Standard Stars (Chromey Ch. 10)

The goal of observing standard stars is to solve for (1) K, the extinction coefficient in mag/airmass in each band, (2) the constant offset, C_0, between the instrumental magnitude system and standard system, and (3) the (at least the first order) color term, C_1, that lets you convert instrumental to standard magnitudes. (There are also higher order color terms).

Extinction Corrections:

Assume (1) extinction doesn't change with time (2) it doesn't change with position on sky. Then extinction is linear with airmass

$$F = F_0 e^{-\tau_0 X}$$

→ both are true in photometric conditions

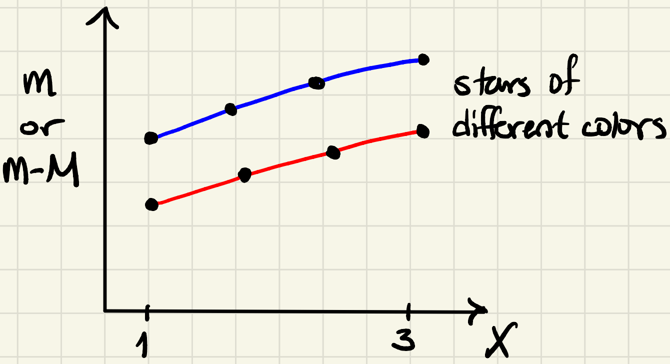
→ 1 is not true if clouds come in

→ 2 is not true at $X \gtrsim 3$.

F_0 - flux above the atmosphere
F - observed flux
τ_0 - optical depth at zenith
X - airmass

$$m_0 = m - 1.085\,\tau_0 X = m - KX$$

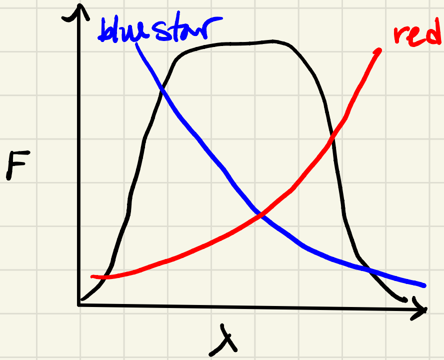
m_0 - magnitude corrected for atmospheric extinction
m - observed instrumental magnitude
K - extinction coefficient



There are second order effects.

$K \sim 0.4$ mag/airmass in U
$K \sim 0.1$ mag/airmass in R

There are second order color terms:



- red and blue stars pass through filter differently
- blue will experience more extinction because it is brighter at bluer λ
- even if they have the same mag, they will have different extinction because blue star has more flux in the blue

* this doesn't happen in narrow bandpasses.

In general for e.g. the v filter:

$$v_0 = v - k_v X - k_{2v}(b-v)X$$

this color ideally includes the filter whose photometry you are correcting

Use lower case v for instrumental magnitudes and upper case V for standard. The last term above is rarely used because second order (color dependent) extinction corrections are small and difficult to measure.

Usually, plot v-V versus X and solve for k_v from slope.

Zero Points and Transformation Coefficients:

This transforms the instrumental system to a standard one:

$$V = v_0 + C_{0,v} + C_{1,v}(b_0 - v_0) + C_{2,v}(b_0 - v_0)^2$$

In practice, the second order color term is rarely significant, or used, unless very high precision photometry is desired. The reason for the color terms is the same as in the extinction solutions: stars of different colors contribute

How do you choose standard stars?

1. You should observe stars with a range of colors to get good color coefficients. Ideally, get these in the same frame.

2. Observe the same stars at a range of airmasses OR a variety of standard stars covering a range of airmasses from 1–2. Or at least covering the airmass range where you observe your targets.

3. Sky conditions must really be photometric (no transparency variations > 0.01 mag) to get good photometry from standard stars and thus good extinction, zero point, and color terms. In general, the zero point and color terms don't change much for a given site + telescope + instrument, so once they are measured other people can use them. But many things can change the extinction coefficients: fires, humidity, volcanoes, seasons etc.