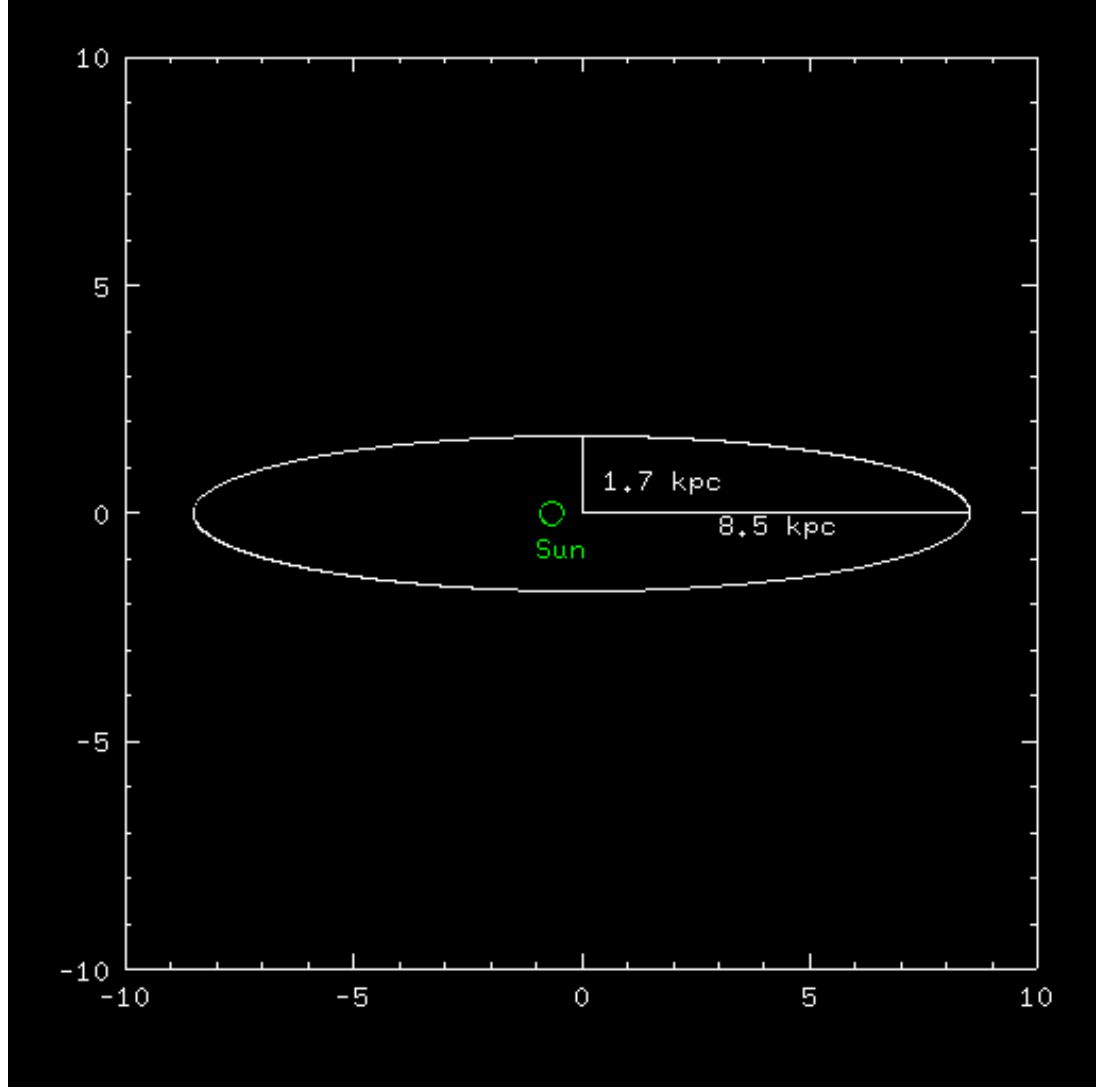
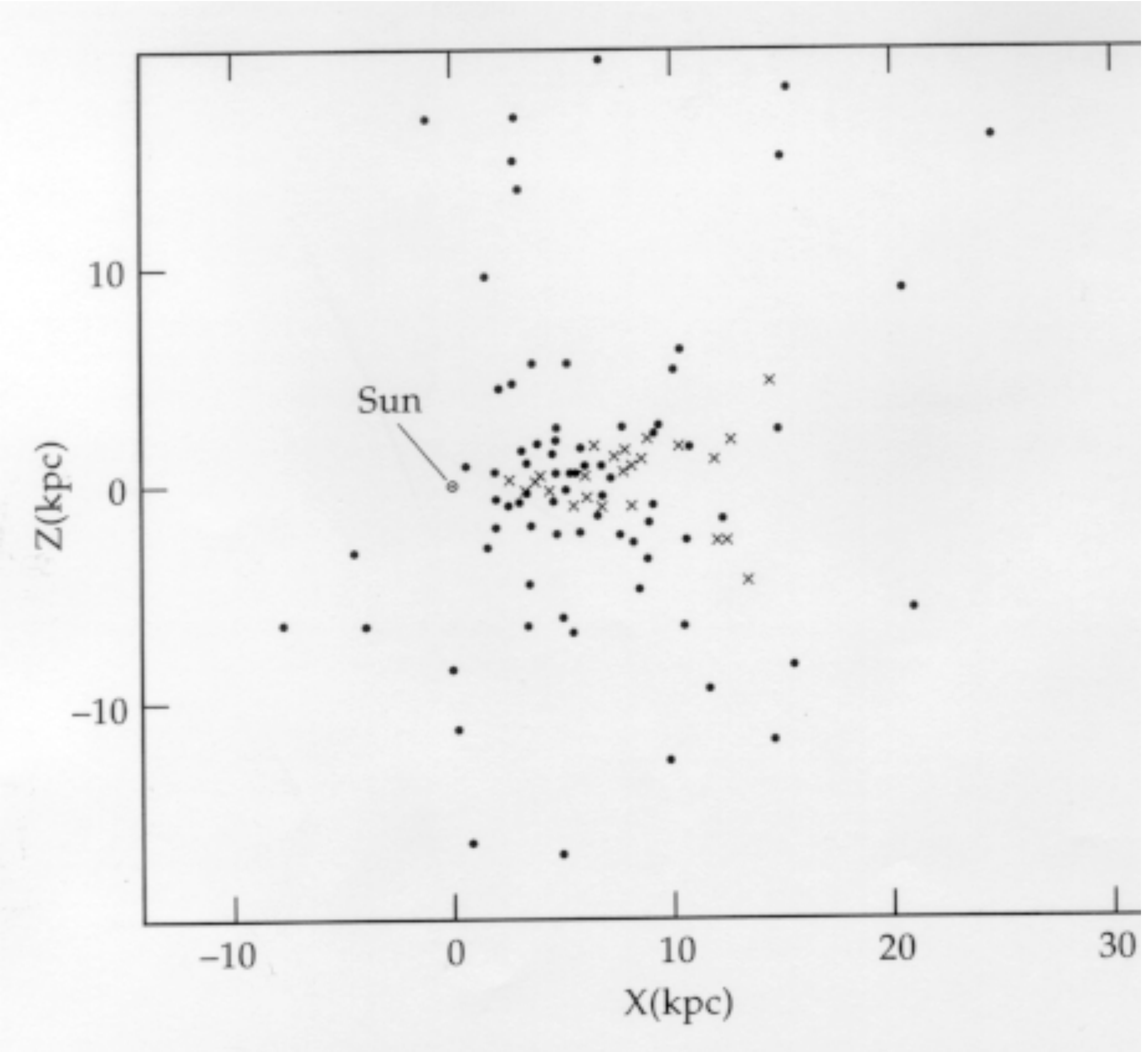
What would you like for Python help options?

