W9L1: CHAPTER 7 - REDSHIFTS

7.1 – read

– space-time

– metrics

– Robertson-Walker metric – homogeneous, isotropic, expanding Universe

– Schwarzschild-metric

7.2 Redshifts

emitted signal ν_0

observed — " — ν ← shifted from ν_0

$\lambda = \frac{c}{\nu}$ $\quad \lambda_0$ rest wavelength

$\Delta\lambda$ + ⇒ redshift $\quad \Delta\lambda$ neg ⇒ blueshift

$E = \frac{hc}{\lambda}$

Generally > 20 Mpc observed λ redshifted

$$z \equiv \frac{\Delta\lambda}{\lambda_0} = \frac{\lambda - \lambda_0}{\lambda_0} = \frac{\lambda}{\lambda_0} - 1$$

redshift parameter

$$\frac{\nu_0 - \nu}{\nu} \leftarrow \text{NB}$$

3 kinds of z - contributions to z

1. Peculiar redshift - object moves <u>through</u> space - kinematic, inherent velocity, Doppler shift
2. Expansion redshift - object moves <u>with</u> space
3. Gravitational z - photon emerges from neighborhood of large mass

(1) Doppler – peculiar

Table I.1

eq 7.2

$$z = \frac{\Delta\lambda}{\lambda_0} = \left(\frac{1 + v_r/c}{1 - v_r/c}\right)^{1/2} - 1$$

observable

v_r = radial velocity

v_r = movement towards/away from us

if $v_r << c$

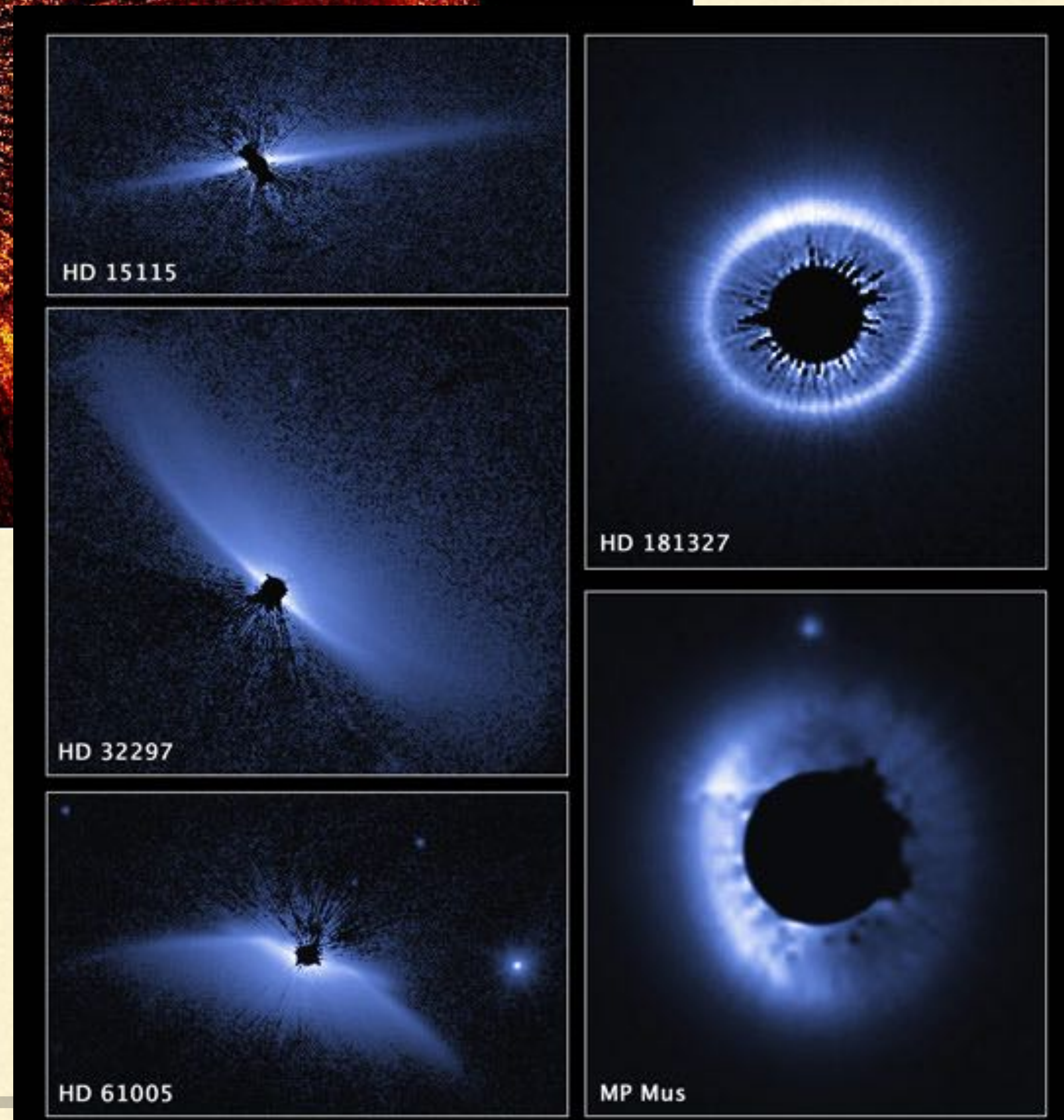
$$\Rightarrow z = \frac{v_r}{c} = \frac{\Delta\lambda}{\lambda_0}$$

