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

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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.

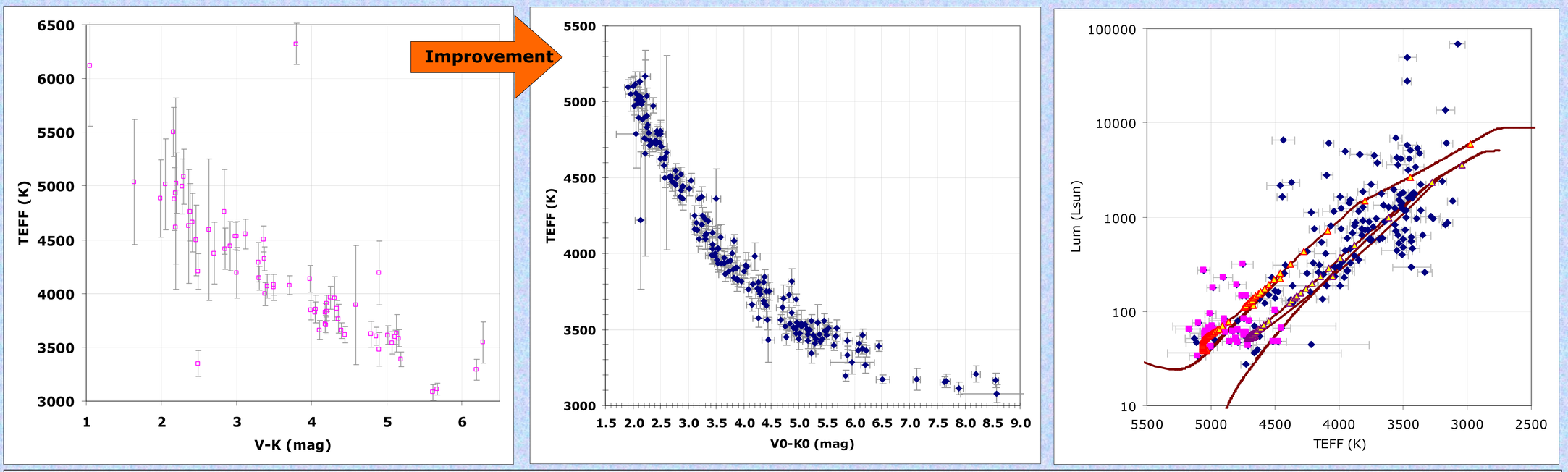

Figure 1a: Effective Temperature (T_{EFF}) as previously measured versus V-K color (left, van Belle et al. 1999), and now (**Figure 1b**) versus explicitly dereddended V0-K0 color (center & right, this work) for the individual data points (**b**. Median scatter per ΔV0-K0=0.01 bin (with a median of 5 stars per bin) is 77K; median error per star is 52K. **Figure 1c**: Empirical HR diagram. Vertical axis errors are not shown, dominated by Hipparcos distance errors (Gaia distances not available). Pink points are stars in our sample ID'd by Gontcharov (2008) as red clump stars. Stellar evolutionary tracks are for 1.2 and 2.4 $M_{\odot}$sun stars in Pietrinferni+ (2008); triangle ticks are at 100Myr intervals after He flash.

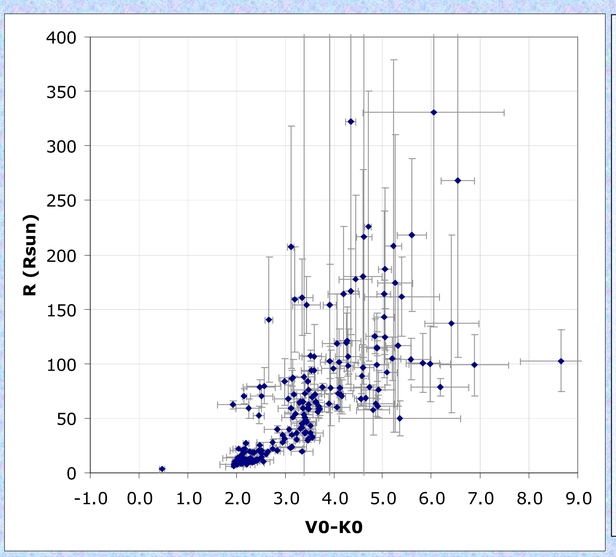

Figure 2: Linear Radius (R) versus V0-K0 color. Median fractional error per star is 8.3%. The redder stars are physically larger; however, since PTI observed stars with 1.5-4.0mas angular size, these objects are more distant – hence, with larger radius errors. Note the outliers in the range of V0-K0={2.0,3.0}: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