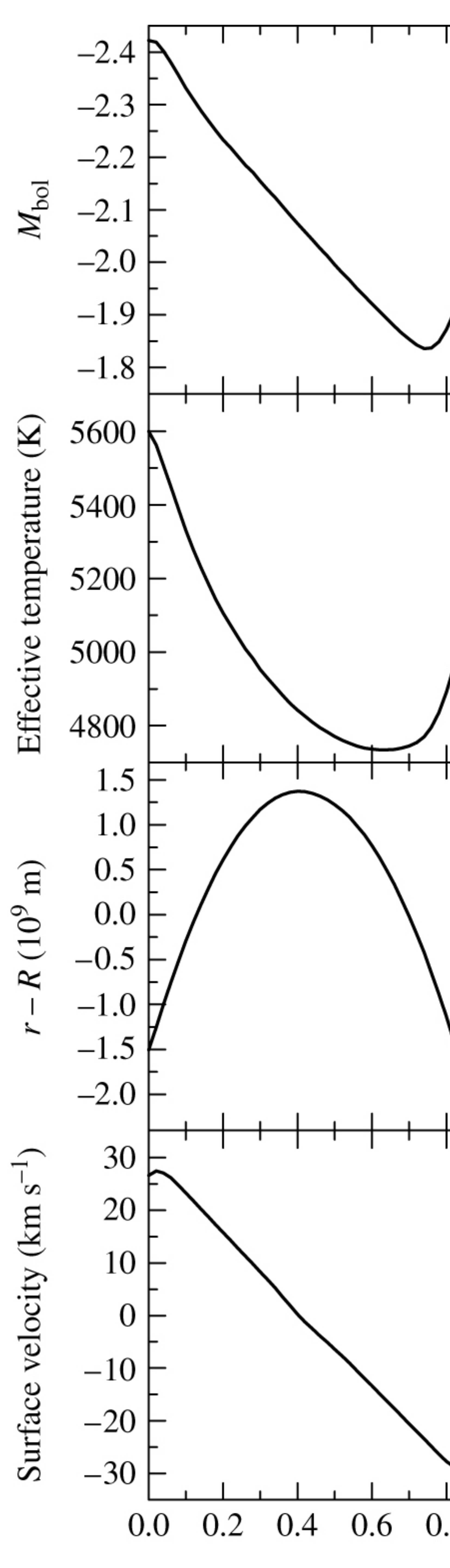
- **Discord chat?**
- **Study sessions?**
- **Office hours?**
- **Email?**

