“Metallicity”

measure of chemical composition of a *star, cluster, galaxy, etc.*

	fraction by mass	Sun’s value
hydrogen	X	0.70
helium	Y	0.28
“metals” (Li and up)	Z	0.02

$$X + Y + Z \equiv 1$$

$$[\mathrm{Fe/H}]_\star = \log_{10} \frac{(\mathrm{Fe/H})_\star}{(\mathrm{Fe/H})_\odot} = \log(\mathrm{Fe/H})_\star - \log(\mathrm{Fe/H})_\odot$$

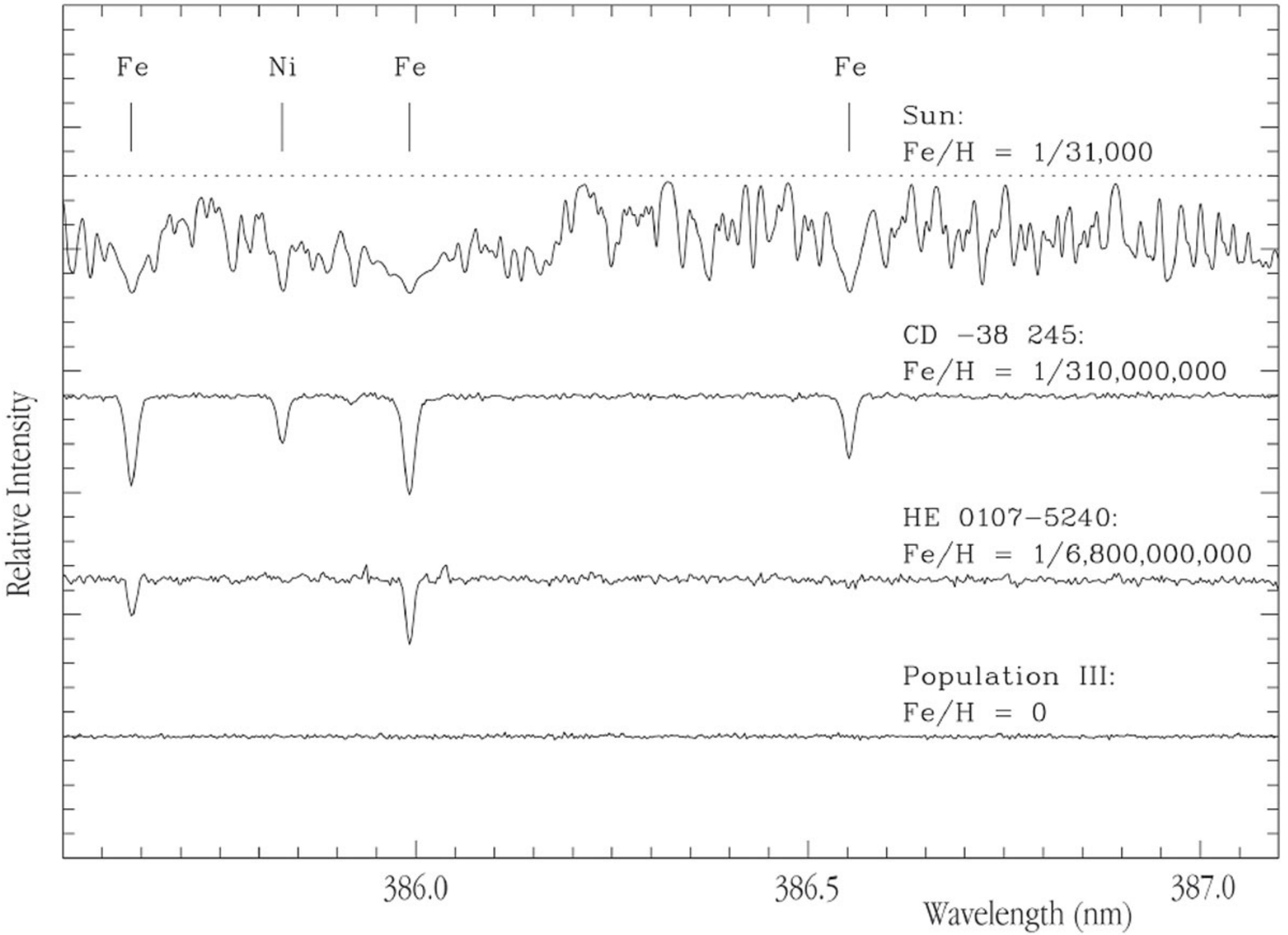
$$[\mathrm{Fe/H}]_\odot \equiv 0.00000$$

