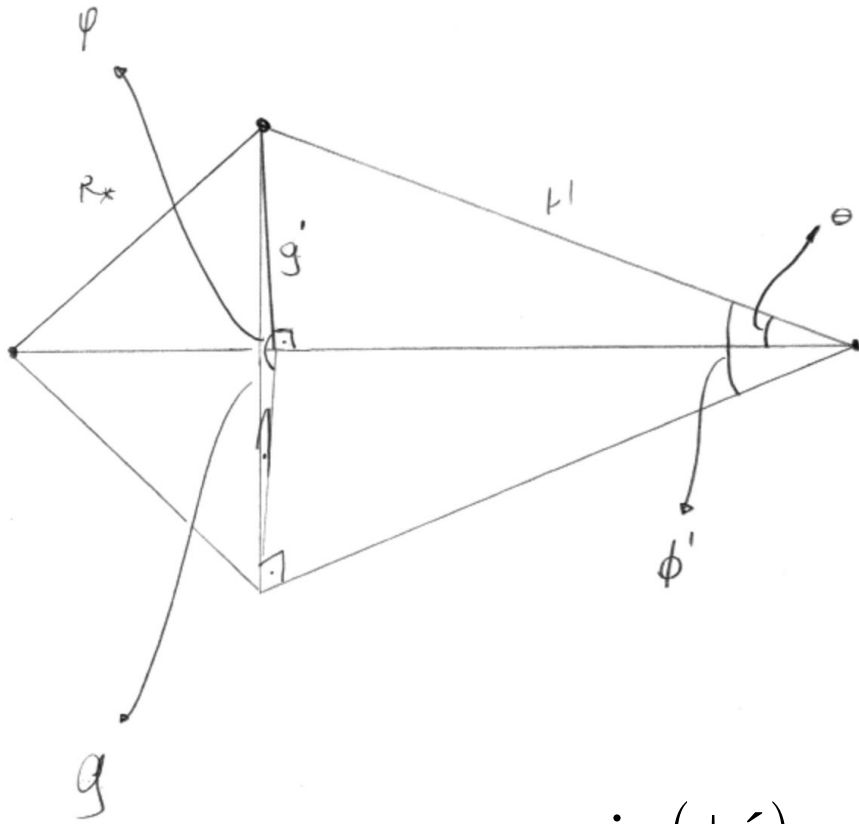
$$F(r) = \int_w \vec{I} \cdot \hat{n}_D d\Omega$$

$$F(r) = 2I_w \int_0^{\pi/2} \int_0^{\theta_{\max}} \cos(\phi) \sin(\theta) d\theta d\varphi$$

$$\phi' = 90 - \phi$$



$$F(r) = 2I_w \int_0^{\pi/2} \int_0^{\theta_{max}} \sin(\phi') \sin(\theta) d\theta d\varphi$$



$$\sin(\phi') = \frac{g}{r'}$$

$$\sin(\theta) = \frac{g'}{r'}$$

$$\sin(\varphi) = \frac{g}{g'}$$

$$\sin(\phi') = \frac{\sin(\varphi)g'}{r'} = \sin(\varphi)\sin(\theta)$$

$$F(r) = 2I_w \int_0^{\pi/2} \int_0^{\theta_{max}} \sin(\varphi) \sin^2(\theta) d\theta d\varphi = 2I_w \int_0^{\theta_{max}} \sin^2(\theta) d\theta$$

$$F(r) = 2I_w \left[\frac{\theta_{max}}{2} - \frac{1}{4} \sin(2\theta_{max}) \right] = I_w \left[\theta_{max} - \sin(\theta_{max}) \cos(\theta_{max}) \right]$$

$$F(r) = I_w \left[\arcsin\left(\frac{R_w}{r}\right) - \frac{R_w}{r} \cos\left(\arcsin\left(\frac{R_w}{r}\right)\right) \right]$$

$$F(r) = I_w \left[\arcsin\left(\frac{R_w}{r}\right) - \frac{R_w}{r} \left(1 - \left(\frac{R_w}{r}\right)^2\right)^{1/2} \right] = \sigma T_{eff}^4(r)$$

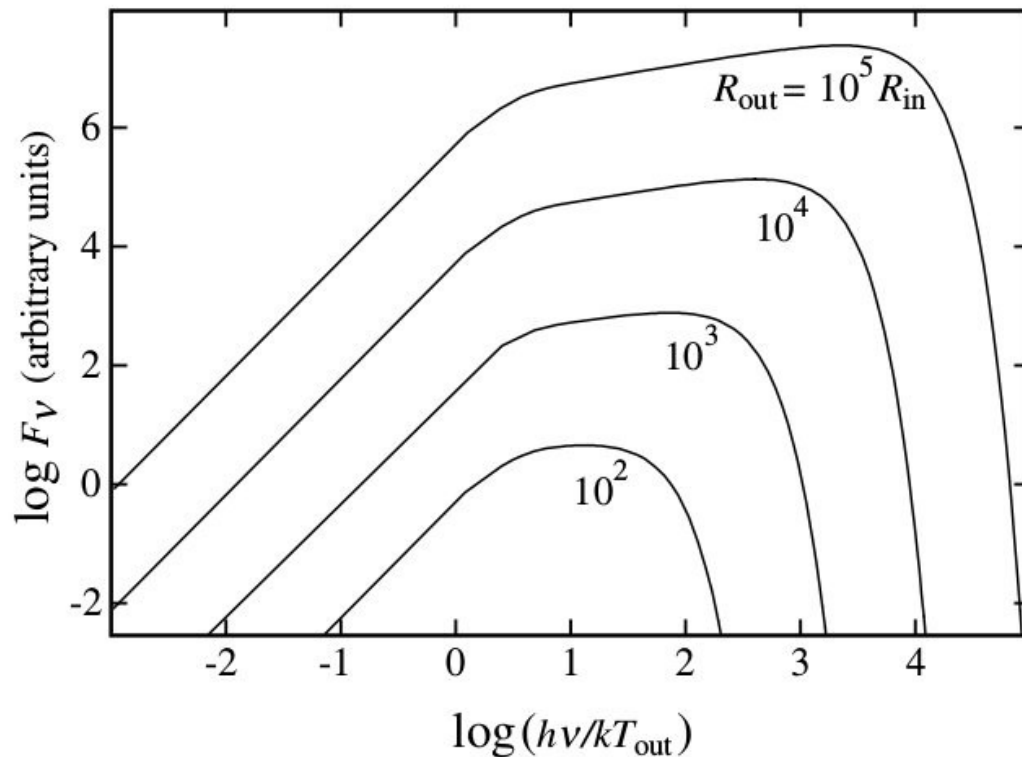
$$F(R_w) = \pi I_w / 2$$

$$F(\infty) = 0$$

$$r \gg R_w \quad \rightarrow \quad F(r) \approx \text{constant} \cdot D_{\text{viscous}}$$

$$D_{\text{viscous}}(r) = \frac{3GM_w \dot{M}}{8\pi r^3} \left[1 - \left(\frac{R_w}{r} \right)^{1/2} \right]$$

standard Shakura & Sunyaev α -disk



(from Frank, King & Raine 2002)