# MODEL PARAMETERS (4)

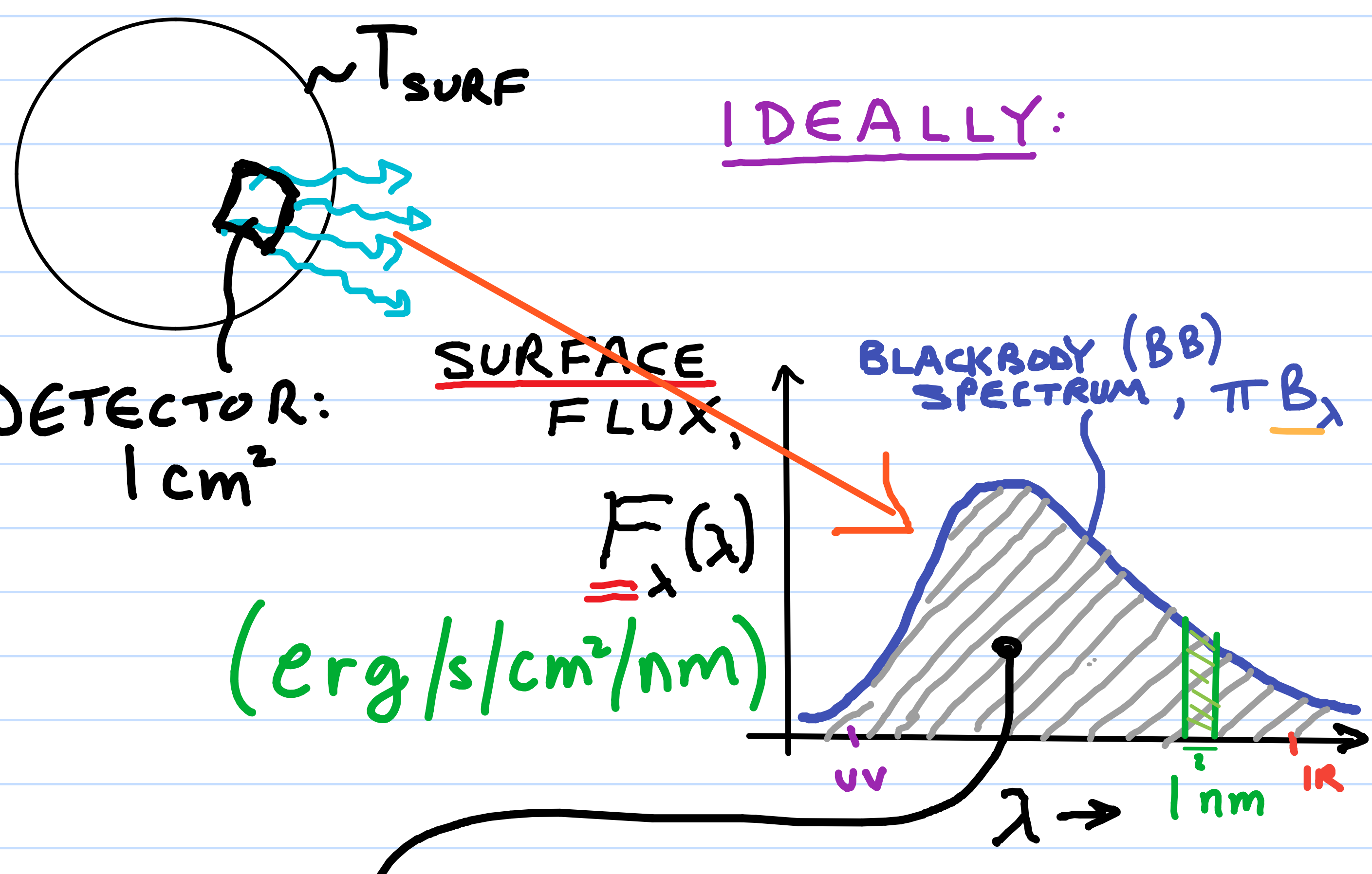
WHAT TYPE OF STAR?