Element	12+log(Z/H)	log(Z/H)	H/Z ratio
C	8.47	-3.53	3388
N	7.85	-4.15	14125
O	8.71	-3.29	1950
Ne	8.15	-3.85	7079
Na	6.21	-5.79	616595
Mg	7.56	-4.44	27542
Al	6.43	-5.57	371535
Si	7.51	-4.49	30903
Ca	6.32	-5.68	478630
Fe	7.48	-4.52	33113

What does it mean to have [Fe/H] = +1.0? [Fe/H] = -2.0?

Most stars have [Fe/H] between -4.5 and +1.0

Why do stars have different metallicities?



Spectra of Stars with Different Metal Content

0.0

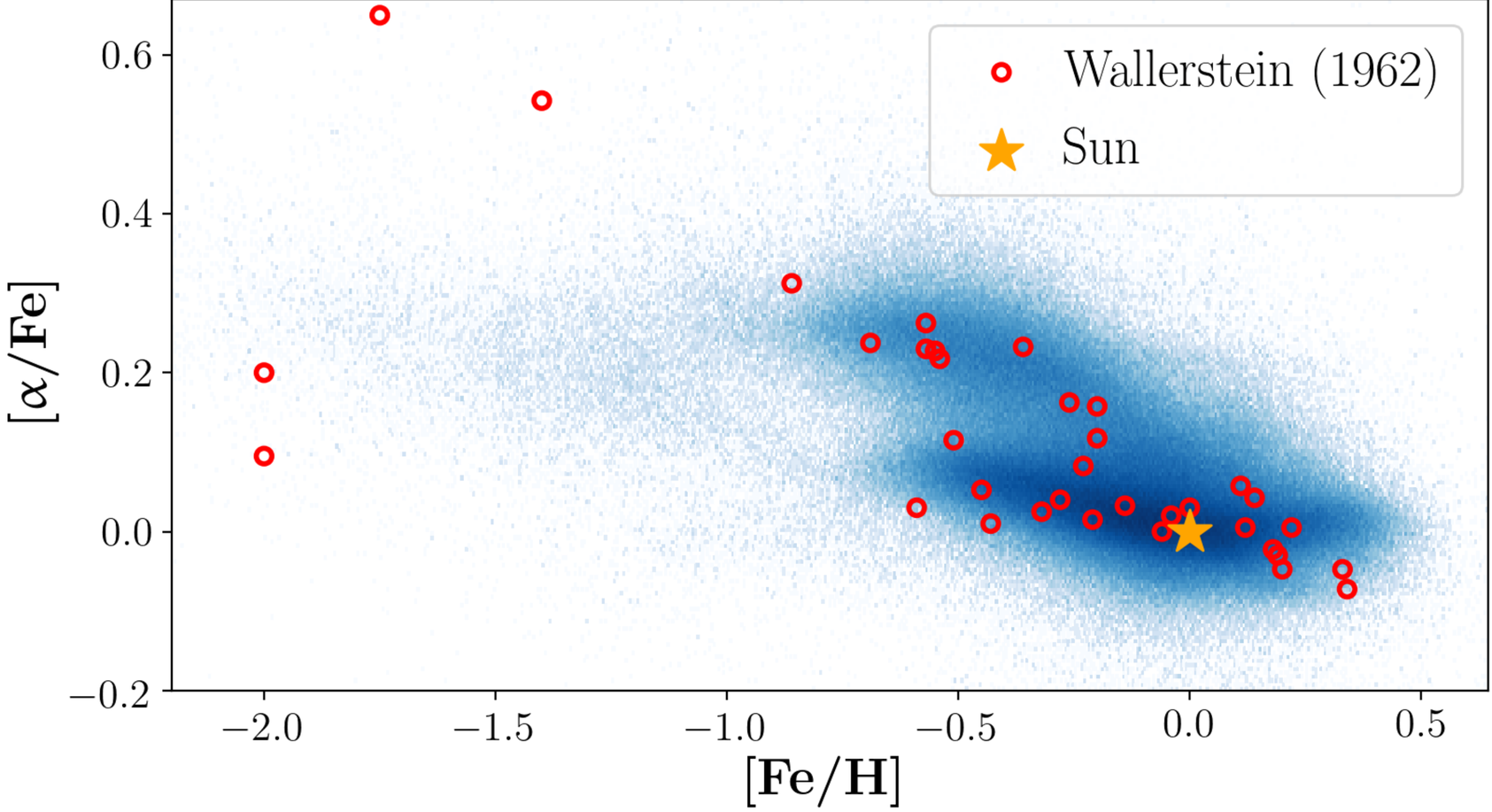
-4.0

-5.35

-∞

