Ay 20 #15 - Star clusters and stellar populations

Understanding the formation histories of groups of stars - clusters, galaxies, and clusters of galaxies - is one of the fundamental problems of astronomy.

* Star clusters
  - Provide excellent opportunities to measure stellar ages. This is usually very difficult due to the nature of stellar isotrons: only stars off the ZAMS (Zero-Age Main Sequence) can be dated individually.
  - Dating accomplished using "main-sequence turnoff" - redder turnoff -> older cluster
  - As you know from the recitation, problems:
    * Selection of cluster members
    * Few stars
    * Dust
    * Metallicity
    * Distance

* Stellar population types

Pop I : young, in disk, metal rich

Pop II : old, halo & bulge, metal poor.

Metallicity definitions :

$$\text{Stars} = X + Y + Z = 1 \quad \text{by mass}$$

X: H, Y: He, Z: other.

$$Z = \sum_{i > \text{He}} \frac{m_i}{M} = 1 - X - Y.$$

$$Z_\odot = 0.0134.$$

By abundance (# of species per unit volume), usually in terms of iron,

$$[\text{Fe/H}] = \log_{10}\left(\frac{N_{Fe}}{N_H}\right) - \log_{10}\left(\frac{N_{Fe}}{N_H}\right)\Big|_\odot$$

Also see $[X/Fe]$ as indicators of different nucleosynthetic processes. (e.g., $[\alpha/Fe]$)

* Stellar population synthesis.

- Starts with the stellar Initial Mass Function (IMF), of ZAMS stars.

In general, mass functions take the form $\frac{d}{dM} N(M)$, where N is a number density.

Salpeter (1955)

$$\frac{d}{dM} N(M) = \xi_0 \left(\frac{M}{M_\odot}\right)^{-2.35}.$$

Kroupa (2001)

$$\frac{d}{dM} N(M) \propto m^{-\alpha}, \quad \alpha = \begin{cases} 0.3, & m < 0.08 \\ 1.3, & 0.08 \leq m < 0.5 \\ 2.3, & m \geq 0.5 \end{cases}.$$

$$\left(m = \frac{M}{M_\odot}\right)$$

All empirical. What are some uncertainties?

- Combined with isochrones to define a Simple Stellar Population (SSP):

$$f_{SSP}(t, Z) = \int_{m_{low}}^{m_{hi}(t)} f_*[T_{eff}(M), \log g(M), Z] \, \phi(M) \, dM,$$

This is the observed spectrum @ t, z gives the stellar spectrum (f_*), the IMF ($\phi(m)$), and population parameters z, m_{low} & m_{up}. Isochrones relate T_{eff}, $\log g$ & $M \leftrightarrow t$, z.

- Then combined with models for the star-formation rate & chemical evolution, and for ISM emission & absorption, to model galaxy spectra.