powerful eq & easy to measure, objects consisting of orbiting bodies – test particle

rotational velocity v_c ← circular velocity

e.g. ⊕ around ☉
☉ around MW
extrasolar systems
★ in galaxies

} V_{sys} | thin disks thickness << diam.

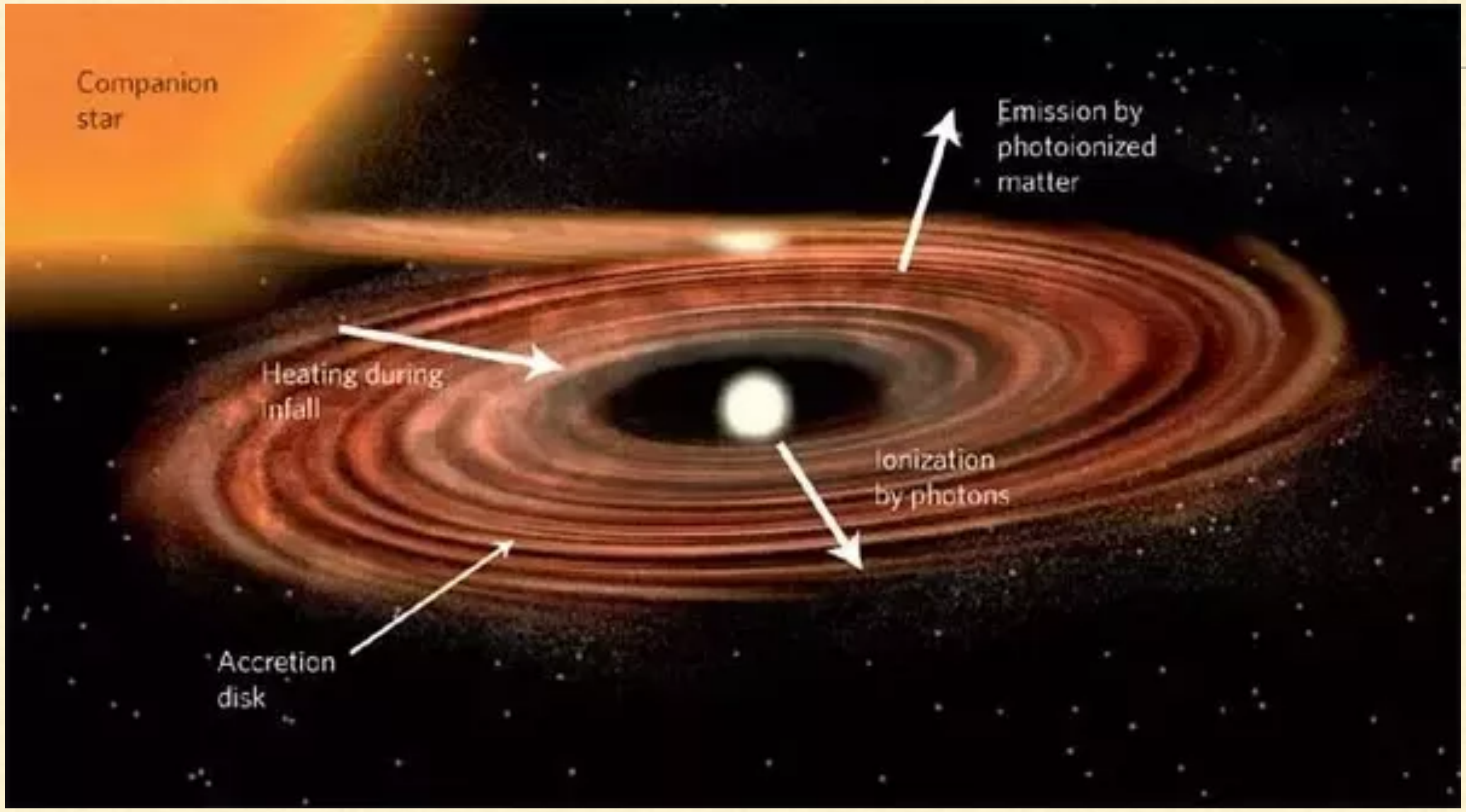


dusty disks around stars

Sombrero
ngc 4594

dusty disks
in elliptical
galaxies

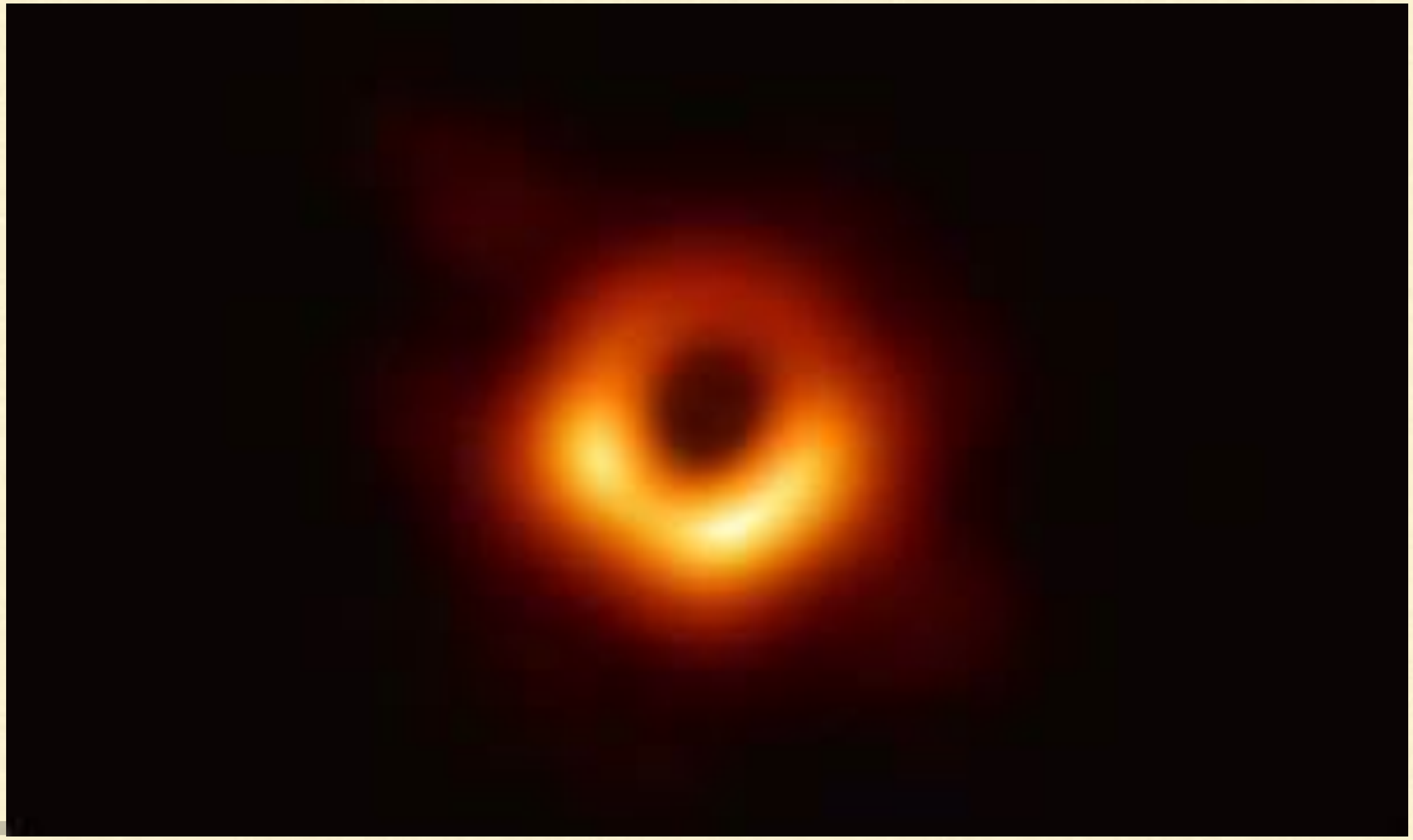
