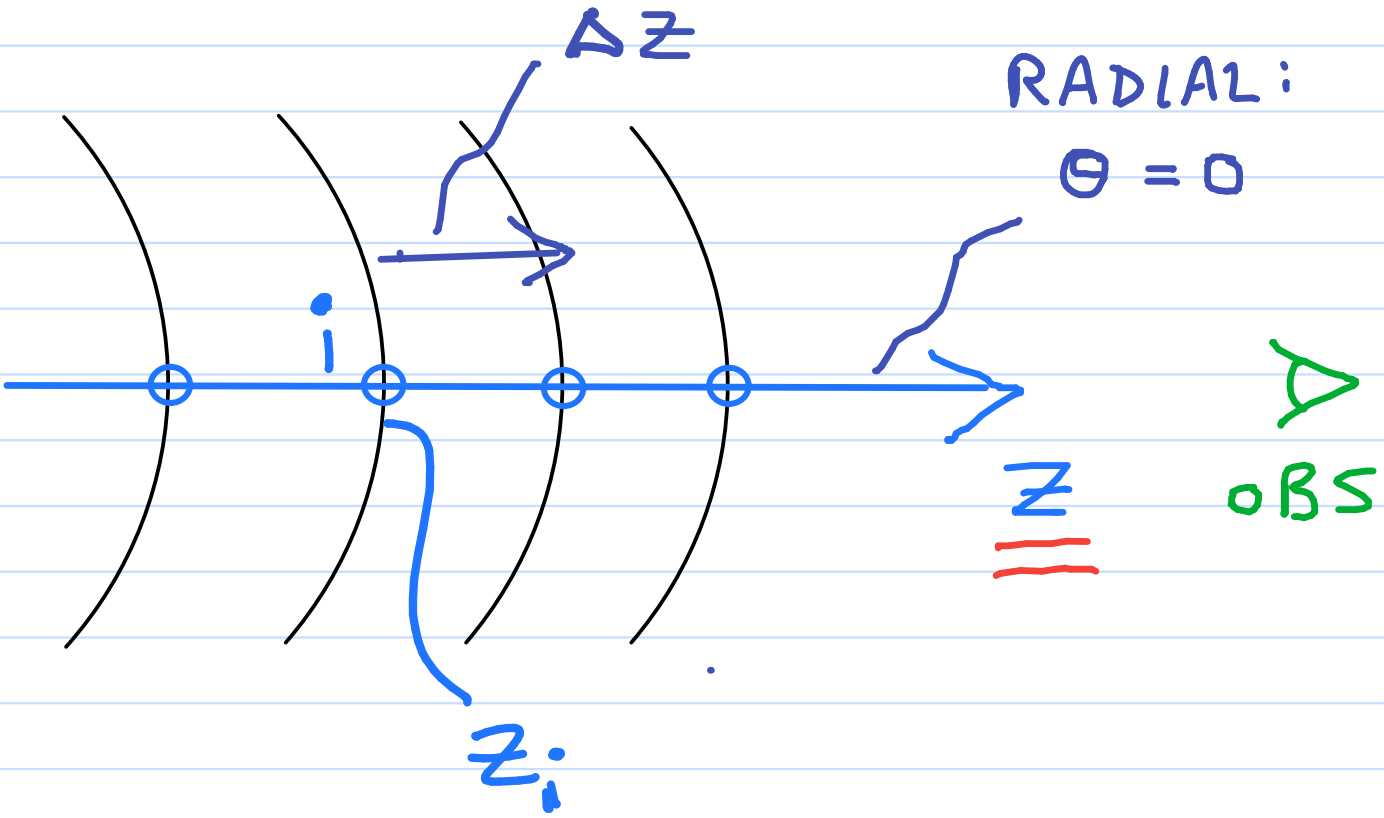
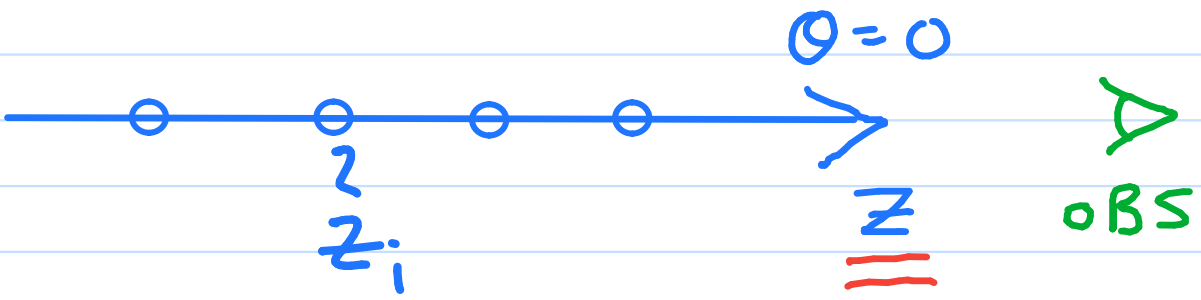
STELLAR ATMOSPHERIC STRUCTURE