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

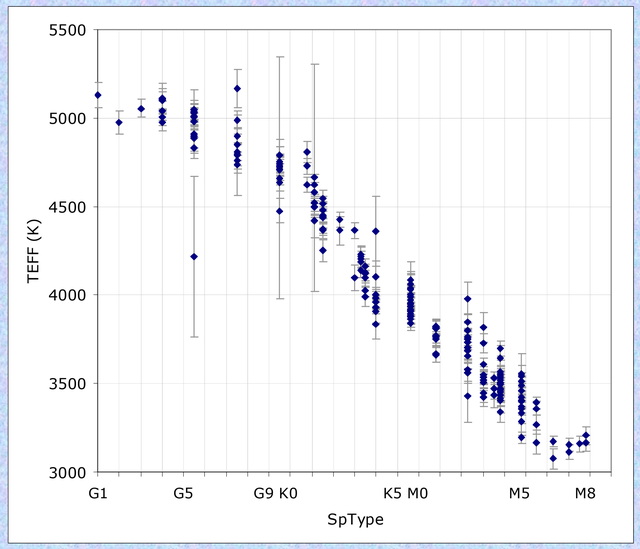

Figure 3: T_{EFF} versus spectral type for this sample. In comparison to T_{EFF} versus the V0-K0 color index (above), using spectral type as an index is significantly less precise. (Errors in spectral type reflect the range of typings for a given star from various investigators.)

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

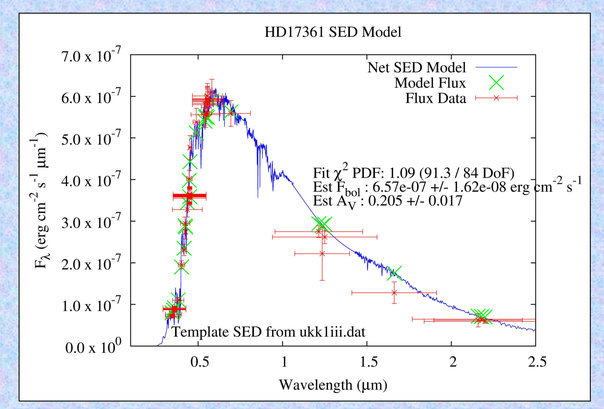

Figure 4: Example `sedFit` plot, for the K1III star HD17361, which illustrates multiple improvments to the bolometric flux computation process, including: Pickles spectral template fitting, wide- to narrow-band photometry, and reddening correction, with a resultant computation of the source F_{BOL}.

ONLINE RESOURCES

Like this poster? Get it!
http://www2.lowell.edu/users/gerard/PTIgiants/

- Additional paper links, references, images
- Raw data

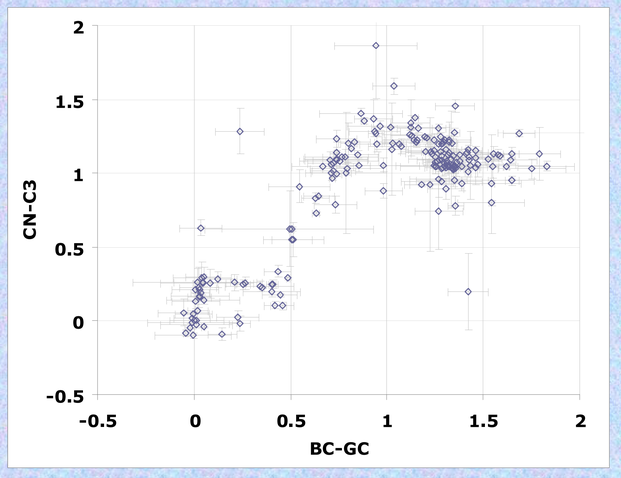

Figure 5: Example photometry collected with the Lowell Observatory 31" robo-scope, which includes Johnson UBVRI and 8 channels from the HB narrowband comet filter set (Farnham, Schleicher & A'Hearn 2000), including NH, CN, C_3, CO^+, blue-continuum, C_2, green-continuum, and red-continuum. CN-C_3 is plotted versus blue – green continuum here. Overall, 2,744 new photometric measures have been collected over 58 nights of observing. A new photometric pipeline has also recently been developed to produce photometry for *all stars* in the survey field.

CONCLUSIONS

A treasure trove of high-resolution observations

- ~225 luminosity class III stars
  - ~100 Miras with multiple epochs set aside for separate study
- 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?
- Bright star photometry & spectrophotometry – particularly in the near-infrared – is a pressing need
  - There are still *very* interesting things to be learned about bright stars
- Data to be hosted at NASA Exoplanet Science Institute

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