spitzer →



hot gaseous disks

accretion disks around compact objects

neutron stars, BH



NGC 4666

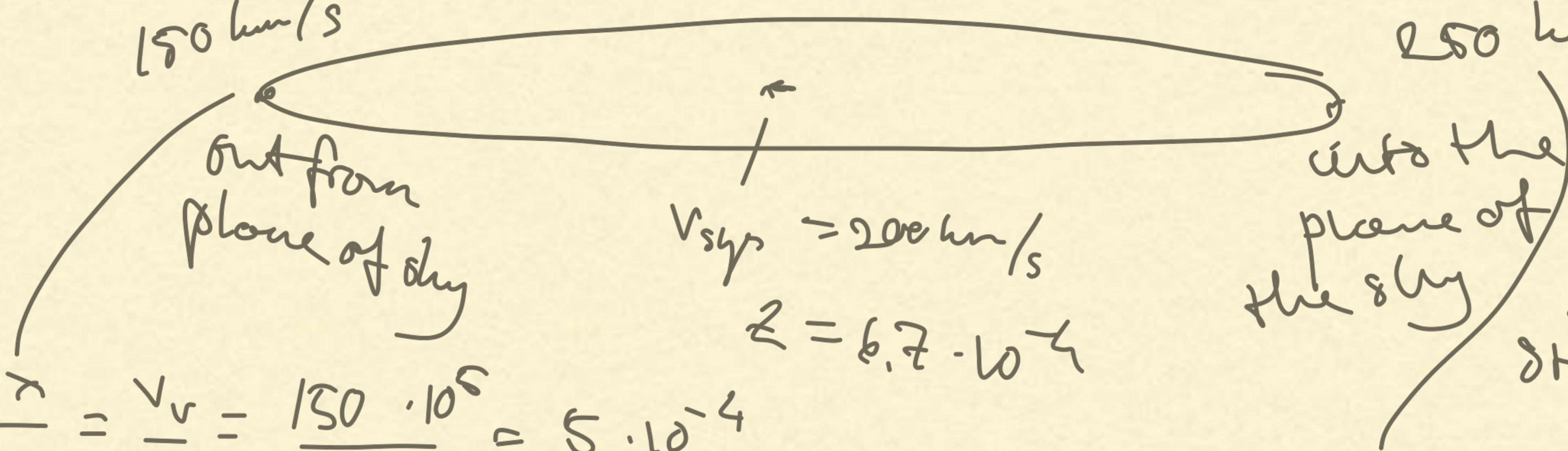
NGC 891

M100

disks are common in astrophysics!