Use “alpha” elements as a different indicator of metallicity— (O, Ne, Mg, Si, S, Ar, Ca, Ti) — and look at alpha/Fe ratio

Different methods of making/dispersing metals: Iron comes from core collapse (fast) AND thermal runaway (slow) supernovae. Alpha elements only come from core collapse (fast) supernovae

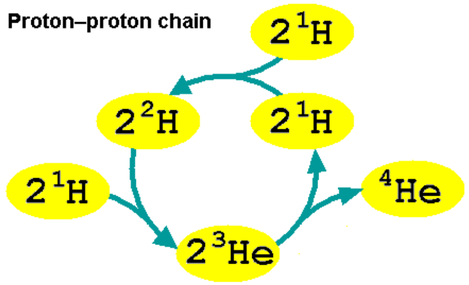


Looking at both measures tells you about the star formation and evolution history of a population of stars

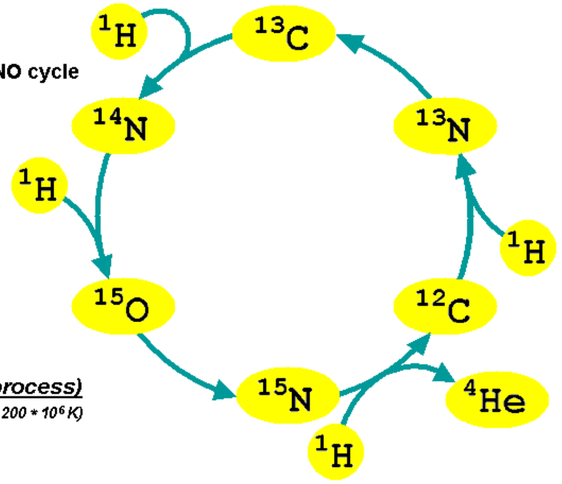
Hydrogen-burning

(15 - 60 * 10^6 K)

