Photometric Calibration

The process of converting instrumental magnitudes to calibrated apparent magnitudes in a standard system is generally referred to as ‘photometric calibration’. The level of complexity at which this is done is dependent to a great extent on the quality of data which one has. If, for example, one has calibration data of milli-magnitude precision, it is necessary to worry about second order effects (such as the colour-term dependence of airmass corrections). This handout presumes data of somewhat more typical (i.e. poorer) quality, sufficient for calibrations with a precision of ~ 0.05 mag. This level of uncertainty is typical of the that found in faint-object observations at modern CCD-equipped observatories.

Presume, for the moment, that one has observations of a number of fields in two filters (call these filters i and j). The basic equation governing the apparent magnitude for a single object in the i filter is as follows:

$$m_i = m_{Ii} + A_{0i} + A_{1i} \times (Airmass) + A_{2ji} \times (m_j - m_i)$$

where

m_i, m_j are the magnitudes of the object in the standard system in the filters i and j,
m_{Ii} is the instrumental magnitude of the object in filter i,
A_{0i} is the zero-point in filter i,
A_{1i} is the extinction coefficient in filter i, and
A_{2ji} is the colour term transformation coefficient in filter i, referenced to the $j-i$ colour.

A similar equation governs filter j. Note that to compute the desired quantities (m_i and m_j) one must establish the values of A_{0i}, A_{1i} and A_{2ji}. This is the primary goal of the photometric calibration.

By observing standard stars, one knows in advance the values of m_i, m_j, and can hence (with enough standard star observations) compute A_{0i}, A_{1i} and A_{2ji}. Even with observations in only a single filter, one can compute the colour term coefficient A_{2ji}, as m_i and m_j are known a priori from the standard magnitude list. However, the *application* of this coefficient to the computation of the calibrated magnitude of unknown objects is not possible without some estimate of the intrinsic colour of said objects. It is hence usually not a useful exercise to compute a colour term coefficient for single filter observations, though some estimate of this may be useful in interpreting measurements of standard stars made in even a single filter.

In essence, provided that one has observations in filter i of standard stars of various colours, at various airmasses, it should be possible to compute A_{0i}, A_{1i} and A_{2ji} for that filter. In practice, it may turn out that neither A_{1i} or A_{2ji} can be computed with any reliability, as the atmosphere may not be stable enough (A_{1i}) or the colour range spanned by the standards not large enough (A_{2ji}) to provide any useful information. At a good transparent site, the magnitude of A_{1i} should typically range from a few tenths to a few hundredths of a mag (U to I bands respectively), and A_{1i} should always be negative. The value of A_{2ji} depends on how closely the transmission of the site + telescope +filter + camera setup used to make the observations matches the standard filter curve used to define the standard system.