galaxy disk, edge-on to los

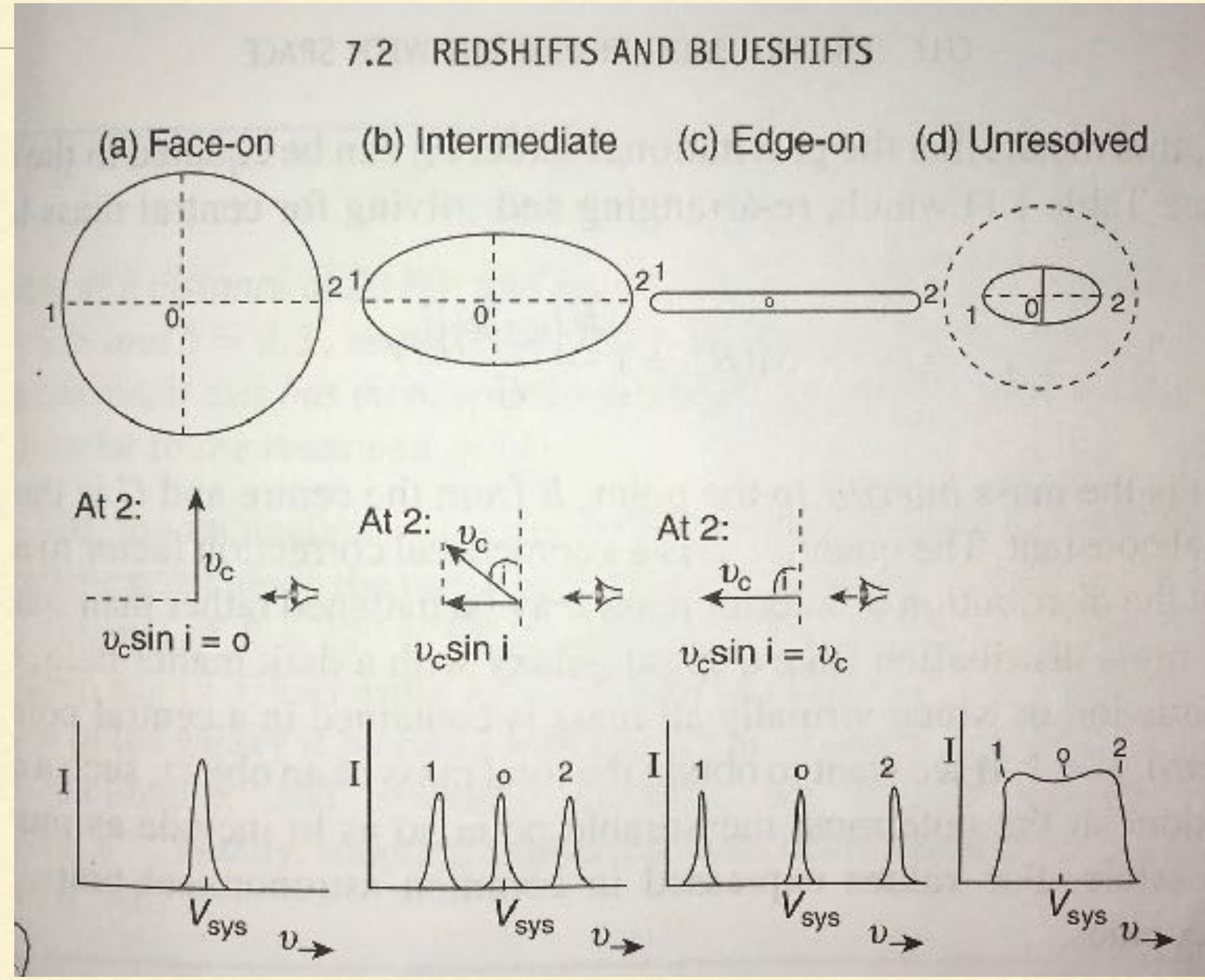
heliocentric radial vel.
0 is point of ref
others: centre of MW, LSR – Local Standard of Rest

