Leibniz-Institut für Astrophysik Potsdam (AIP)
The Ohio State University
LBT Large Binocular Telescope

# Tests of convective zone radial differential rotation in intermediate-mass core-helium burning stars with PEPSI

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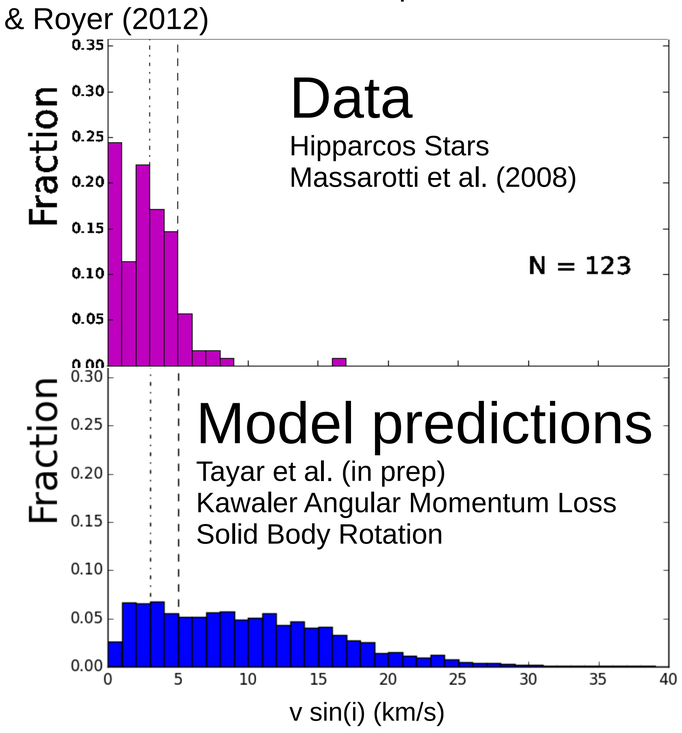
PEPSI — The Potsdam Echelle Polarimetric and Spectroscopic Instrument

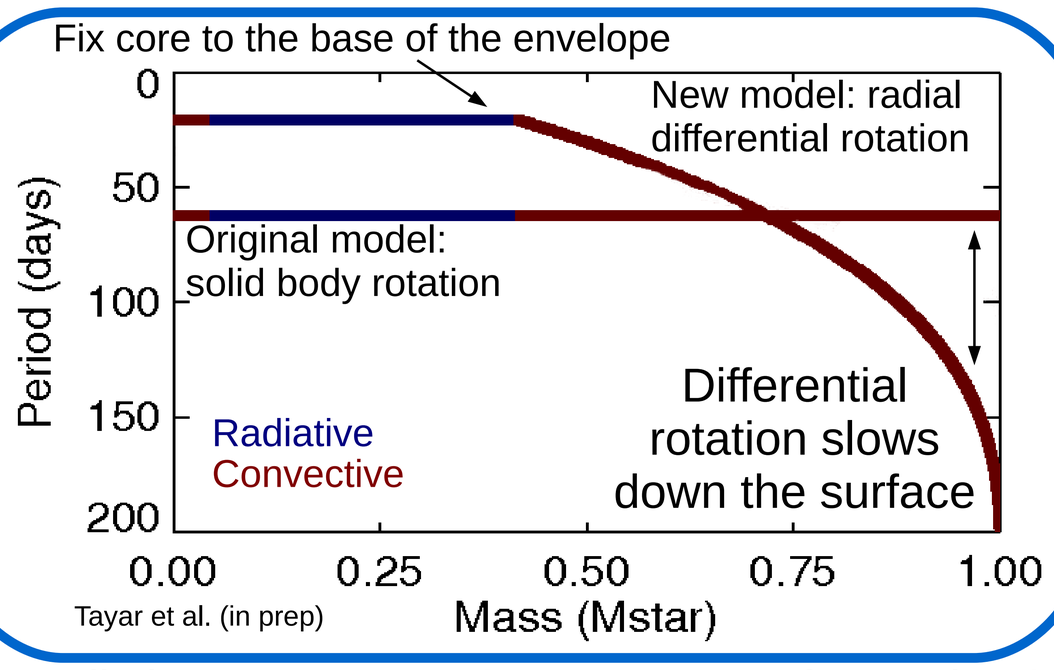
## The problem:
## surface rotation rates of secondary clump stars are MUCH slower than models predict