RUTTEN ch.7

GRAY ch. 9



STELLAR ATMOSPHERIC STRUCTURE



GAS:

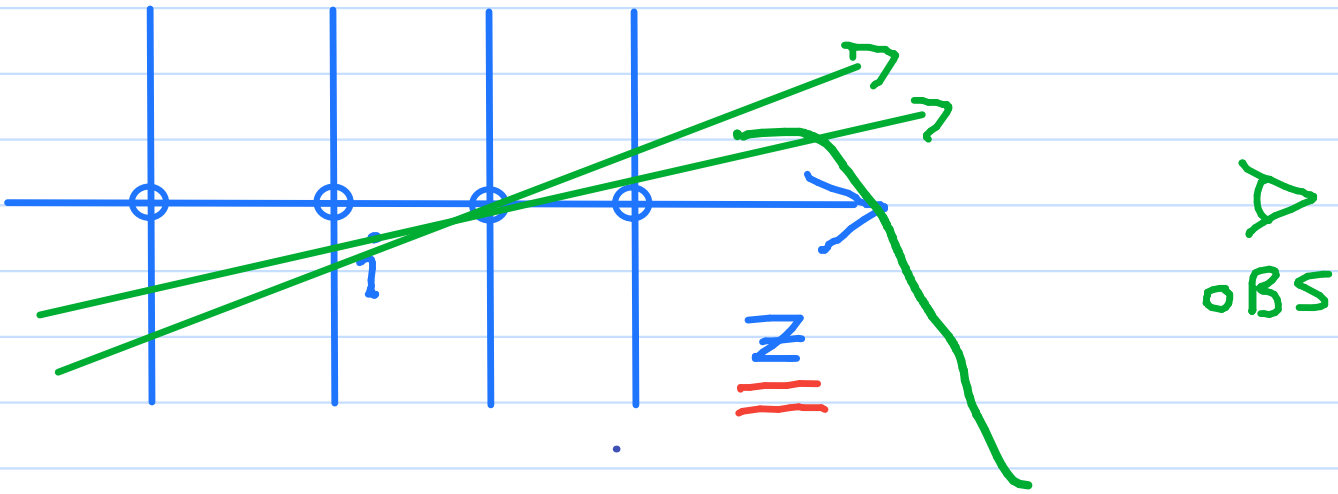
e^- PRESSURE

$T_{KIN}(z_i)$, $P_{gas}(z_i)$, $P_e(z_i)$, $\rho(z_i)$, $\mu(z_i)$ (m.m.w.), ...

$K_\nu(z_i, \nu)$, $\tau_\nu(z_i, \nu)$, ...

- K_ν = PHOTON MASS EXTINCTION COEFFICIENT (OPACITY)
- τ_ν = OPTICAL DEPTH

STELLAR ATMOSPHERIC STRUCTURE



RADIATION PENCIL BEAM

RADIATION:

$B_\nu(z_i, \nu)$, $P_{RAD}(z_i)$,

$F_\nu(z_i, \nu)$, $j_\nu(z_i, \nu)$, ...