DETERMINES STRUCTURE

## 1) EFFECTIVE (SURFACE) TEMPERATURE, $T_{eff}$ (K)

- EQUIVALENT SOLID SPHERICAL BLACKBODY SURFACE TEMPERATURE

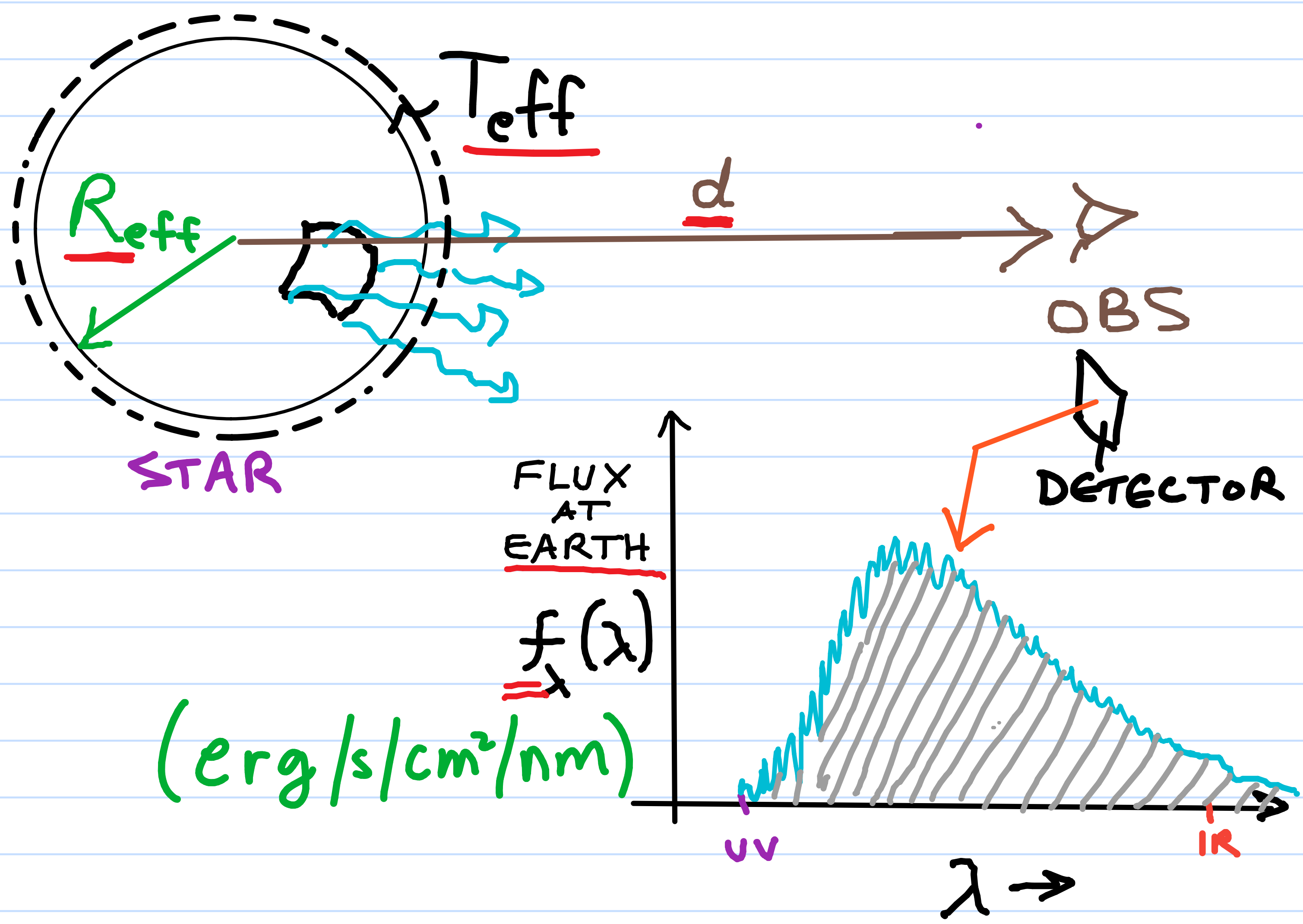
IDEALLY:




BOLOMETRIC SURFACE FLUX, $F$ (ergs/s/cm²)

$$F = \int_0^\infty F_\lambda(\lambda)\, d\lambda = \sigma T_{SURF}^4$$

# OBSERVATIONALLY:




BOLOMETRIC FLUX AT EARTH,
$f$ (ergs/s/cm²)

$$f = \int_0^\infty f_\lambda(\lambda)\, d\lambda$$

PROJECTION FACTOR

$$F \cdot 2\pi R^2 = f \cdot 2\pi d^2 \quad \therefore \quad F = \left(\frac{d^2}{R^2}\right) f$$

STEFAN-BOLTZMANN LAW OF BB RADIATION

$$F = \sigma T_{eff}^4$$

$$\Rightarrow T_{eff} \equiv \left(\frac{F}{\sigma}\right)^{1/4}$$

$3200 < T_{eff} < 50000$ K

M5 STAR — O5 STAR

SUN: $T_{eff} = 5800$ K

- G2 V STAR

BROWN DWARFS (L, T, Y STARS):

$1000 < T_{eff} < 3000$ K

- $f_\lambda(\lambda)$ w. $\lambda_{MAX}$ IN IR

2) SURFACE GRAVITY,

$g$ (cm/s², dynes/g)

$$g = \frac{GM}{R_{eff}^2}$$

$$\log g = \log G + \log M - 2 \log R_{eff}$$

REALLY DEFINED BY HSE:

$$\frac{dP(z)}{dz} = -g\rho(z)$$

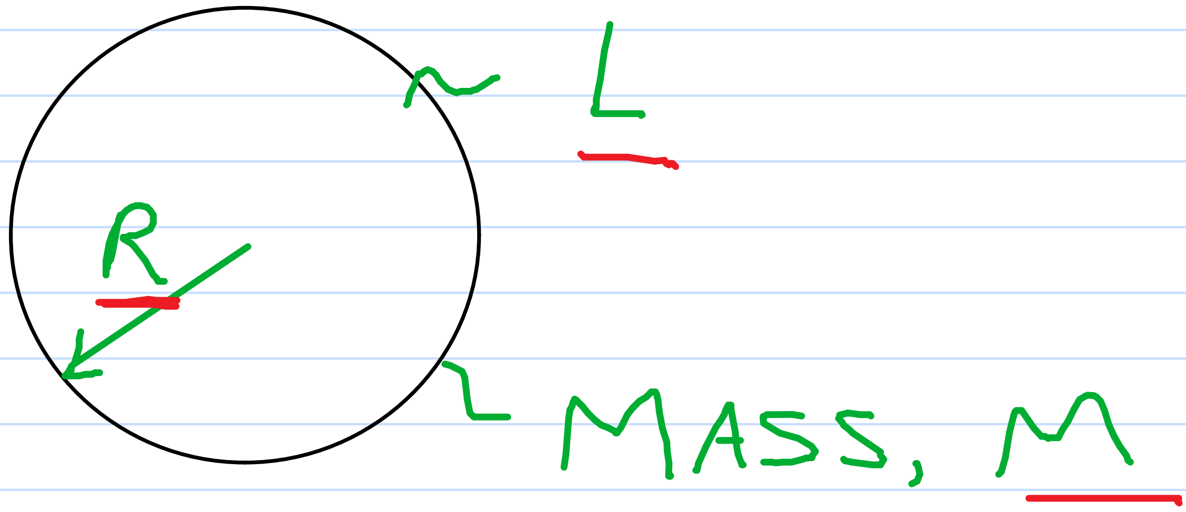
$$-0.5 < \log_{10}(g) < 5.5$$

SUPERGIANTS (L CLASS I) — SUB-DWARFS (L. CLASS VI)

SUN: $\log(g) = 4.44$
(G2 V STAR)

WHITE DWARFS (WD):

$$7.0 < \log(g) < 8.5$$




$$M = \frac{g R^2}{G}$$

BOLOMETRIC LUMINOSITY, L (erg/s)

$$L = F \cdot 4\pi R^2$$
$$= \sigma T_{eff}^4 \cdot 4\pi R^2$$

BUT:

PLANE-|| MODEL

$\therefore$ R = $\infty$ (UNDEFINED)

$\therefore$ L UNDEFINED

M UNDEFINED

BUT, $T_{eff}$, $\log(g)$

ARE DEFINED!