Proton–proton chain

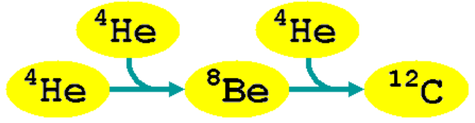


CNO cycle

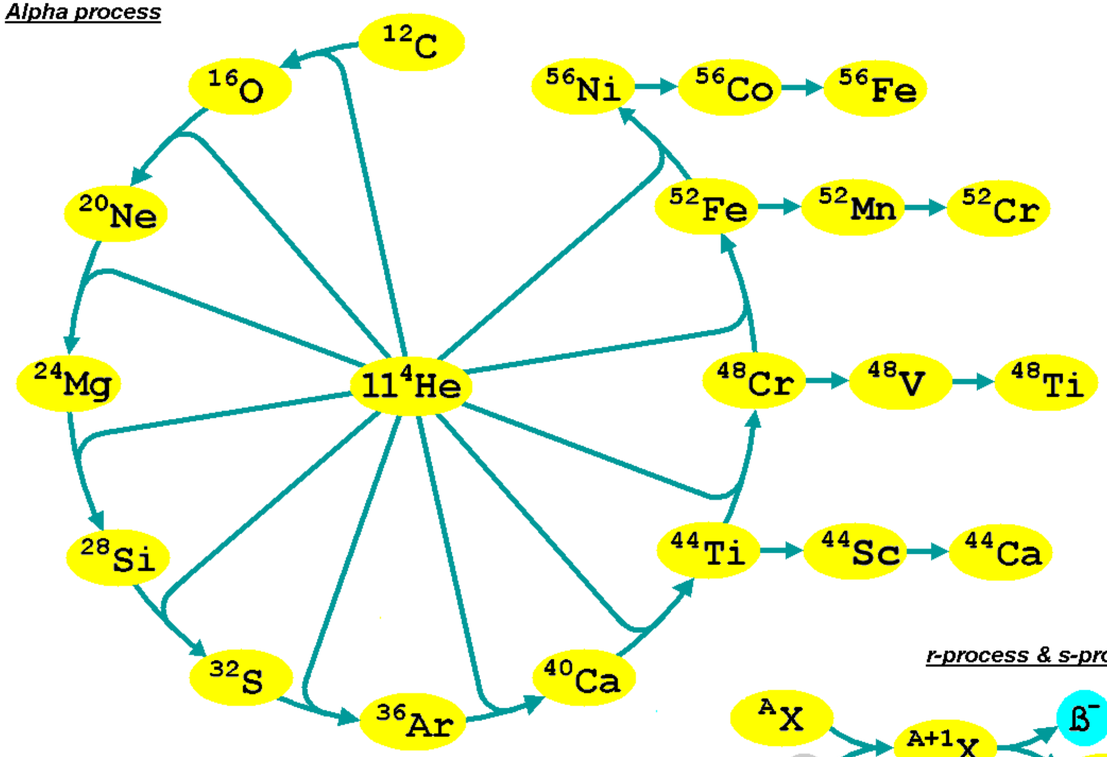


Helium-burning (triple-alpha process)

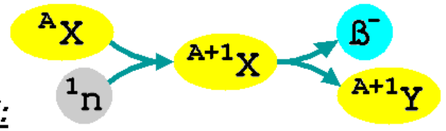
(100 - 200 * 10^6 K)