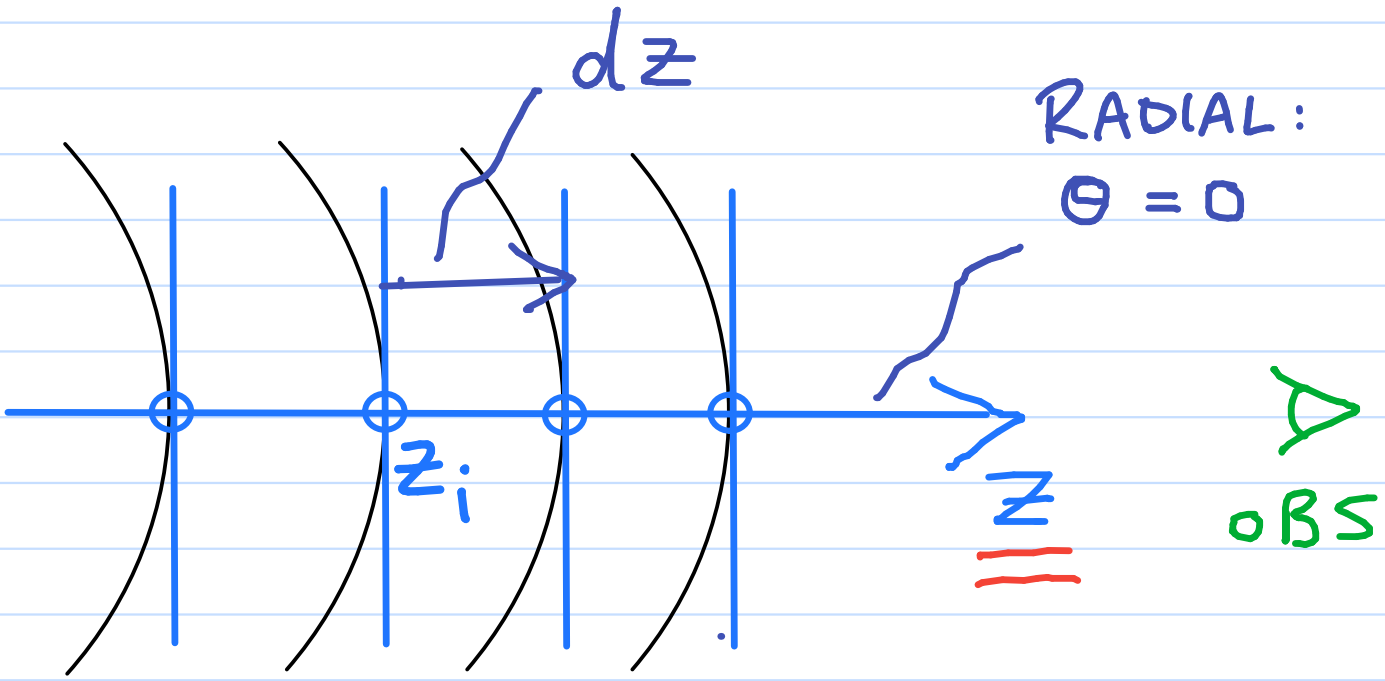
B_ν = PLANCK fn (BLACKBODY (BB) SPECTRUM)

F_ν = FLUX (erg/s/cm^2/Hz)

j_ν = PHOTON EMISSIVITY

MODELLING ASSUMPTIONS & APPROXIMATIONS (8)

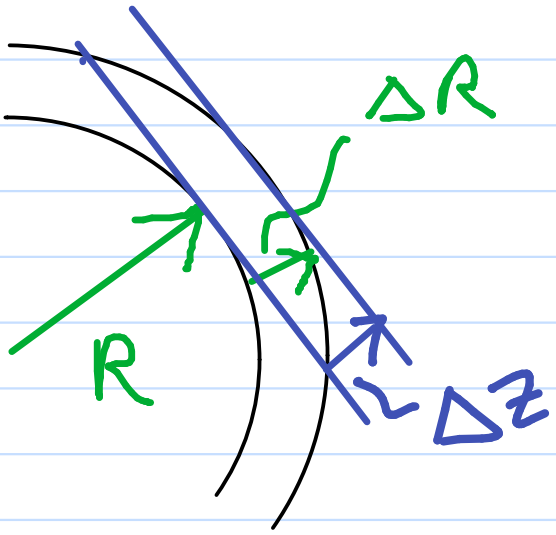
1) PLANE-|| GEOMETRY



- LOCALLY FLAT
- 1D GEOMETRY
  - HEIGHT z
  - z IS RADIAL (POLAR)

NOTE: $R = \infty$ - UNDEFINED

1) PLANE-|| GEOMETRY



- APPROXIMATELY VALID IF $\frac{\Delta R}{R} \ll 1$

$\Rightarrow$ LARGE $g = GM/R^2$

$\Rightarrow$ LATE-B TO M MAIN SEQUENCE (MS) STARS (L CLASS V)

2) HORIZONTAL HOMOGENEITY

FOR LOCAL PROPERTY, "f":

$$f(x,y,z) = f(z)$$

⇒ NO HORIZONTAL STRUCTURE

eg. SPOTS,

CONVECTION CURRENTS

1D MODEL:

ASSUMPTIONS 1) & 2)

TOGETHER

AXI-SYMMETRY ABOUT

Z-AXIS:

$$f(\theta,\phi) = f(\theta)$$

3) 3D CHEMICAL HOMOGENEITY

- NO VERTICAL CHEMICAL STRATIFICATION

(BUT $\frac{P_e}{P_{gas}} = \frac{P_e}{P_{gas}}(z)$)

4) STASIS, $f(z,t) = f(z)$

(OR AT LEAST QUASI-STATIC)

(STATISTICAL EQUILIBRIUM (SE))

$\Rightarrow \frac{d\langle n_i \rangle}{dt} = 0$

- n_i = ATOMIC E-LEVEL POPULATION OR IONIZATION STAGE POP.

