The PTI Giant Star Angular Size Survey: Effective Temperatures & Linear Radii

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Abstract: We report new interferometric angular diameter observations of over 200 giant stars observed with the Palomar Testbed Interferometer (PTI). These angular diameters are combined with bolometric fluxes derived from detailed spectral energy distribution (SED) fits, to produce robust estimates of effective temperature (T_{EFF}). These SED fits include reddening estimates and are based upon fits of empirical spectral templates to literature photometry, and narrow-band photometry obtained at the Lowell 31" telescope. Over the range from V0-K0={2.0, 6.0}, T_{EFF} estimates are precise to 100K per 0.125mag bin. Radius estimates are limited by the improved Hipparcos estimates of van Leeuwen (2007) and are typically ~10% per star.

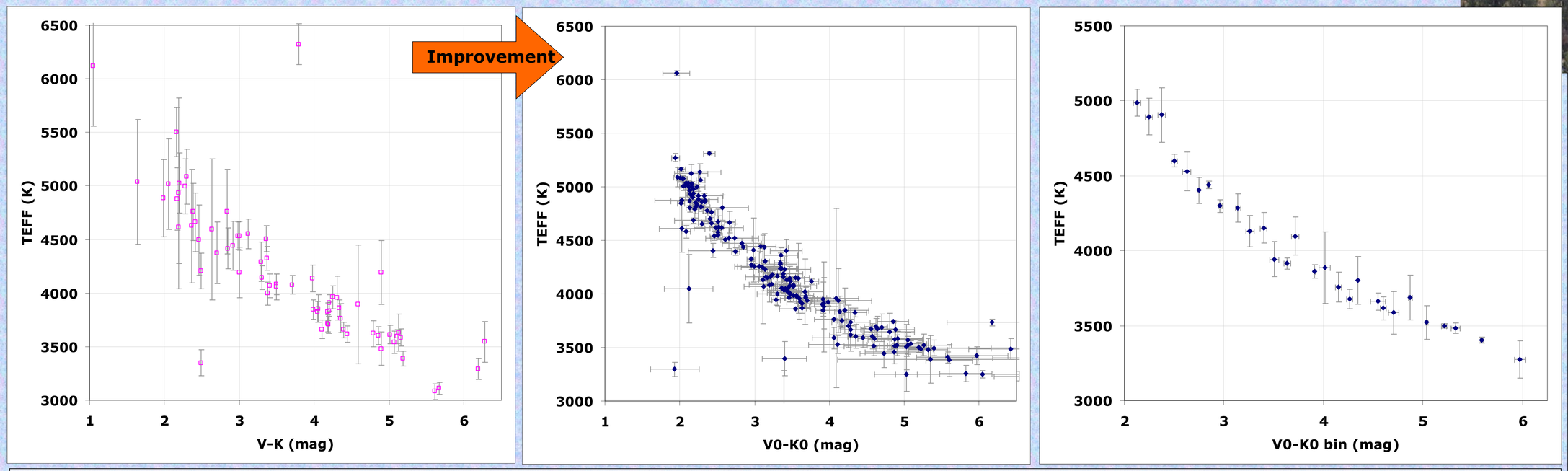

Figure 1a: Effective Temperature (T_{EFF}) as previously measured versus V-K color (left, van Belle et al. 1999), and now (**Figures 1b,c**) versus explicitly dereddended V0-K0 color (center & right, this work) for the individual data points (**b**), and (**c**) binned into ΔV0-K0=0.125 steps. Median scatter per ΔV0-K0 bin (with a median of 5 stars per bin) is 98K.

The Palomar Testbed Interferometer: PTI operated from 1996 until 2008, next to the historic 200" Hale telescope atop Palomar Mountain (Colavita et al 1999). PTI demonstrated dual-star astrometric techniques for the Keck Interferometer, and its highly automated operations enabled these giant star observations. PTI's three baselines were 85 to 110 meters in length, and were operated at H & K bands, resulting in resolution at the ~1.5-4.0mas level.

OPTICAL INTERFEROMETRY

Direct measures of angular size (θ)

- Measures of fundamental parameters
  - Distance + θ → Linear size (R)
  - Bolometric flux + θ → Effective Temperature (T_{EFF})
- Useful for empirical calibration of those fundamental stellar parameters
- Necessary for testing / guiding stellar models
  - Atmospheric structure
  - Evolutionary tracks

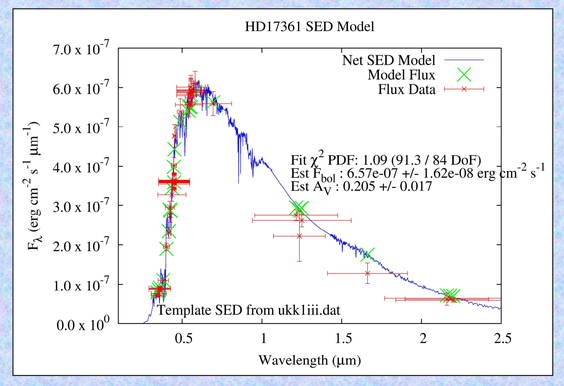

Figure 4: Example `sedFit` plot, for the K1III star HD17361, which illustrates multiple improvments to the bolometric flux computation process, including: Pickles spectral template fitting, wide- to narrow-band photometry, and reddening correction, with a resultant computation of the source F_{BOL}.