- early 1900s: **Jacobus Kapteyn** uses quantitative star counts to measure the size of the Galaxy.
  - ellipsoidal
  - ~ 10 kpc in size
  - Sun near center



- ~1920: **Harlow Shapley** uses RR Lyrae variable stars to get distances to globular clusters.
  - Galaxy is ~ 100 kpc in size
  - Sun is ~ 15 kpc away from the center of the GC distribution.

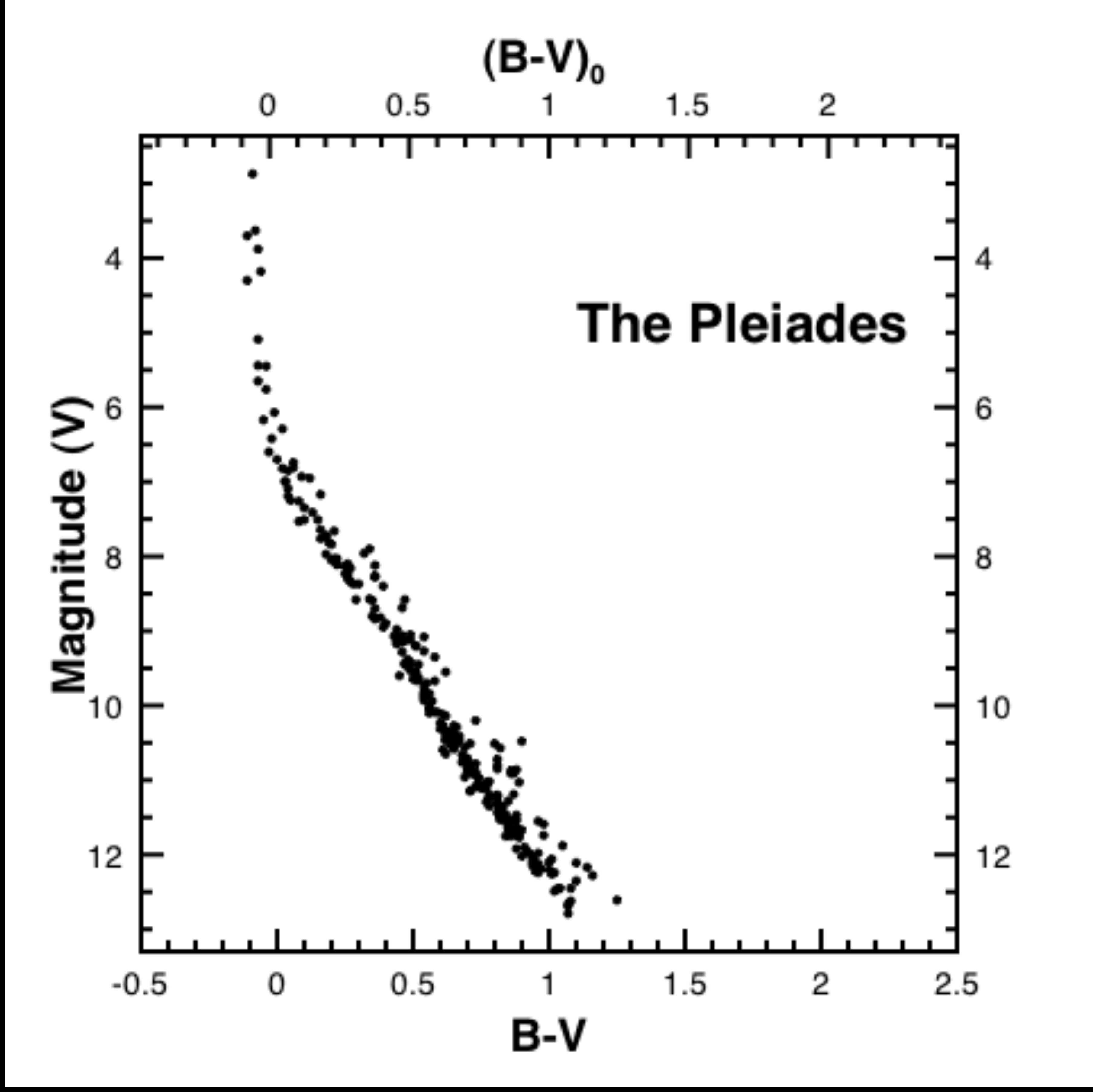


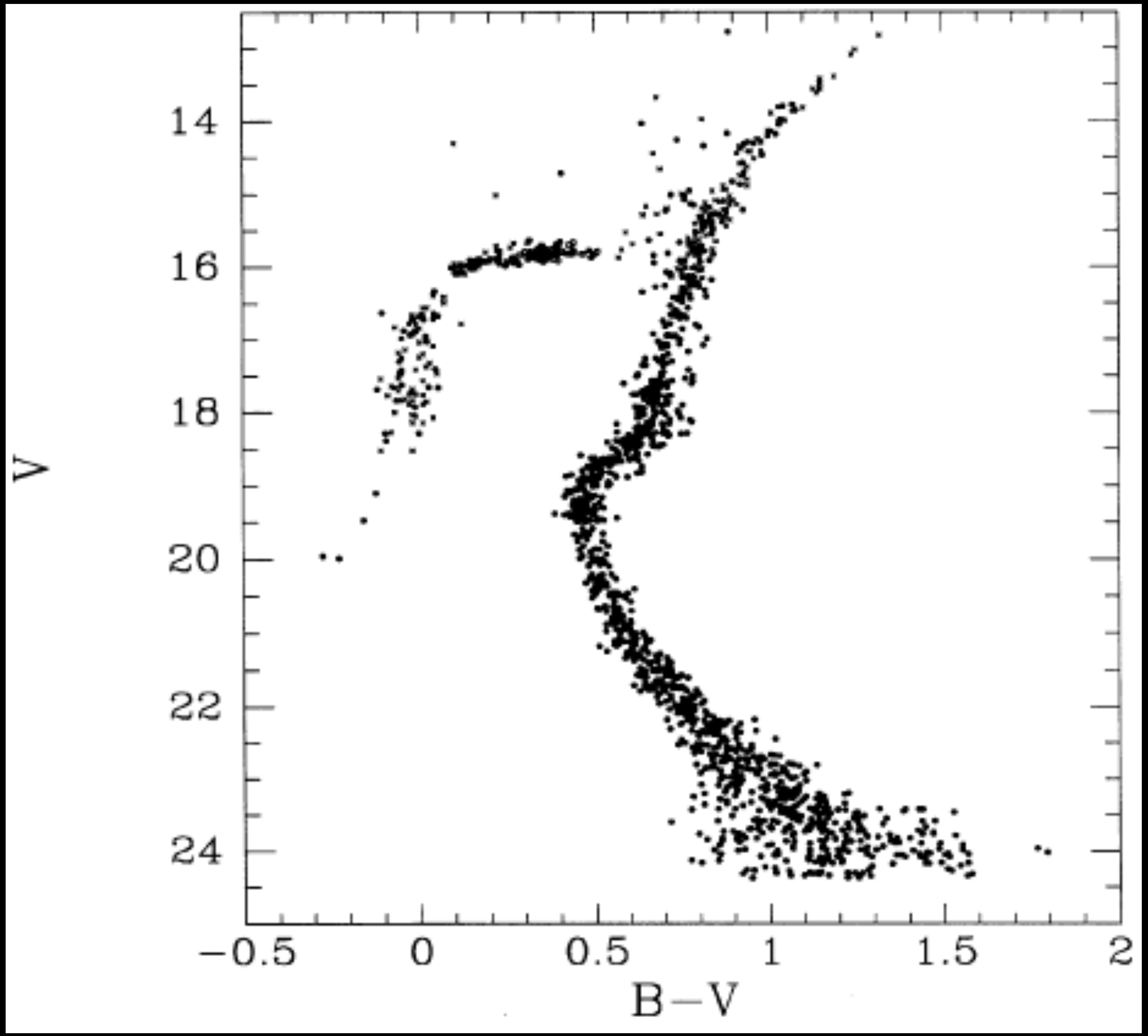


Who's right? Actually, both were wrong. Their observations were compromised by the effects of interstellar dust, the presence of which was unknown at the time.

- **Kapteyn's problem:** because dust make stars fainter, Kapteyn couldn't see the already faint stars at large distances, so he thought the Galaxy was "running out of stars" at about 10 kpc away.
- **Shapley's problem:** since he was observing clusters of stars (instead of individual stars) he could see them further away. But since dust made them fainter, he thought they were even further away than they actually were.

Of the two, ***Shapley was much closer to the truth***. When the effects of dust were realized and corrected for, studies of galactic structure entered the modern era.


(B-V)0
0
0.5
1
1.5
2
The Pleiades
Magnitude (V)
4
6
8
10
12
-0.5
0
0.5
1
1.5
2
2.5
B-V



