3 Stars notes 2019/08/26 - Mon - Observing Stars

3.1 Observing Stars: Magnitudes and colors continued

What is actually measured is collected photons: has uncertainty. Only know to $\pm\sqrt{N}$. Note background is included in N, and so contributes to uncertainty. (see HW problem)

Flux bands:

λ_0 is the central wavelength. and the last column is the flux in the band for Magnitude zero.

Band	λ_0(Å)	FWHM(Å)	photons/ (cm^2 sec Å)
U	3650	680	780
B	4400	980	1450
V	5500	890	1000
R	7000	2200	610
I	9000	2400	380

(FWHM = full width at half max)

A "color" is then found by taking the difference of two magnitudes, which actually measures a flux ratio relative to the same ratio for Vega:

$$B-V = -2.5\log_{10}\left(\frac{F_{\text{Bband}}}{F_{\text{Bband,Vega}}}\right)+2.5\log_{10}\left(\frac{F_{\text{Vband}}}{F_{\text{Vband,Vega}}}\right) = -2.5\log_{10}\left(\frac{F_{\text{Bband}}/F_{\text{Vband}}}{F_{\text{Bband,Vega}}/F_{\text{Vband,Vega}}}\right)$$

Magnitude depends on distance (further=dimmer=larger magnitude)
Color does not, as all fluxes vary as 1/distance^2.

Since color is basically a flux ratio at different wavelengths, it is also a measure of T_{eff}.

3.2 Absolute and bolometric

"Absolute" magnitudes, M, are the magnitude a star would appear if it were 10 pc away. Distance modulus is $M - m$, the difference between apparent and absolute magnitude.

Bolometric magnitude is

$$M_{Bol} = -2.5\log\left(\frac{L}{L_0}\right), \qquad L_0 = 3.0128 \times 10^{28} \text{ W}$$

(See resolution B2 from IAU 2015:
https://www.iau.org/static/resolutions/IAU2015_English.pdf
This makes the Sun $M_{Bol,\odot} = 4.74$.

"bolometric correction" is

$$BC_V = M_V - M_{bol}$$

Note that the sign convention is not universal, and is, for example, opposite in Clayton and Binney & Merrifield, two of our texts.

Below: Stars with good distance measurements by Hipparcos satellite (distance needed to obtain absolute brightness).
Sun – $m_V = -26.74$, $M_V = 4.83$, $B - V = 0.6$, $M_{Bol} = 4.74$, $B.C. = 0.1$
Variety of ages (including young stars!)

M.A.C. Perryman et al.: Parallaxes and the Hertzsprung-Russell diagram from the preliminary Hipparcos solution H30 75