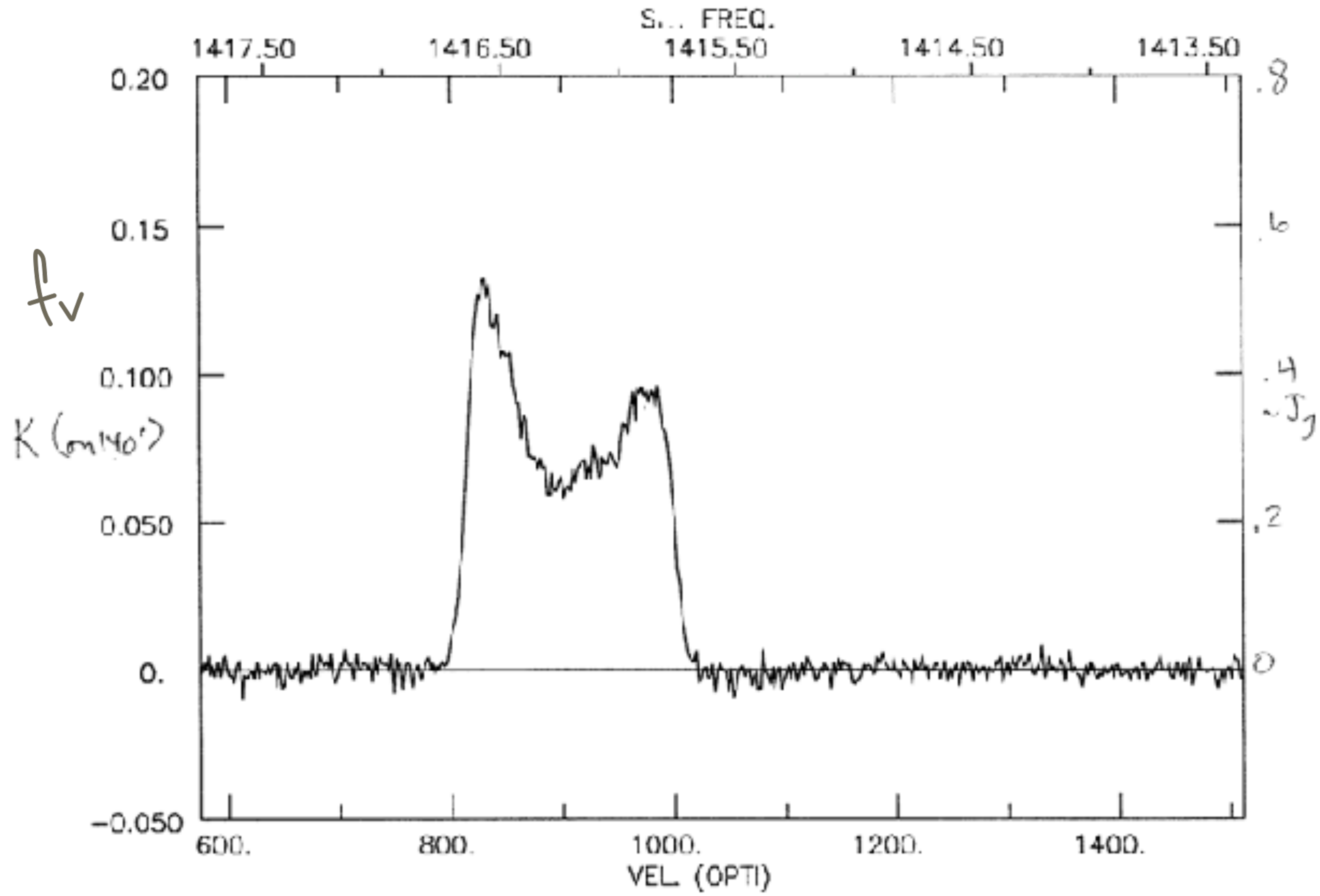


$$z = \frac{\Delta\lambda}{\lambda_0} = \frac{v_r}{c} = \frac{150 \cdot 10^5}{3 \cdot 10^{10}} = 5 \cdot 10^{-4}$$

