News

• Lab 4
  – Handed back next week (I hope).

• Lab 6 (Color-Magnitude Diagram)
  – Observing completed; you should have been assigned data if you were not able to observe.
  – Due: instrumental color-magnitude diagram: email it to me by tomorrow (or whenever you finish it). Whole lab due November 30.
Lab 6: Color-Magnitude Diagram

• Target is the open cluster M34.
  – CMD can determine the cluster distance and age.

• Will again perform differential photometry by using stars in the field with known standard magnitudes.
  – So the observations can be taken through thin scattered clouds.

• Will observe in both the B and V filter to get stellar colors, B−V.
  – Color measures stellar surface temperature.
One field approximately centered on M34.
A field with the center offset.
More central M34 field in I band. Note the many faint stars.
M34 B 300 sec

Same field in B band. Note fewer faint stars.
M34 instrumental $(v, b-v)$ color-magnitude diagram. 1,235 stars
Location of the offset field.
907 stars; some are outside plot bounds
M34 Offset Field
Background stars in the Galactic disk (mostly).

Still a few M34 stars?

Background red giants or foreground dim red main-sequence stars.
M34 CMD
WIYN 0.9m
telescope
Green – proper motion member
Red – radial velocity member
Blue – photometric member

Transformation to Standard Magnitudes

• Thus, the standard transformation equations are:
  
  \[ \text{B} - \text{V} = \phi_{bv} + \mu_{bv} (b - v) \]
  
  \[ \text{V} - v = \phi_v + \varepsilon (B - V) \]

  • Here, B and V are the standard magnitudes and b and v are the instrumental magnitudes.
  
  • These can be considered first-order Taylor expansions. We will ignore higher order terms (they are usually unimportant).
  
  • The \( \mu_{bv} \) coefficient would be 1.0 and \( \varepsilon \) would be 0 if our system matched the standard one.
  
  • Actually differ from these values by 0.2 – 0.4.
Fitting the Transformations

• B–V equation:
  – Calculate a column of
    \[ \Delta_{B-V} = (B-V) - (\phi_{bv} + \mu_{bv} (b - v)) \]
  – Make another column of \((\Delta_{B-V})^2\) and sum to form
    \[ \chi^2 = \sum_i (\Delta_{B-V,i})^2. \]
  – Minimize \(\chi^2\) by varying \(\phi_{bv}\) and \(\mu_{bv}\) using solver in excel.

• V equation:
  – Calculate a column of
    \[ \Delta_V = V - (v + \phi_v + \varepsilon (B - V)) \]
  – Proceed as above to determine \(\phi_v\) and \(\varepsilon\).
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<th>i0</th>
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<th>B-V</th>
<th>V-i</th>
<th>V-v0</th>
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The smaller range of b-v compared to B-V may arise because the CCD quantum efficiency weights our B band towards long $\lambda$’s and our V band towards short $\lambda$’s, thus reducing our wavelength baseline (hence, sensitivity to T).
Interstellar Extinction & Reddening

• Caused by scattering from “dust” grains in the interstellar medium.
  – About 1 magnitude of dimming per kiloparsec of distance in the plane of the Galaxy.
  – A major headache.

• Scattering cross-section is larger at shorter wavelengths (Rayleigh scattering), so light is reddened.
Interstellar Extinction & Reddening

• Dust grains properties uniform, so there is a (nearly) universal relation between reddening and extinction.
  – Reddening: \( E(B-V) = (B-V) - (B-V)_0 \)
  – Extinction: \( A_V = V - V_0 = 3.1 \ E(B-V) \)

• Reddening is not easy to determine.
  – Measure spectral type of stars and use relation between color and type for very nearby stars.

• For Lab 6 you are given \( E(B-V) \) and use it to correct your photometry to \( V_0 \) and \( (B-V)_0 \).
Cluster Distance

- Slide a theoretical “zero-age” main sequence isochrone vertically until it matches the cluster main sequence.

\[ m - M = 5 \log(d/10\text{ pc}) + A_V \]

\[ m = M_V + 5 \log(d/10\text{ pc}) + A_V \]

- \( M_V \) = isochrone absolute magnitudes
- \( m = \) shifted isochrone apparent magnitudes \( M_V \)
- \( d = \) cluster distance
- \( A_V \) = extinction due to interstellar dust.
Pre-main-sequence stars

Blue: \( \log(\text{age/years}) < 7 \)
Green: \( 7 \leq \log(\text{age/years}) < 8 \)
Black: \( 8 \leq \log(\text{age/years}) \)

Isochrones
Increasing the m–M adopted for the isochrone in steps of 0.1.
Increasing the m−M adopted for the isochrone in steps of 0.1.
Increasing the $m-M$ adopted for the isochrone in steps of 0.1.
Cluster Age

- Match the main-sequence turnoff.
Isochrones with different ages and best $(m-M)$