Direct determination of physical parameters for main sequence stars

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Abstract

The environment of planetary formation and evolution is mainly characterized by its host star's physical properties. Until recently most fundamental stellar parameters, like e. g. the star's radius and effective temperature, have only been estimated indirectly; but with advances in interferometric observing technique it is now possible to obtain a direct estimate of them. In this poster we present preliminary results from measured interferometric fringe visibilities of main-sequence stars. These visibilities will be used to determine their stellar radii and effective temperatures and will allow us to better characterize planets around these stars.

Introduction

Considerable improvements in interferometric observation technique allowed us now to obtain stellar parameters, like the stellar radius, directly. Surprisingly, these interferometric direct measurements showed that the interferometrically determined radii were by more than 10% (Berger et al. 2005; Boyajian et al. 2012) smaller then the calculated ones and that due to the underestimated stellar radii; the effective temperatures were overestimated by ~1.5% to 4%, which in turn affects other stellar parameters like surface gravities *log g*, masses and ages and eventually the planetary parameters. These recent results show that is important to observe more low-mass stars. In order to improve stellar models it is necessary to obtain a statistically robust distributions of their measured parameter.

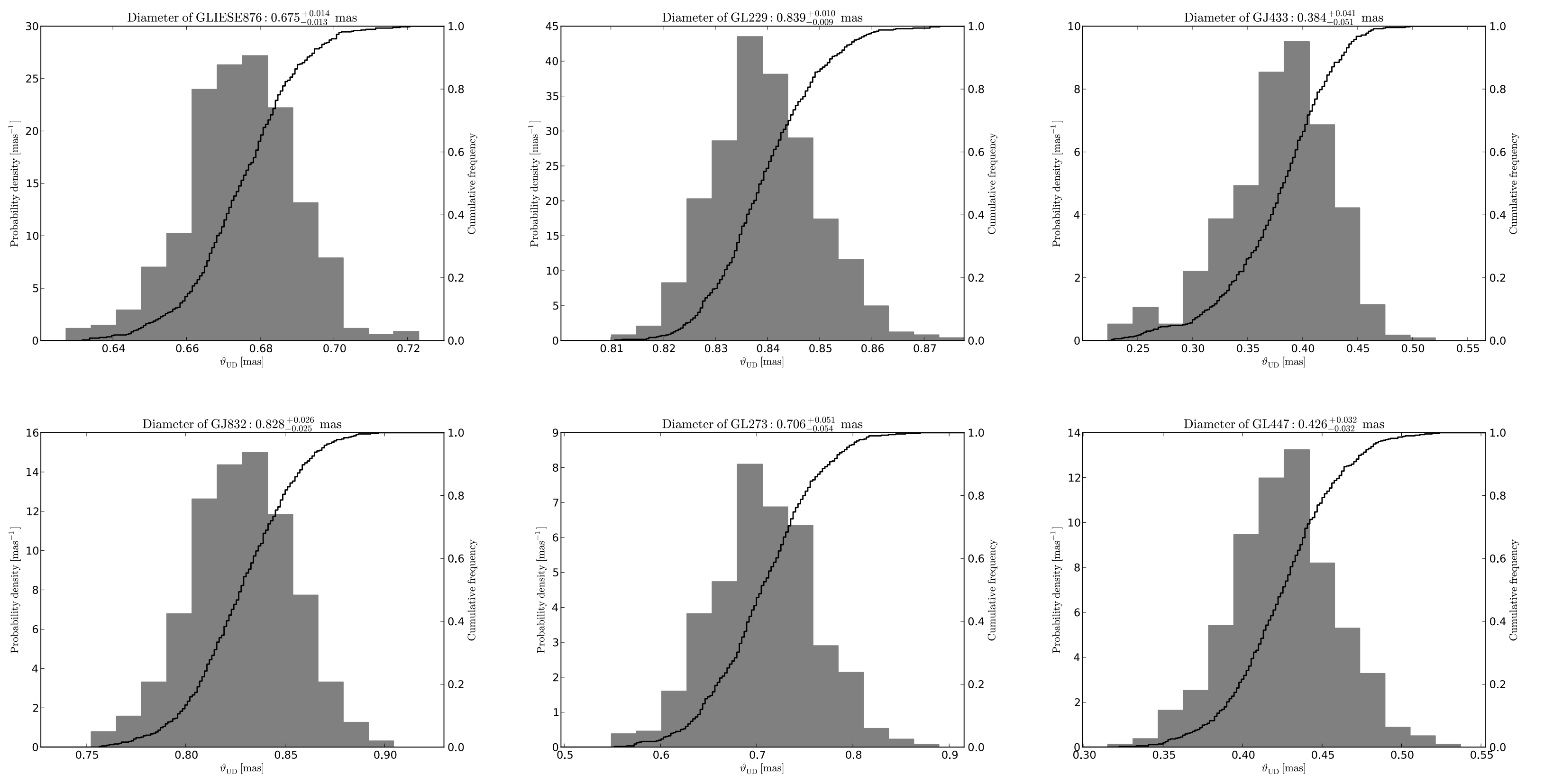

Fig. 1: Distributions of diameters using the bootstrap method (see text) for our observed M-dwarf star sample. From this distributions the statistical error in the measurement are determined.

Data Collection and Analysis

In order to measure the angular diameter of stars we observed with the VLTI/PIONIER in the H-band, using the 1.8-m Auxiliary Telescopes in A1-G1-K0-J3 quadruplet configuration. This configuration gave us the longest baseline (140m). Our observing strategy was to bracket each science frame with calibrator stars. The calibrators were chosen to be point-like nearly unresolved stars (van Belle & van Belle, 2005) and uncertainties in their diameter did not influence the targets' diameter estimate. The data reduction was performed several hundred times, each time randomizing the set of fringes by the bootstrap method and the calibrators' diameters. This allowed us to take into account error correlations across spectral channels, between consecutive observations, and overnight. Each result is least-squares fitted by a uniform disc, yielding a value for the science target diameter. From the distribution of diameters we estimate the statistical error in this measurement, see Fig. 1.