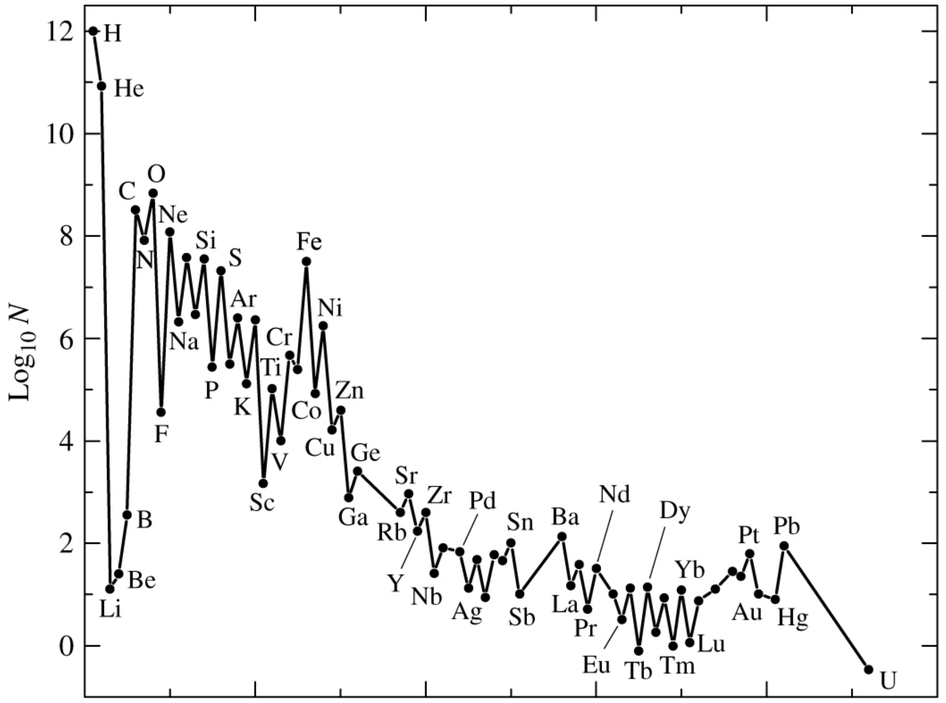
Alpha process

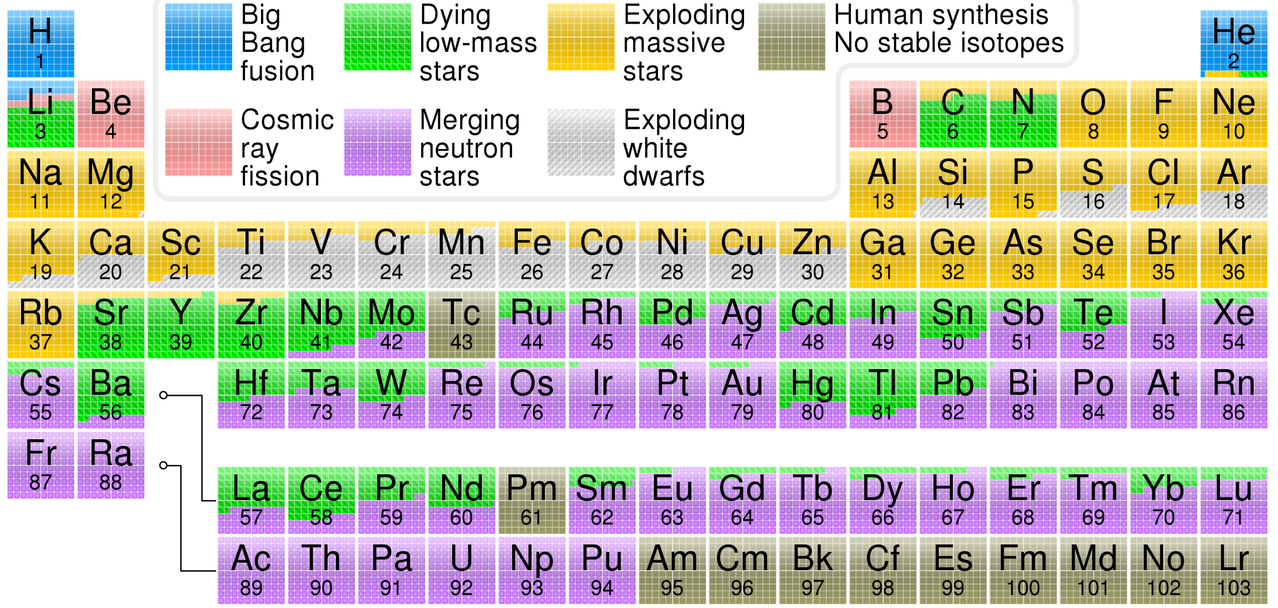


r-process & s-process



Beyond iron and nickel:





Stellar Populations

categorizing stars based on their metallicity

Observations:

Globular clusters are
generally metal-poor

Disk stars span a range of
metallicities

Open clusters are
generally more metal-rich

what does this mean?