## 3) CHEMICAL COMPOSITION ("METALLICITY")

GENERALLY, FOR STARS & ISM, BY NUMBER OF PARTICLES:

- H: $\sim 92\ \%$
- He: $\gtrsim 7.8\ \%$
- "METALS": $\lesssim 0.2\ \%$

- MOST ABUNDANT METALS:
  O, C, N, Fe

# INDEX ELEMENT BY ATOMIC NUMBER, $Z$

$N_Z$ = NO. DENSITY OF ELEMENT $Z$ $(cm^{-3})$

$$A(Z) \equiv \frac{N_Z}{N_H}$$

FOR DISK STARS (POP. I):

- FOR $4 < Z < 28$:

  (4 = Be, 28 = Ni)

$$10^{-9} < A(Z) < 10^{-3}$$

# $A_{12}$ SYSTEM:

$$A_{12}(Z) \equiv \log_{10}\left(\frac{N_Z}{N_H}\right) + 12$$

FOR DISK STARS (POP. I):

- FOR $4 < Z < 28$:

$$3 < A_{12}(Z) < 9$$

"ABUNDANCE", $\left[\frac{A(Z)}{H}\right]$ OF ELEMENT Z:

$$\left[\frac{A(Z)}{A_H}\right] \equiv \log_{10}\left\{\frac{\left(N_Z/N_H\right)}{\left(N_Z/N_H\right)_\odot}\right\}$$

$$= \log\left(\frac{N_Z}{N_H}\right) - \log\left(\frac{N_Z}{N_H}\right)_\odot$$

$$= A_{12}(Z) - A_{12}(Z)_\odot$$

"METALLICITY" $\approx \left\langle \left[ \frac{A(Z)}{H} \right] \right\rangle$

FOR SELECT ELEMENTS, Z

(Fe, Ti, Ca, Mg, Si, . . .)

$$-2 < \left\langle \left[ \frac{A_Z}{H} \right] \right\rangle < +0.3$$

METAL-POOR (POP. II)

METAL-RICH (POP. I)

VERY-, EXTREMELY-, ULTRA-METAL-POOR (VMP, EMP, UMP STARS):

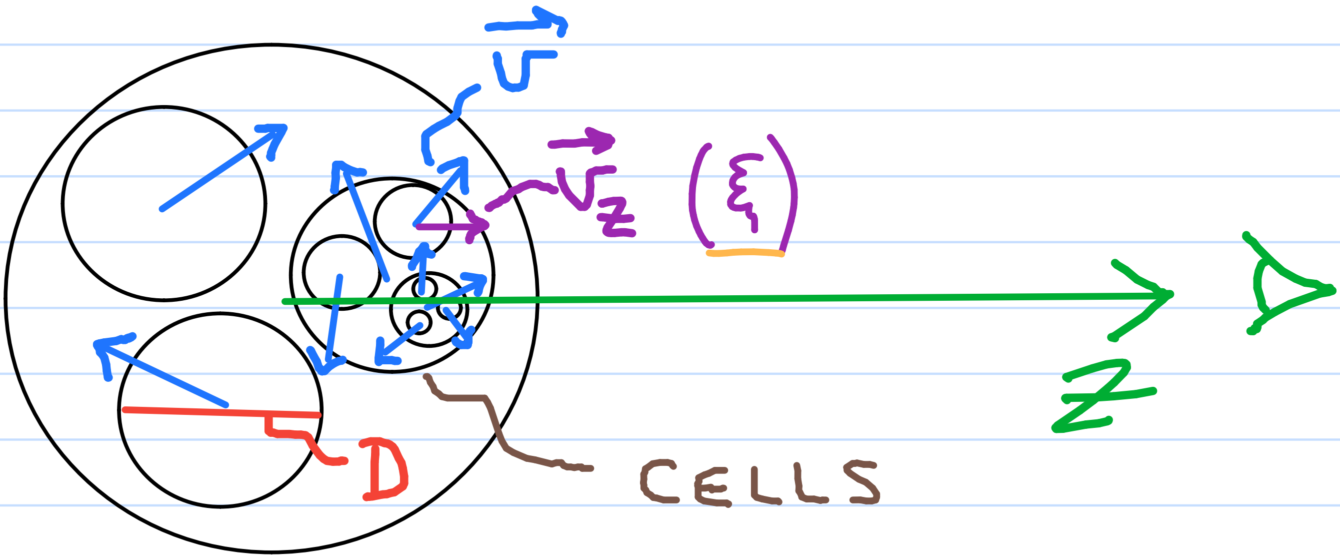
$$-\underline{\underline{6}} < \left\langle \left[ \frac{A_Z}{H} \right] \right\rangle < -2$$