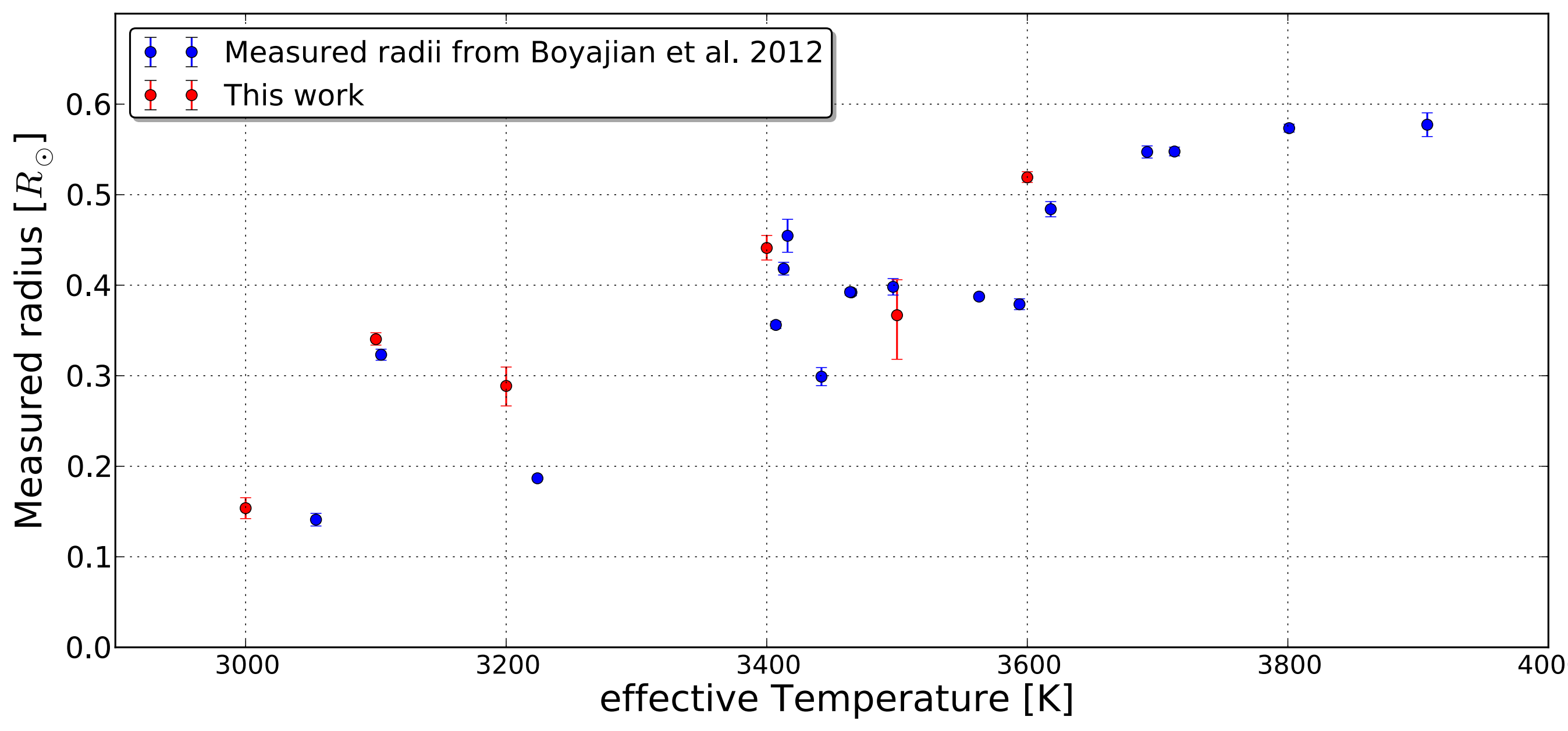

Fig. 3: Measured radii from this work and Boyajian et al. 2012 as function of effective temperature.

Results

We have obtained diameter measurements for 6 M-dwarf stars with statistical errors between 1 and 13%, see Fig. 1. Stars with a lower precision have been observed only on one night. Our experience has shown that observing the targets on different nights will help us to improve the precision as a result of reduced systematic noise. This program is still ongoing and targets with higher errors will be observed again. Our aim is to measure the radii to a precision of better than 2%. For each target we obtained parameters like effective radius, effective temperature and mass, from our measurements, the best-fit stellar model and the literature see Table 1.

Name	UD [mas]$^{1)}$	R_S [R_{Sun}]$^{1)}$	Spectral type	T_{eff} [K]$^{2)}$	Mass [M_{Sun}]$^{3)}$
Gl229	0.839	0.519	M1V$^{3),4)}$	3,600	0.58
Gl832	0.828	0.441	M1V$^{3)}$/M2V$^{4)}$	3,400	0.45
Gl433	0.384	0.367	M2V$^{3),4)}$	3,500	0.47
Gl876	0.675	0.340	M3.5V$^{3)}$/M4V$^{4)}$	3,100	0.34
Gl273	0.706	0.289	M3.5V$^{3)}$/M3V$^{4)}$	3,200	0.29
Gl447	0.426	0.154	M4V$^{3),4)}$	3,000	0.17

Table 1: M-dwarfs observed with VLTI/PIONIER and their physical parameters from literature and as obtained in this work.

1) Measured values with PIONIER, this work. The errors in diameter measurements are given in Fig. 1.
2) Husser et al. (2013) to published photometry best fit values, this work
3) Spectral type and masses taken from Bonfils et al. 2013
4) Pickels et al. (1998) best-fit spectral type, this work