Stellar Populations

categorizing stars based on their metallicity

Observations:

Globular clusters are generally metal-poor

Non-cluster stars span a range of metallicities

Open clusters are generally more metal-rich

what does this mean?

Population I	**Population II**
“metal-rich” [Fe/H] > -1	“metal-poor” [Fe/H] < -1
open clusters	globular clusters
lots in solar neighborhood	not many in solar neighborhood

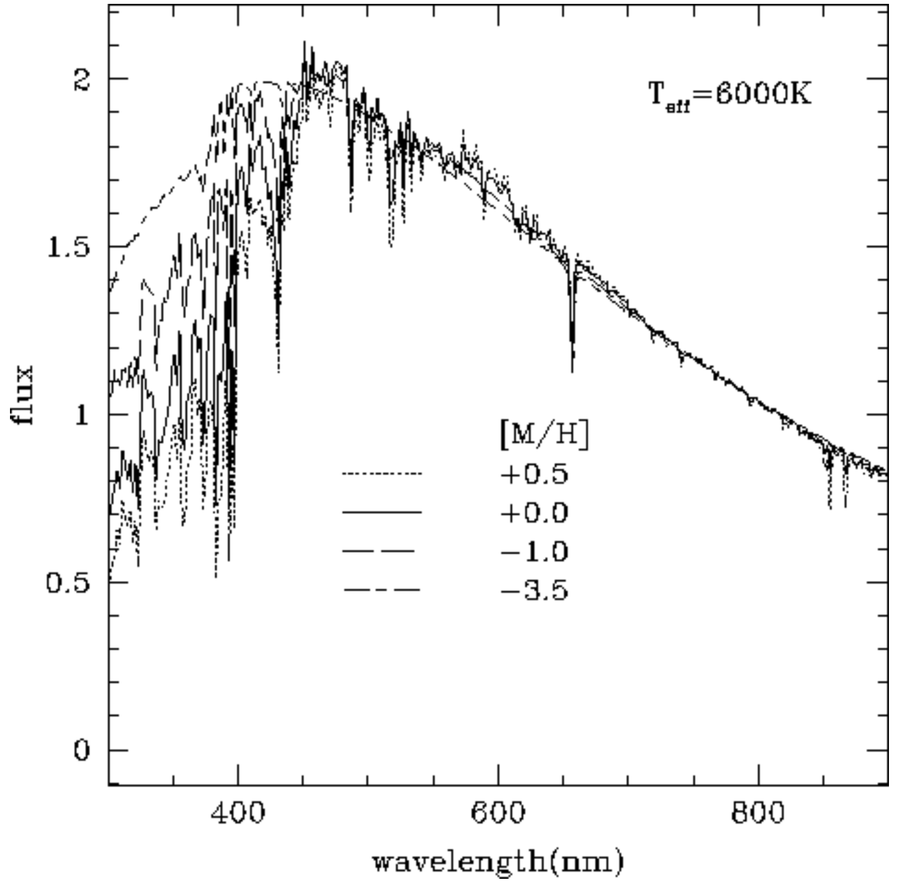
Population III — (theoretical) population with NO metals; never observed

Metallicity correlates with color:
metal-poor stars bluer
metal-rich stars redder

why?