A + A 304, 69

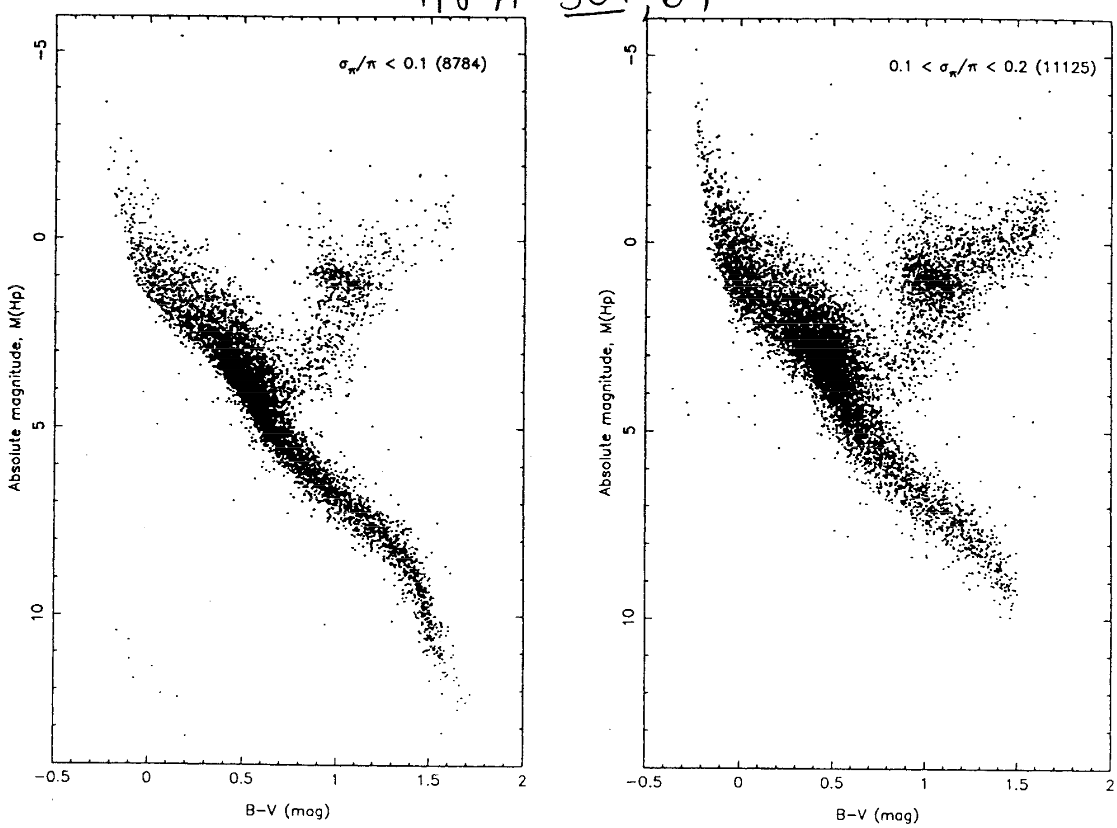

Fig. 6. a The observational HR diagram constructed from the preliminary Hipparcos catalogue H30, for the 8784 stars with $\sigma_\pi/\pi < 0.1$ and $\sigma_{B-V} < 0.025$ mag, and supplemented by six white dwarfs as described in the text. The ordinate gives the absolute magnitude, M_{Hp}, derived from the satellite-determined parallaxes and the median satellite-derived Hp magnitudes. The abscissa gives the colour index $(B - V)$, derived from the ground-based observations compiled in the Hipparcos Input Catalogue. **b** as for **a**, but based on the 11 125 stars from H30 satisfying $0.1 \le \sigma_\pi/\pi < 0.2$ and $\sigma_{B-V} < 0.025$ mag.

Below: Color-magnitude diagrams, historically best of clusters – all stars at same distance, age

