First signature of strong differential rotation in A−type stars

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Context

■ **stars of spectral type earlier than F2**

➡ **no or very thin convective envelopes**

■ **onset of convection ?**   between A7 and F5

Wolff et al. (1986), Schmitt (1997),
Renzini et al. (1977), Gray & Nagel (1989)

■ **coupling between convection and differential rotation ?**

■ Gray (1977)   no indication of differential rotation in A−type stars

Reiners & Schmitt (2003)   differential rotation in F−type stars (as early as F0)
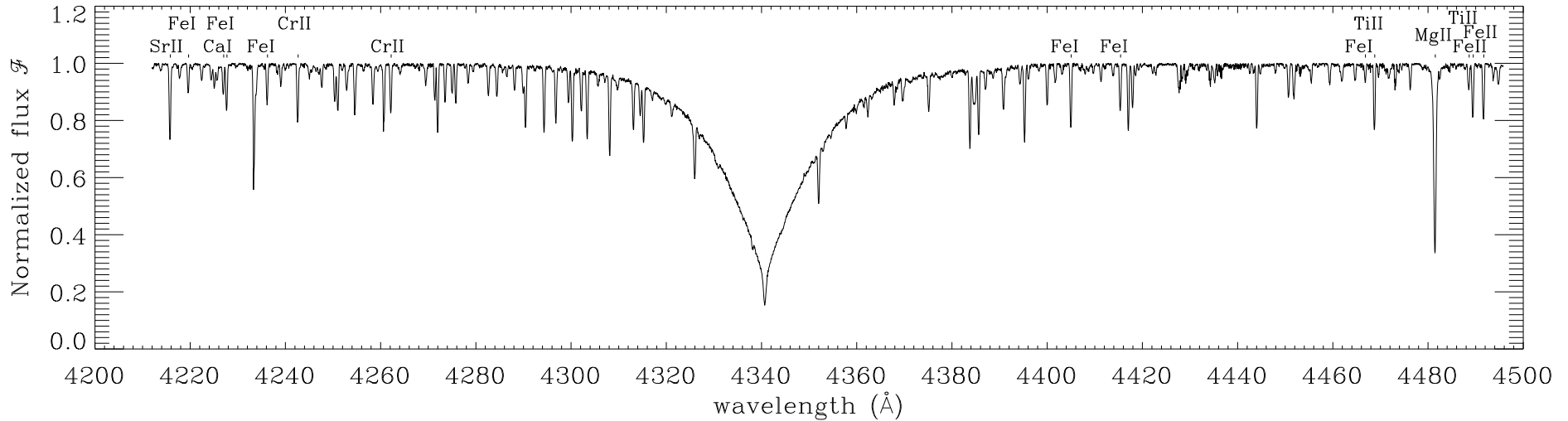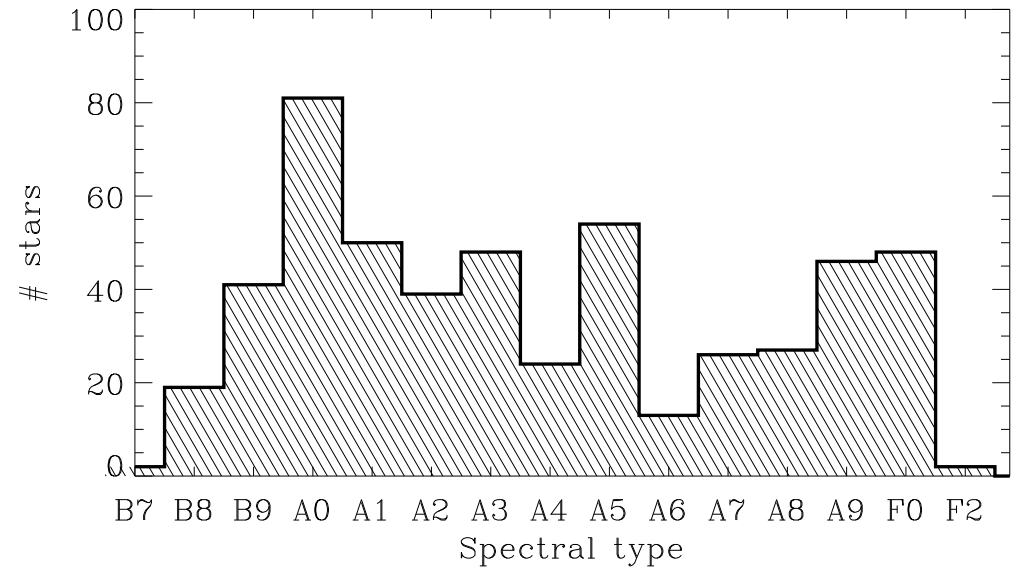
Observational material