- OLD GALACTIC HALO RED GIANTS

# 4) MICROTURBULENT

VELOCITY DISPERSION

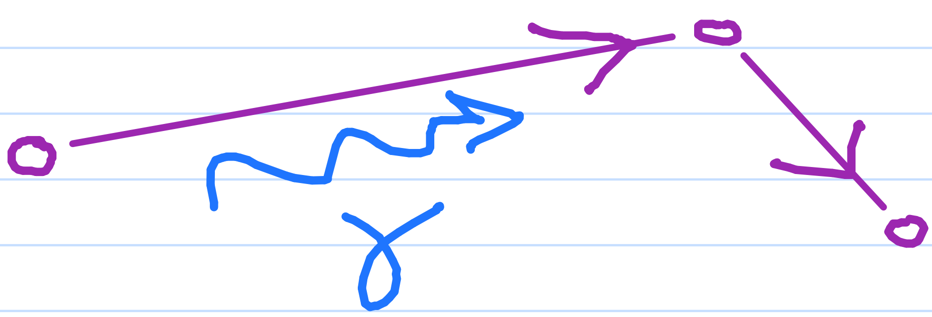
$\xi_T$ ($v_T$) (Km/s)




TURBULENCE IS HEIRARCHICAL

$v$ DISTRIBUTION IS
MAXWELL-BOLTZMANN (M-B)

PHOTON MEAN FREE PATH, $\ell_\gamma$ (cm)



# $D > l_v$: MACROTURBULENCE

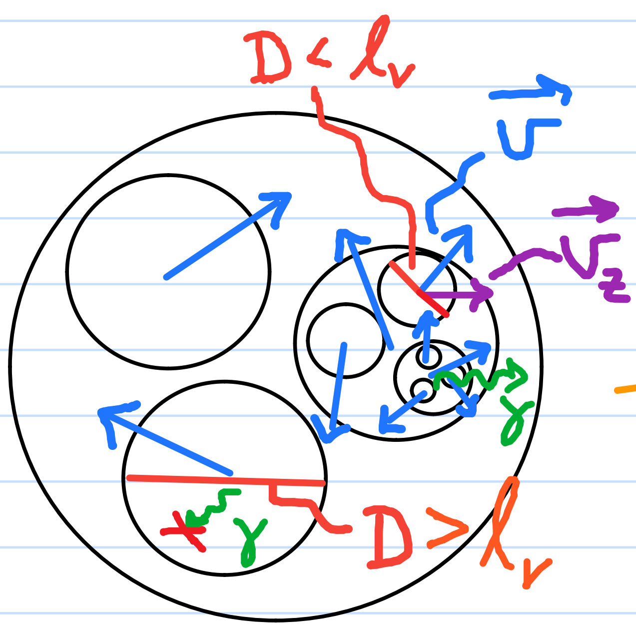
→ BROADENS SPECTRAL LINES WHILE CONSERVING POWER ABSORBED (AREA)