- Masses between 2.0 and 3.0 $M_o$, log(g) between 3.1 and 2.0
- Forward model from main sequence rotation distribution of Zorec & Royer (2012)




- Similar results using APOGEE-*Kepler* v sin(i)s (Tayar et al. 2015), *Kepler* surface rotation periods (Ceillier, Tayar, et al. submitted), and seismic envelope rotation rates (Deheuvels et al. 2015)

## One solution: radial differential rotation in the surface convection zone




## The prediction: cores, envelopes, AND surfaces should have different rotation periods

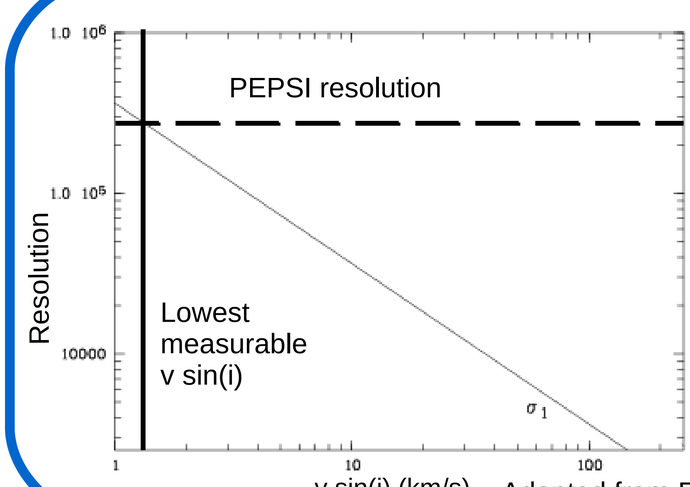
| KIC ID | $P_{core}$ | $P_{env}$ | $P_{surf}$ (Days) |
|---|---|---|---|
| 3744681 | 60 | 184 | |
| 4659821 | 70 | 147 | |
| 5184199 | 58 | 184 | |
| 7467630 | 96 | 121 | |
| 7581399 | 69 | 138 | 151 |
| 8962923 | 84 | 147 | |
| 9346602 | 71 | 218 | |

Core and envelope periods from Deheuvels et al. (2015)

Surface period from Ceillier, Tayar et al. (submitted)

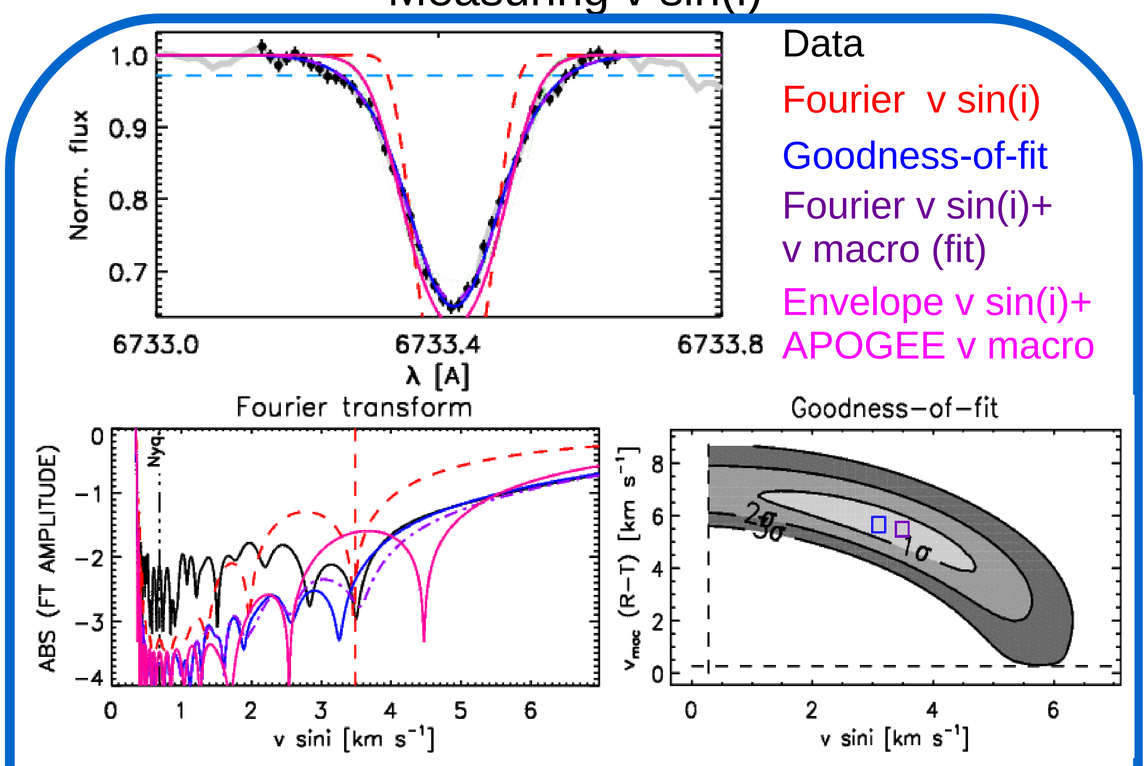
- Core and envelope rotation periods are different
- Only one star in the sample has a measured surface period from spots
- Without surface periods, we can't tell whether the differential rotation is in the surface convective zone