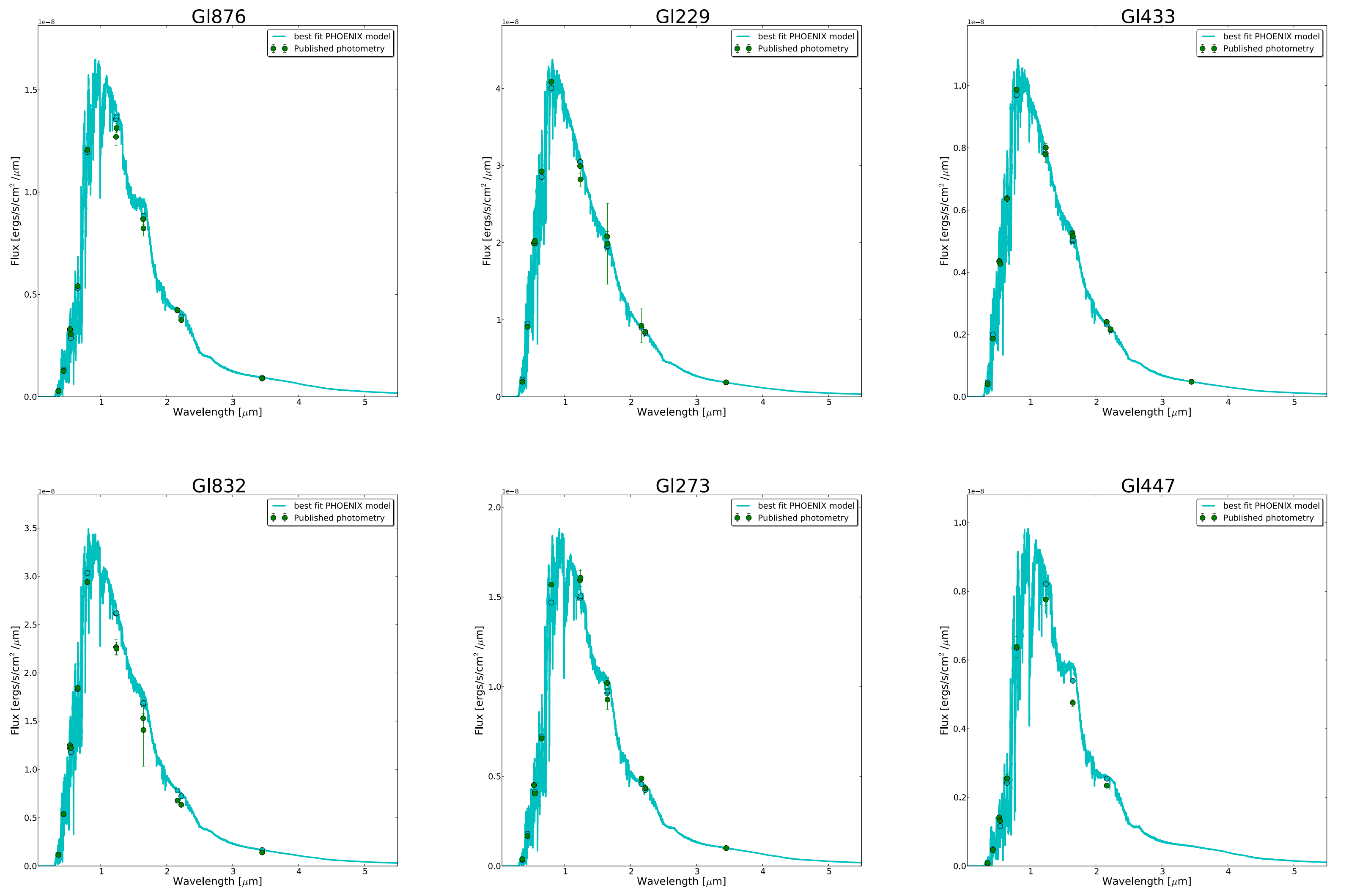

Fig. 2: Best-fit between spectral energy distributions from Husser et al. 2013 and photometrical observations taken from Koen et al. 2010 and 2MASS.

Conclusion and future work

Using the VLTI and PIONIER we measured with high precision angular diameters of M-stars. In Fig. 3 we show our measured radii and the ones obtained by Boyajian et al. 2012 versus the effective temperature. Our wavelength range is similar to the one from Boyajian et al. 2012, but our baseline at the VLTI is smaller. We note that some of our measurements have lower precision and a more uniform analysis of both data sets is necessary. Furthermore, our linear radii are calculated without taking into account limb darkening. Finally, we plan to continue this program with the aim to decrease the error of our measurements by repeating some observations and to obtain a statistically more robust conclusion by observing more stars.

References

Berger, et al., 2006, ApJ, 644, 475
Bonfils, et al. 2013, A&A, 549, 109B
Boyajian, et al., 2012, ApJ, 757, 112
Husser et al., 2013, A&A, 553, 6A
Koen et al., 2010, MNRAS, 403, 4
Pickles, 1998, PASP, 110, 863
van Belle & van Belle, 2005, PASP, 117, 1263

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