14
16
18
20
22
24
V
−0.5
0
0.5
1
1.5
2
B−V

“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

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

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

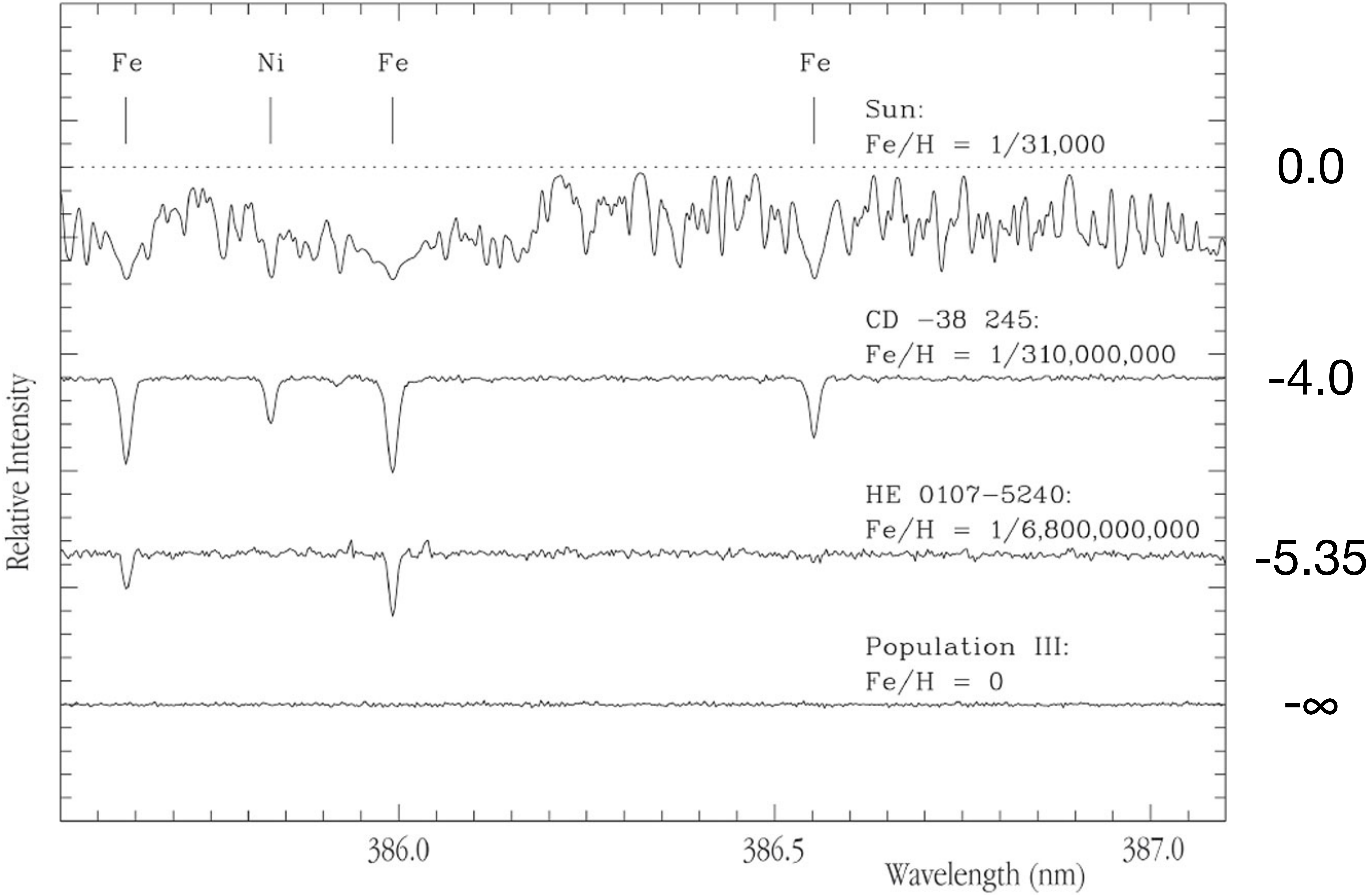
$$[\mathrm{Fe/H}]_\star = \log_{10}\frac{(\mathrm{Fe/H})_\star}{(\mathrm{Fe/H})_\odot} = \log(\mathrm{Fe/H})_\star - \log(\mathrm{Fe/H})_\odot$$