## Why we needed PEPSI



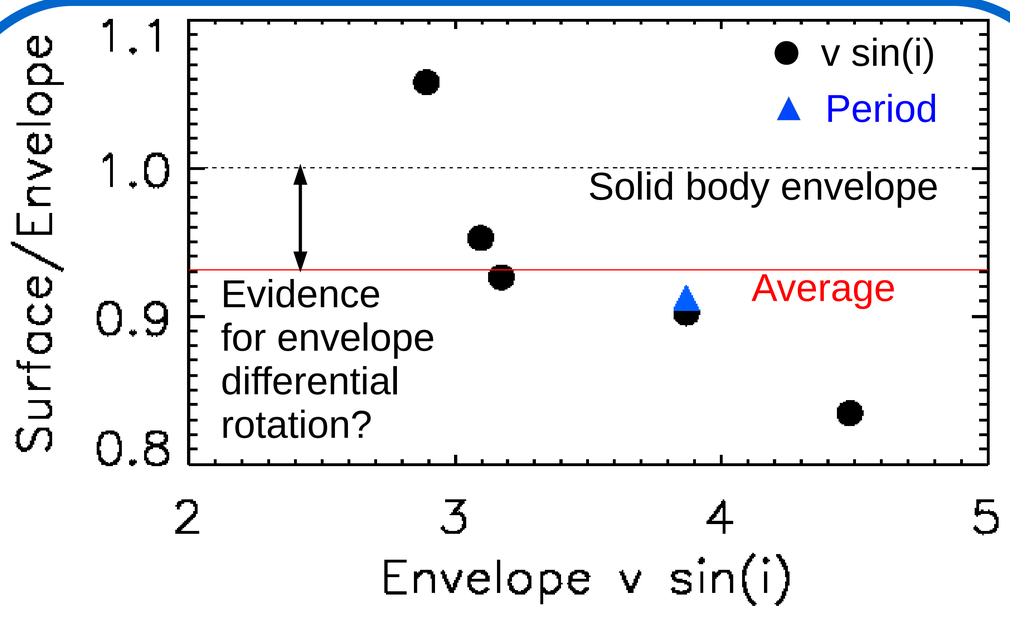

- R=270,000 allows us to measure v sin(i) down to ~ 1.3 km/s
- Using the seismically measured radii and inclination angles, we can convert between v sin(i) and period
- Envelope rotation periods predict v sin(i) from 2.4-4.4 km/s
- Differential rotation would predict lower v sin (i)

## Measuring v sin(i)




- Rotational velocities and macroturbulent velocities are comparable
- Take the Fourier transform of individual lines to separate the two broadening components
- Use the iacob_broad package from Simon-Diaz & Herrero (2014)

## Preliminary results




- Y error bars are currently off the scale of this plot
- Ongoing work: adding more lines, removing blended lines, improving error analysis, checking calibration, validating method

**We have tentative evidence of radial differential rotation in the surface convection zone of intermediate-mass core-helium burning stars**