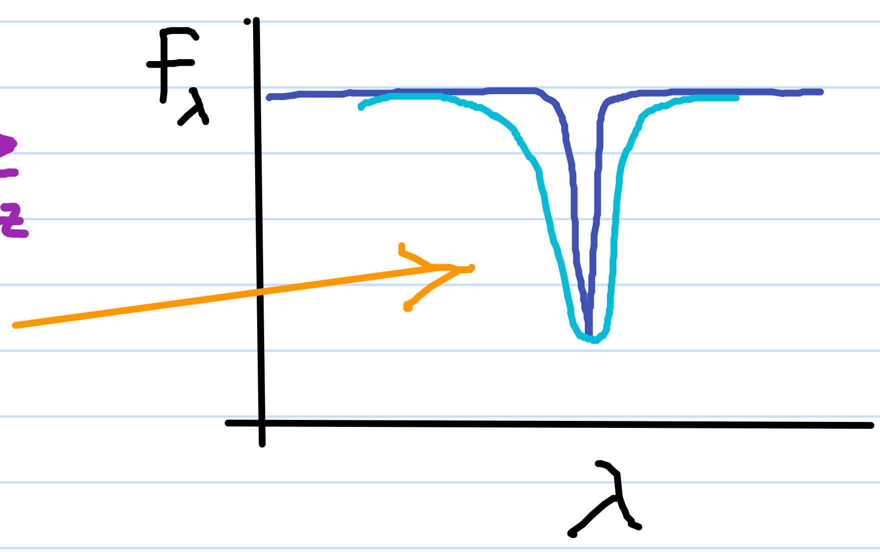
- POST-PROCESSING CORRECTION

# $D < l_v$: MICROTURBULENCE

→ BROADENS SPECTRAL LINES AND INCREASES POWER ABSORBED

→ AFFECTS STRUCTURE



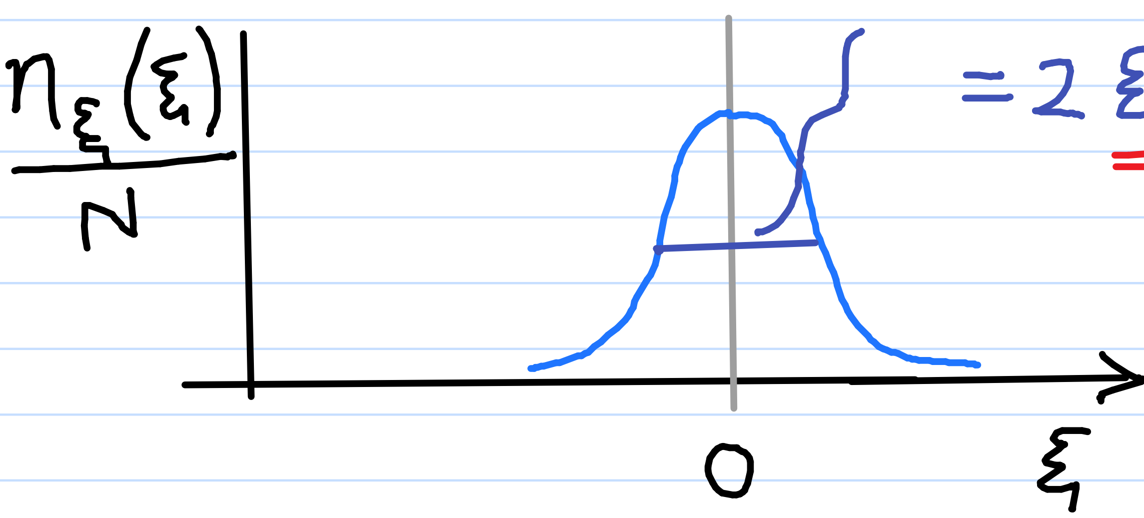

MICROTURBULENT LINE BROADENING

$N$ = NO. MICROTURBULENT CELLS

$n_\xi(\xi)$ = NO. CELLS WITH LINE-OF-SIGHT VELOCITY, $\xi$ ($v_z$)

1D MAXWELL-BOLTZMANN (M-B) $\xi$ DISTRIBUTION: GAUSSIAN:

$$\frac{n_\xi(\xi)}{N}\, d\xi = \frac{1}{\sqrt{\pi}\,\xi_T}\, e^{-\xi^2/\xi_T^2}\, d\xi$$




FWHM $= 2\,\xi_T\sqrt{\ln \frac{1}{2}}$

$1 < \xi_T < 8$ km/s

SUN — SUPERGIANTS