Echelec spectra (ESO, La Silla)

4210 – 4500 Å

R ~ 28000
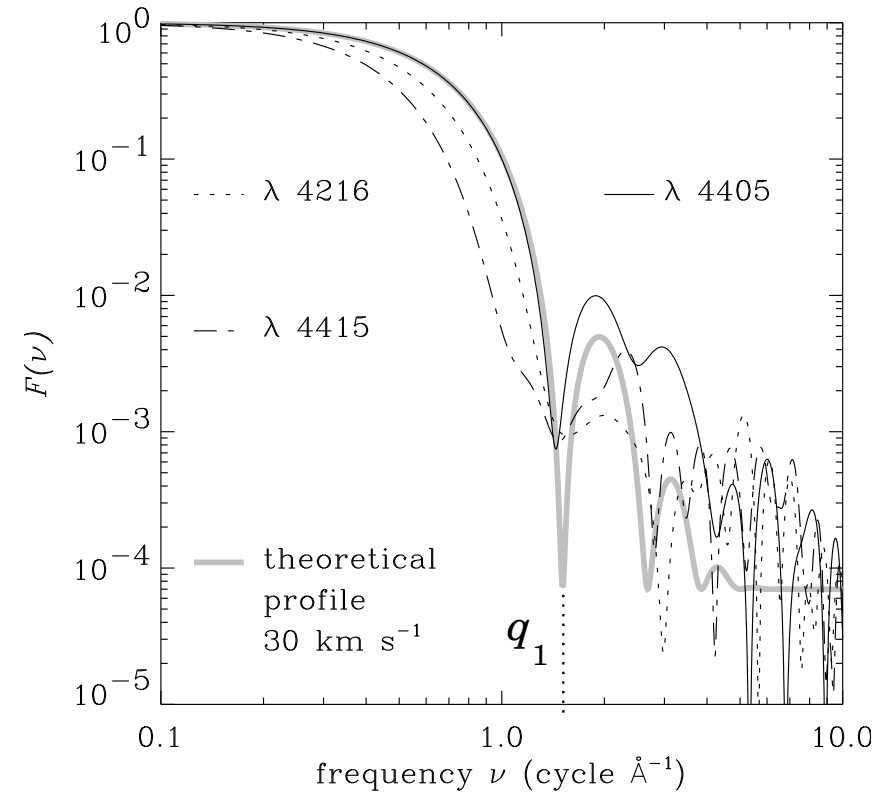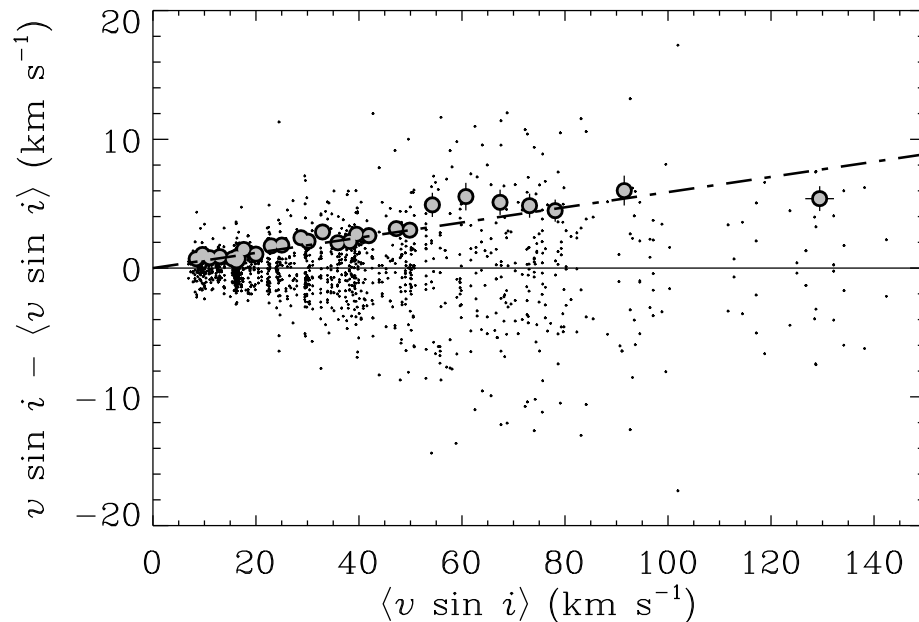
~ 500 stars, spectral types B8–F2