$\Rightarrow$ NO LARGE-AMPLITUDE OR SHORT-PERIOD PULSATORS

5) HYDROSTATIC EQUILIBRIUM (HSE)

$$a_z(z) = 0$$

$$\therefore F_{NET,z}(z) = 0, \text{ ALL } z$$

⇒ NO LARGE-AMPLITUDE OR SHORT-PERIOD PULSATORS

NO MASSIVE STELLAR WINDS

6) THERMAL EQUILIBRIUM

$$\frac{dT_{KIN}(z)}{dt} = 0$$

$$\frac{dT_{RAD}(z)}{dt} = 0$$

$\Rightarrow$ NO NET SOURCES OR SINKS OF ENERGY IN ATMOSPHERE

- ie. INERT

eg. NO NUCLEAR FUSION

7) ENERGY TRANSPORT BY RADIATION & CONVECTION ONLY

⇒ NO CONDUCTION, PRESSURE WAVES, OR MHD WAVES

∴ NO CHROMOSPHERE OR CORONA

8) LOCAL THERMODYNAMIC EQUILIBRIUM (LTE)

SAHA — BOLTZMANN

$$T_{IONIZATION}(z) = T_{EXCITATION}(z)$$

$$= T_{RADIATION}(z) = T_{KINETIC}(z)$$

PLANCK fn, B_ν

MAXWELL-BOLTZMANN (M-B)