IMPROVEMENTS TO THE TECHNIQUE

Why a new calibration of the R & T_{EFF} scales?

- Substantially larger body of PTI data now available
  - 10 years versus ~1 year for van Belle et al. (1999; vB99)
  - Multiple nights per star versus ~1 for vB99
  - Improved pipeline & calibration techniques
  - Refined corrections for uniform disk-to-limb darkened disk now available (Davis, Tango & Booth 2000)
- Significant improvements to measures of bolometric flux (F_{BOL})
  - SED template fitting with `sedFit` (written by Andy Boden, Caltech)
    - Extensive photometric databases
    - Availability of Pickles (1998) templates for fitting
    - Greater available computational power for detailed fitting
  - A_V fitting
    - Improves both F_{BOL} and establishes 'true' colors
  - F_{BOL} errors now 1-5%, instead of 10-20%
    - Now limited by photometric calibrations and not technique
- Improved distances from new Hipparcos reduction (van Leeuwen 2007)
  - Parallaxes now good to ~0.5mas, instead of ~1.0mas
  - NB. parallaxes still dominant error for linear sizes, by a median factor of ~12× [!]
- Improved resource for spectral type with Skiff (2013)
  - Still an imprecise, subjective index
  - V0-K0 color (reddening corrected) preferred

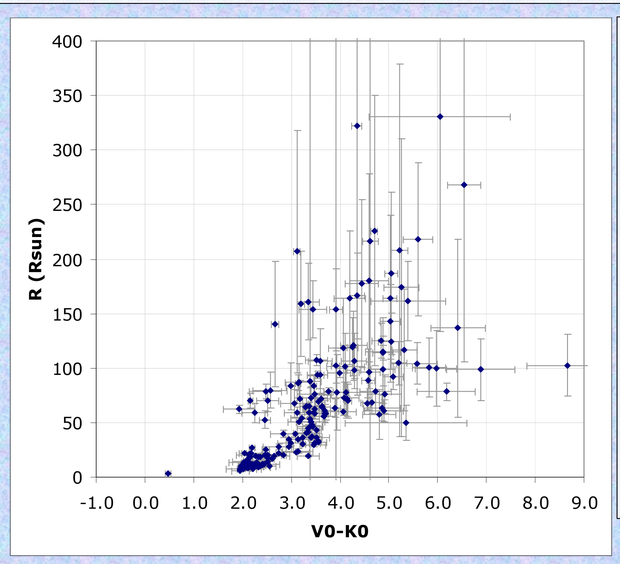

Figure 2: Linear Radius (R) versus V0-K0 color. Median fractional error per star is 8.3%. The redder stars are physically larger; however, since PTI observed stars with 1.5-4.0mas angular size, these objects are more distant – hence, with larger radius errors. Note the outliers in the range of V0-K0={2.0,3.0}: possible luminsoity classification errors?

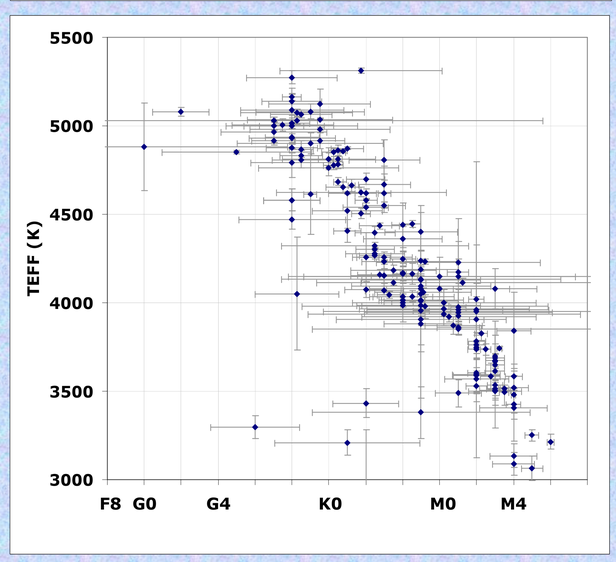

Figure 3: T_{EFF} versus spectral type for this sample. In comparison to T_{EFF} versus the V0-K0 color index (above), using spectral type as an index is significantly less precise. (Errors in spectral type reflect the range of typings for a given star from various investigators.)

CONCLUSIONS

For now

- As expected, substantial improvement for T_{EFF} measurements, some improvement for R (limited by parallax)
- Gaia distances will help significantly
  - *If* stars don't exceed bright limit
- Need to scrub outliers: data problems or interesting astrophysics?

References:
Colavita et al. (1999)
Davis, Tango & Booth (2000)
Pickles (1998)
van Belle et al. (1999; vB99)
van Belle & van Belle (2005)
van Belle et al. (2008)
van Leeuwen (2007)

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