edge-on ⇒ incl is 90°
face-on — " — 0°
} partially inclined $0 < i < 90$

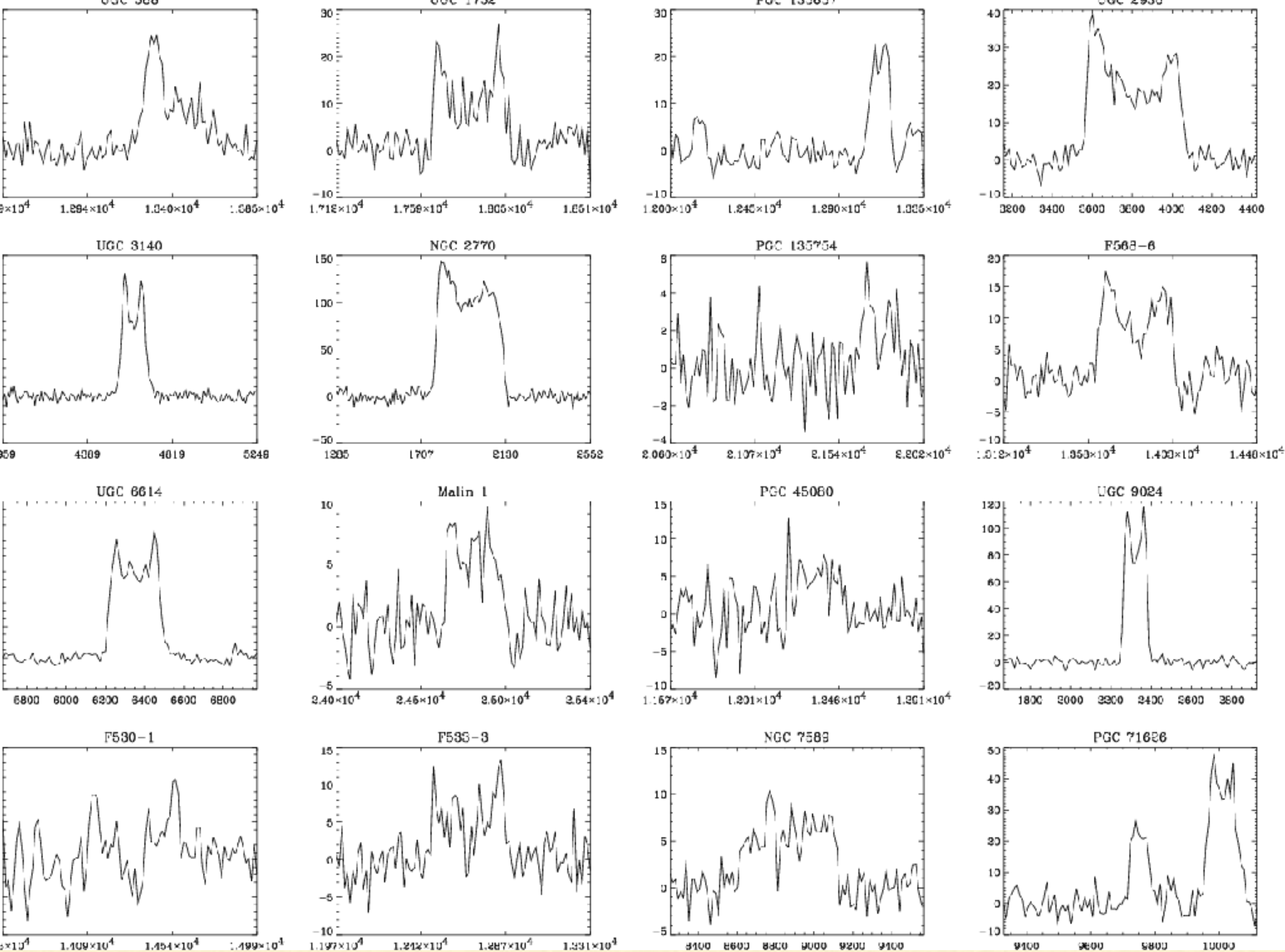
fig 7.4


7.2 REDSHIFTS AND BLUESHIFTS
(a) Face-on
(b) Intermediate
(c) Edge-on
(d) Unresolved
1
2
0
At 2:
v_c
$v_c \sin i = 0$
$v_c \sin i$
$v_c \sin i = v_c$
i
I
V_{sys}
v



double-horned profile

This integrated HI spectrum of UGC 11707 obtained with the 140-foot telescope (beamwidth ≈ 20 arcmin) shows the typical two-horned profile of a spiral galaxy.