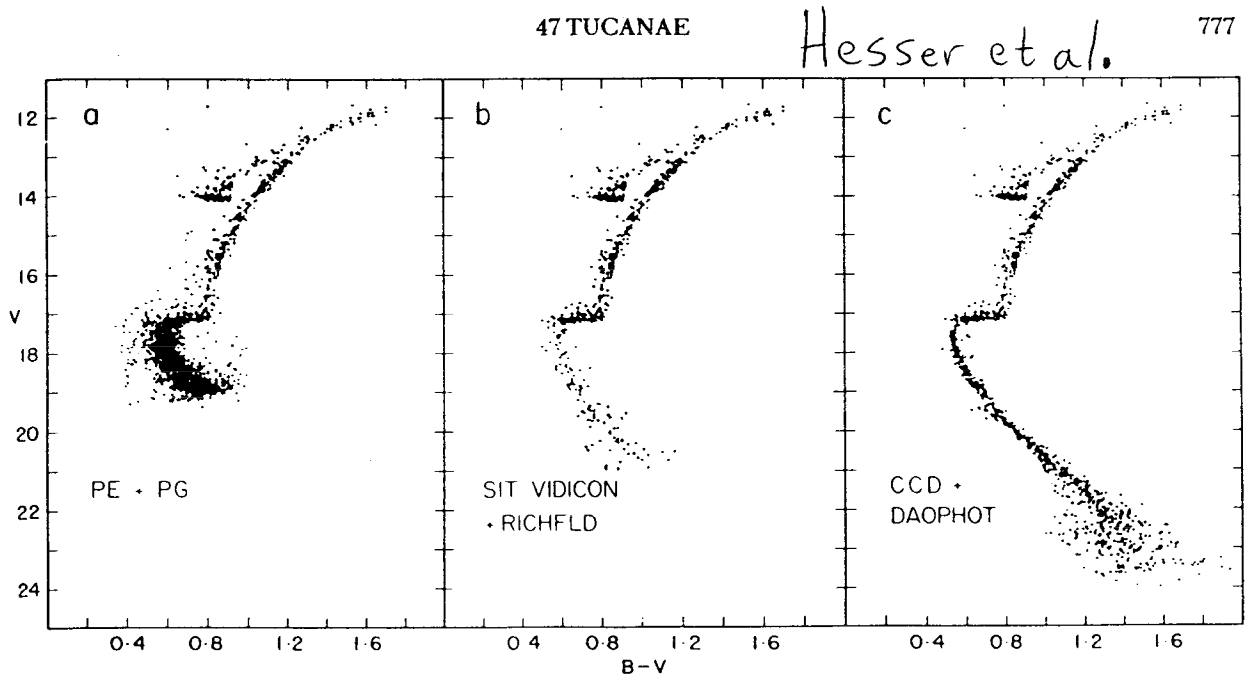

FIG. 9–CMDs for 47 Tuc derived from three independent studies: (a) photoelectrically calibrated photographic photometry (Hesser and Hartwick 1977), obtained with the CTIO 1.5-m telescope and traditional iris photometry, (b) photometry with a SIT Vidicon camera (Harris *et al.* 1983*a*,*b*), obtained with the CTIO 4-m and reduced through RICHFLD; (c) the present CCD+DAOPHOT photometry. In all three cases the giant and horizontal branches are the same (photographic) data; only the main-sequence data ($V > 17.2$) are different, to illustrate the progression in depth and internal precision that has been achieved

Our goal: Why? – Why do stars have the L, R, $T_{\rm eff}$ that they have now? and how does this change with time?

3.3 How are Stars Important?

A sense where stars matter in the broader context of cosmology and extragalactic astrophysics.

1. Production of "metals" (everything heavier than He) All of this stuff, C,O, etc is made in stars. to understand the abundances in different places we need to understand stars.

2. Stellar physics plays an important role in what we call the distance ladder. The classic example is Cepheid varibles, calibrated standard candles. SN Ia explosion dynamics/nucleosynthesis also stellar physics.

And for physics of the interstellar medium (ISM)

- Energy and material input – Supernovae shape, heat and enrich the gas in the plane of our galaxy (and other galaxies).

- Dust (Carbon or silicate grains, solid material) is made in the winds from dying stars. our sun in its late stages will give off such a dusty wind.

A few open problems:

1. How does convective mixing occur that leads to observed creation of elements in giant stars? and generally how does convection actually work in general?
2. what is role of rotation? How is angular momentum moved around inside a star? basically everthing we'll discuss in this course neglects rotation. Has been well studied for the sun – which gives cause for concern.
3. what is the role of magnetic field? These are generally small effects because they don't effect the hydrostatic balance, but critical in other ways. Notably angular momentum transport.
4. what is the role of binarity? Most massive stars are binaries that will, at some point, interact with their companion. How does this change the stars' evolution?

3.4 MESA demo

short demo of the 'getting started' exercise from mesa.sourceforge.net.

The getting started tutorial problem is running a 15 $M_\odot$ star from the pre-main sequence up until hydrogen burning starts. Then stopping and restarting it to run until hydrogen becomes depleted in the core.