DARK ENERGY SURVEY

A Fermi View of Color Terms: Uber Mangled Syn

We've been discussing color terms.
These are notes describing an approach.

Doug Tucker, Huan Lin, John Marriner, JTA

How to does one do DES zero points in the face of color terms? During Global Absolute Calibration

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The issue is that each CCD sees (and is a component in) a slightly different system response and thus are on different "filter systems". So, how do we get zeropoints? We do a χ^2 over all stars in the survey as measured on single pass data:

$$\chi^2 = \Sigma_n (m_l - m_{ln,ADU} - a_i - k_j X_i - f_k - V_i - b_k C_l)^2 / \sigma^2_n$$

Where observation *n* has attributes:

l is a given star
i is a given image
j is a given night
k is a given CCDs

and:

σ^2 is the variance of the observation
m_{ADU} is the instrumental counts
a is the zeropoint
k is the extinction
X is the airmass
f is some model for the flat field errors
V is some model for illumination errors
b is the color term coefficient and C is the color of star *l*

"Ubercal"

Now, the magic is in $b_k C_l$: we precompute b_k and solve for *C* as a parameter in the fit. We'll get a lousy constraint on *C* but we're not interested in *C*- it is a nuisance parameter. We can precompute b_k as we have the system response curves.

This gets us optimal zeropoints for each CCD image.

How to does one do DES color terms?
In a catalog level operation after Global Absolute Calibration:

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The issue is that what we care about is the coadded catalog, and the coadded catalog is a form of averaging of fluxes taken through different system responses. So, how do we apply the color terms? It isn't as elegant as the last step:

1. Prerequisites:
    1.1. We work at the coadd catalog level
    1.2. A Mangle mask that tracks only image boundaries must be computed
        1.2.1. This mask incorporates all bandpasses

"Mangle"

b is a given bandpass,
i is a given image.

In 2.2 I'll drop the per bandpass notation and switch over to all images in a given filter notation.

2. Then for each homogeneous area in the coadd,
    2.1. Locate:
        1. The single pass images that are inputs
        2. The system response curves of those images, $T_i(\lambda)$
    2.2. For each bandpass, compute the effective bandpass
        2.2.1. As $F_b = \int F_\lambda(\lambda) T_b(\lambda) \lambda^2 d\lambda$ is linear in $T_b(\lambda)$, we can form a weighted effective bandpass: $T_{eff} = \Sigma_i T_i / w_i$.
        2.2.2. The w_i are the weights that went into the coadd, including zeropoint (which includes exposure time).
    2.3. and compute the fiducial to effective bandpass ratio: $T_{fid}/T_{eff}(\lambda)$.

To be concrete, I'll work with the g-band and g-r colors.

    2.4. For a library of spectra *F*, say the Pickles Stellar Atlas, compute "color correction"
        2.4.1. "color correction" is defined as $g_{fid} = g_{eff} + c\,(g\text{-}r)_{eff}$ and we know $g_{fid} - g_{eff} = -2.5*[\mathrm{Int}(F\,\lambda^2 T_f/T_e)]$, so
        2.4.2. finding "c" is actually a lookup table that goes from the observed $(g\text{-}r)_{eff}$ to the computed $g_{fid} - g_{eff}$
    2.5. So, for each object
        2.5.1. get its (g-r), find the right $g_{fid} - g_{eff}$, and add it to g_{eff} .

"Synthetic"

Uber Mangled Syn