UGC 3140
NGC 2770
PGC 135754
F568-6
UGC 6614
Malin 1
PGC 45080
UGC 9024
F530-1
F533-3
NGC 7589
PGC 71686

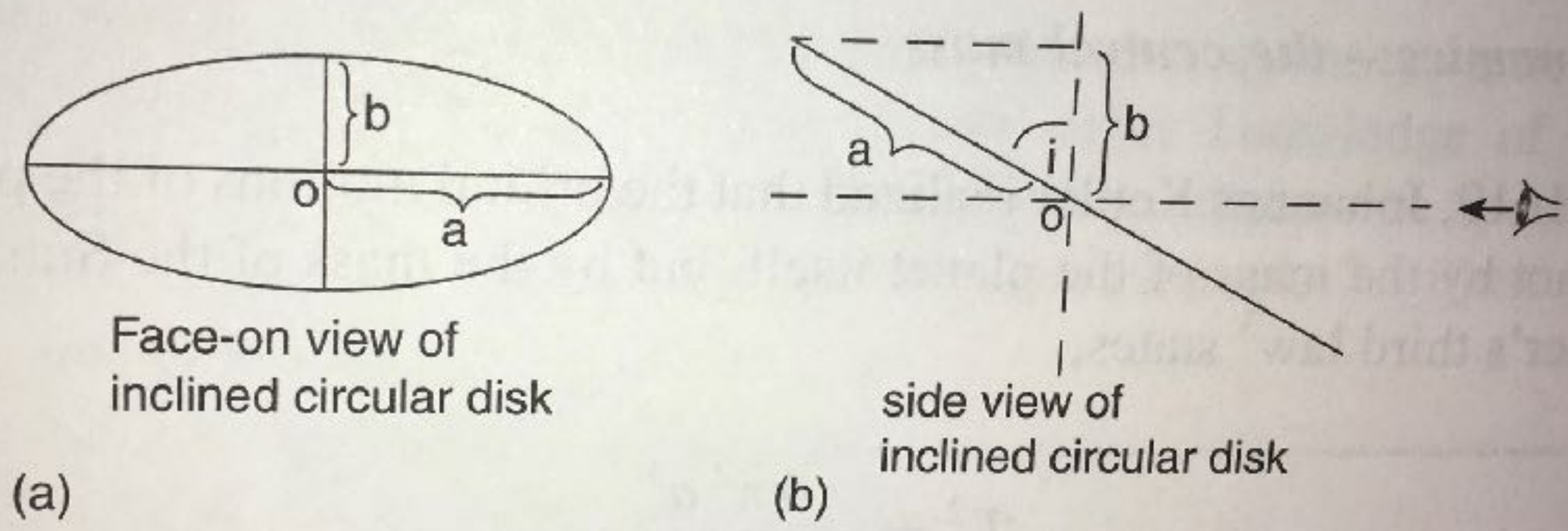


Figure 7.3 **(a)** A circular galaxy that is inclined to the line of sight will look *elliptical* in projection. The galaxy's true radius is *a*. When inclined, its apparent semi-major axis is *a* but its semi-minor axis is *b*, as shown. **(b)** This side view shows the minor axis of the inclined galaxy of (a) and its inclination.

V_r measured : $V_r = V_{true} \sin i$

need i : $\cos i = \frac{b}{a}$ — semiminor axis / — semimajor axis (usually degrees.)

Get mass enclosed by "test particle" for which we measure V_c

$\frac{GMm}{R^2} = \frac{mV_c^2}{R} \Rightarrow M = \frac{V_c^2 R}{G}$ need mass of gal? measure V_c @ outermost point