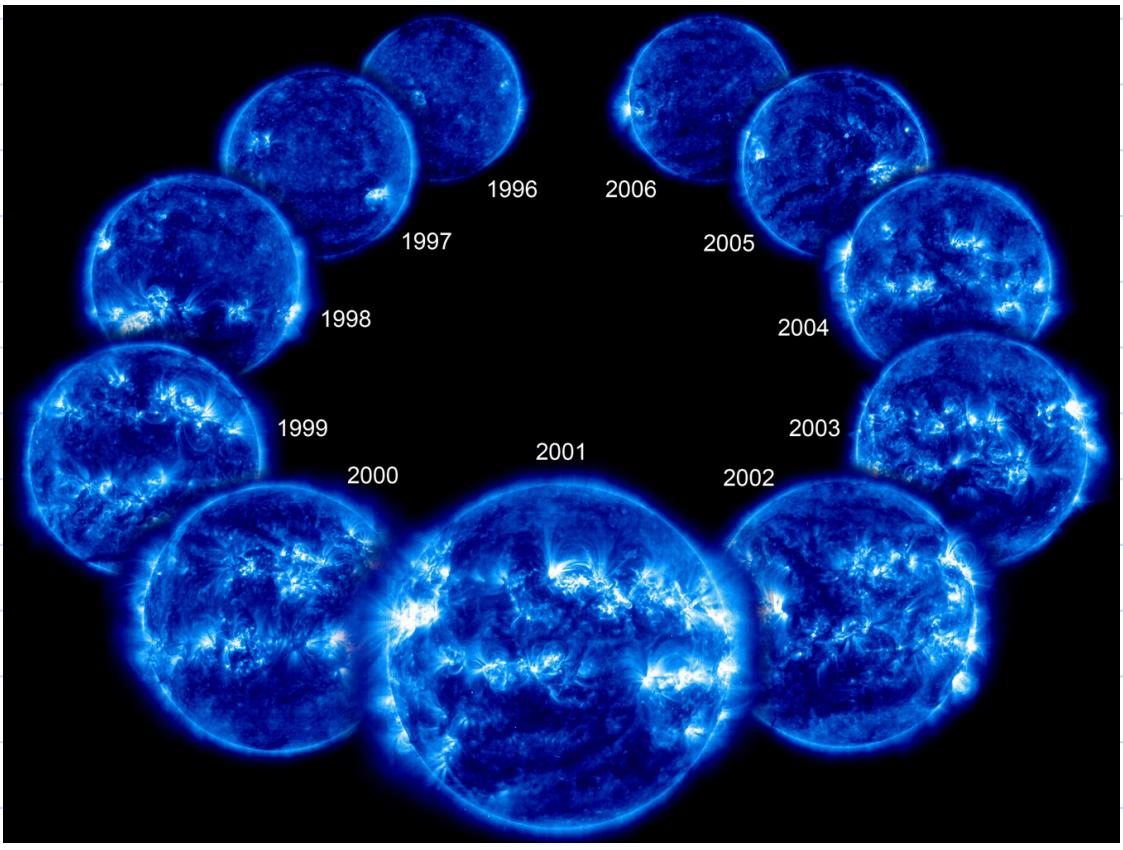
ASSUMPTIONS 1-8 RULE OUT

ALL STARS

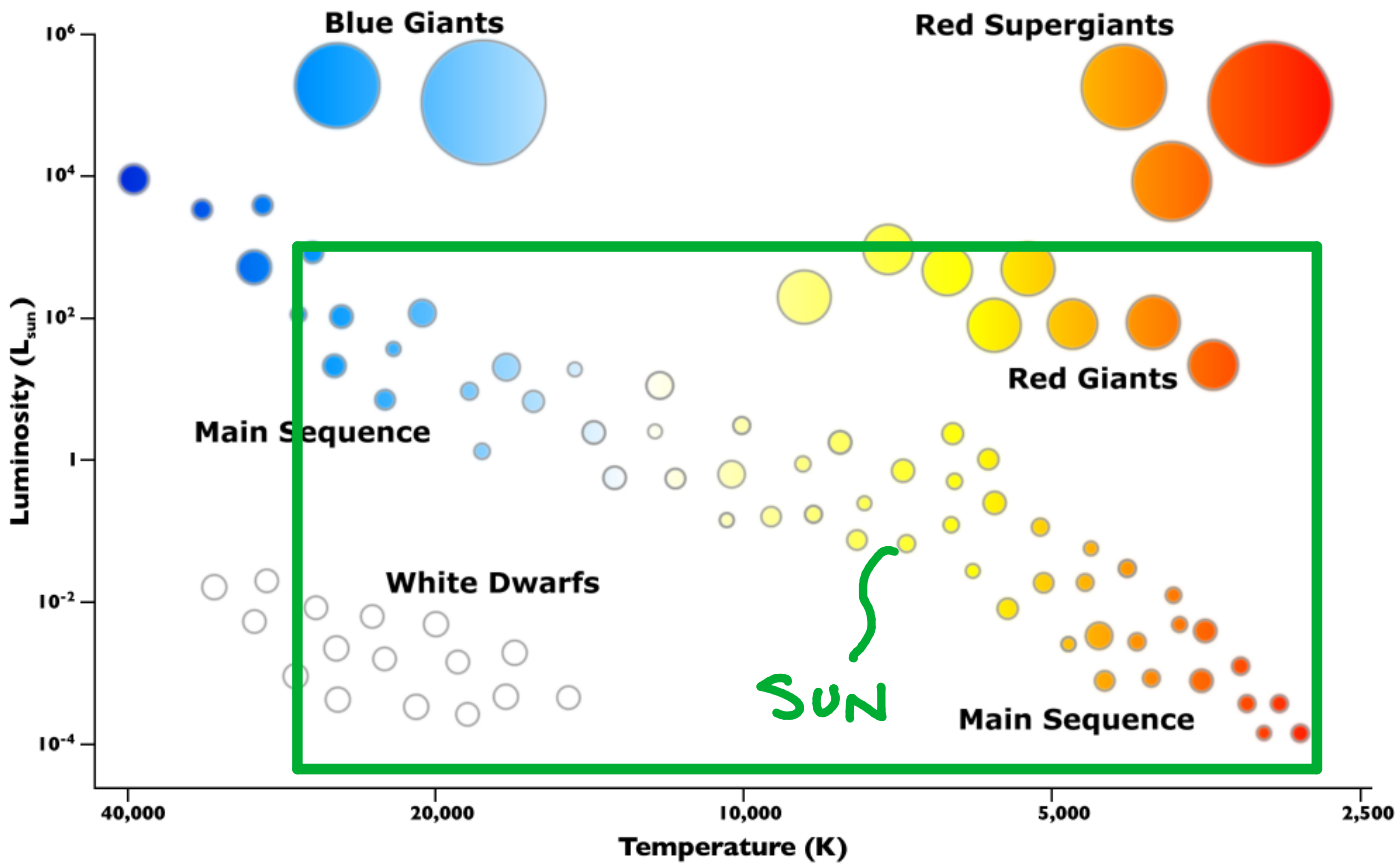
BUT

REASONABLE FOR MANY STARS

Eg. SUN (EUV BAND) (IMAGE CREDIT: SOHO)



REGION OF GREATEST VALIDITY



THEORIST'S HR DIAGRAM

IMAGE CREDIT: LAS CUMBRES OBSERVATORY SPACEBOOK