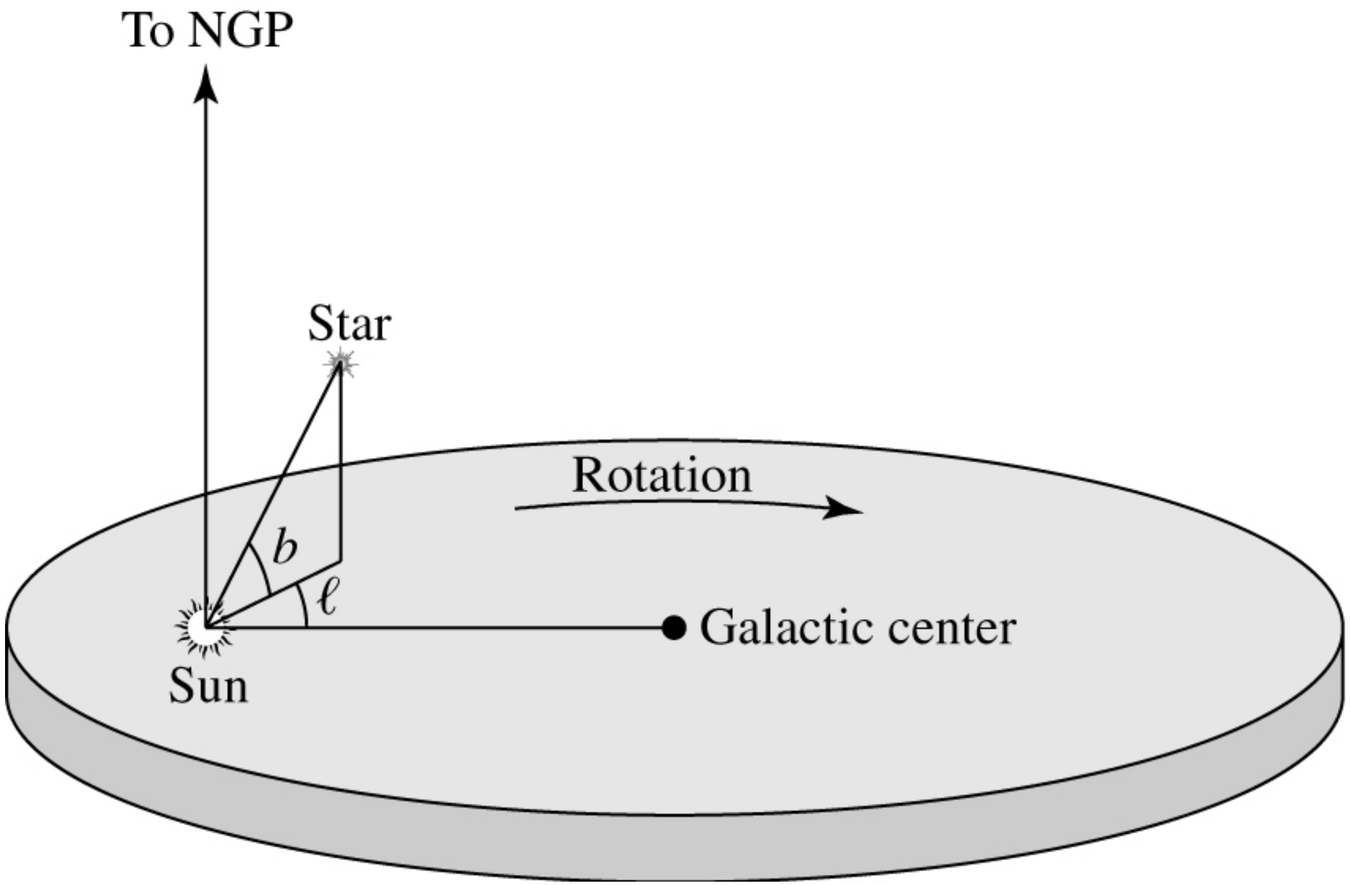
“line blanketing”: more metal absorption lines in blue part of spectrum, take out blue light preferentially

opacity: more metals means more absorption lines to catch photons. stars with higher opacity get bigger due to convection effects and cool down = redder



Lots of things affect the color of a star:

Age (blue stars are young, red stars are old)
Metallicity (metal-rich = red, metal-poor = blue)
Dust (makes everything red)



Galactic Coordinates

ℓ = Galactic longitude

b = Galactic latitude

d = distance

centered on Sun

$$X = D \cos \ell \cos b$$

$$Y = D \sin \ell \cos b$$

$$Z = D \sin b$$