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

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

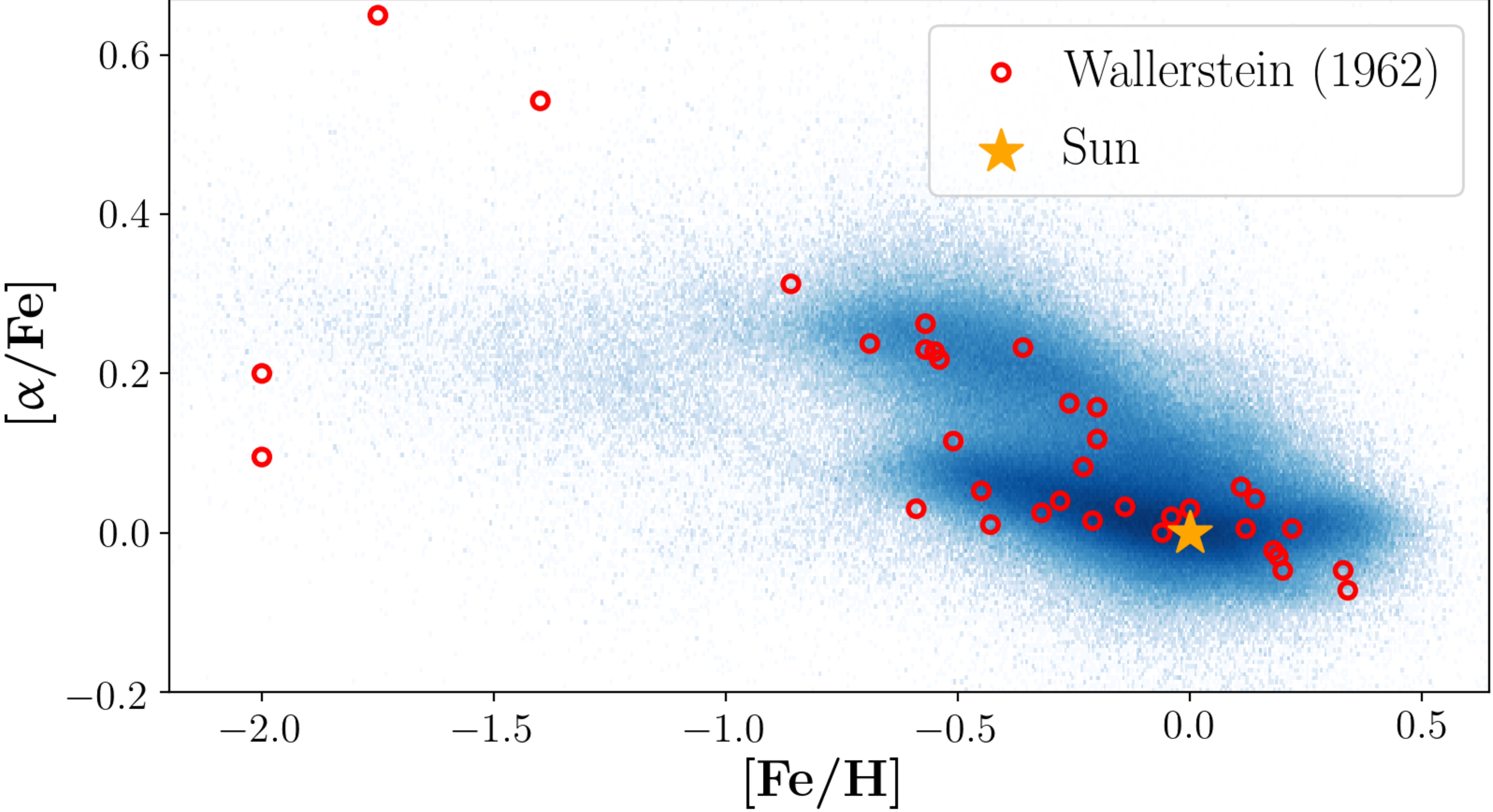
Most stars have [Fe/H] between -4.5 and +1.0

Why do stars have different metallicities?



Spectra of Stars with Different Metal Content

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