Determination of radial velocities: Grenier et al. (1999)

Determination of rotational velocities: Royer, Gerbaldi et al. (2002)

$v \sin i$ determination

Royer, Gerbaldi et al. (2002)

- Fourier Transform (FT) of line profiles

- 15 candidate lines

- a priori selection (spectral type, broadening) and a posteriori (FT)
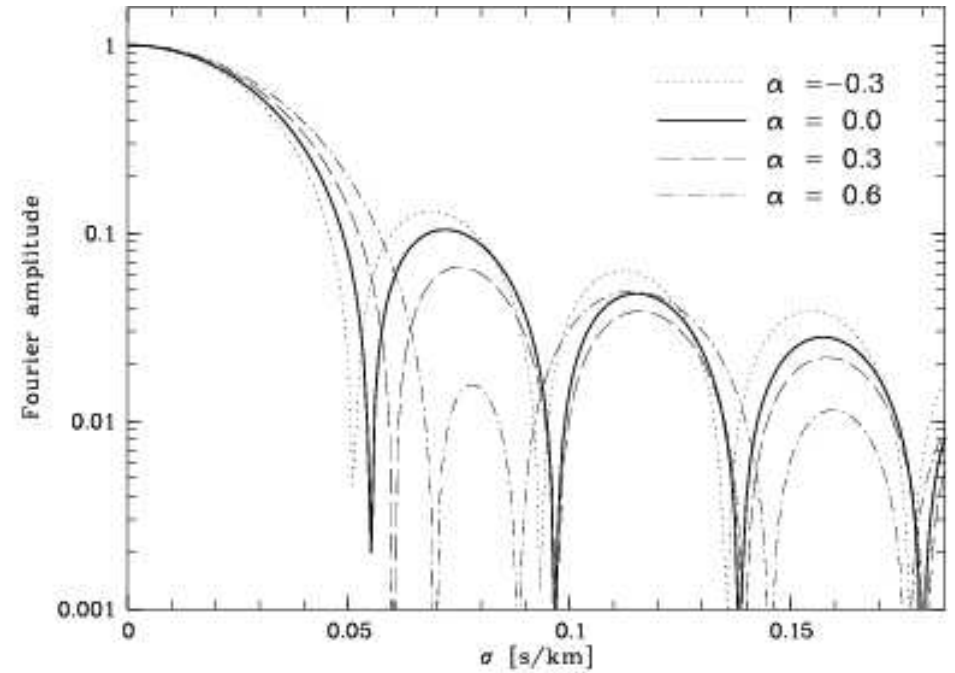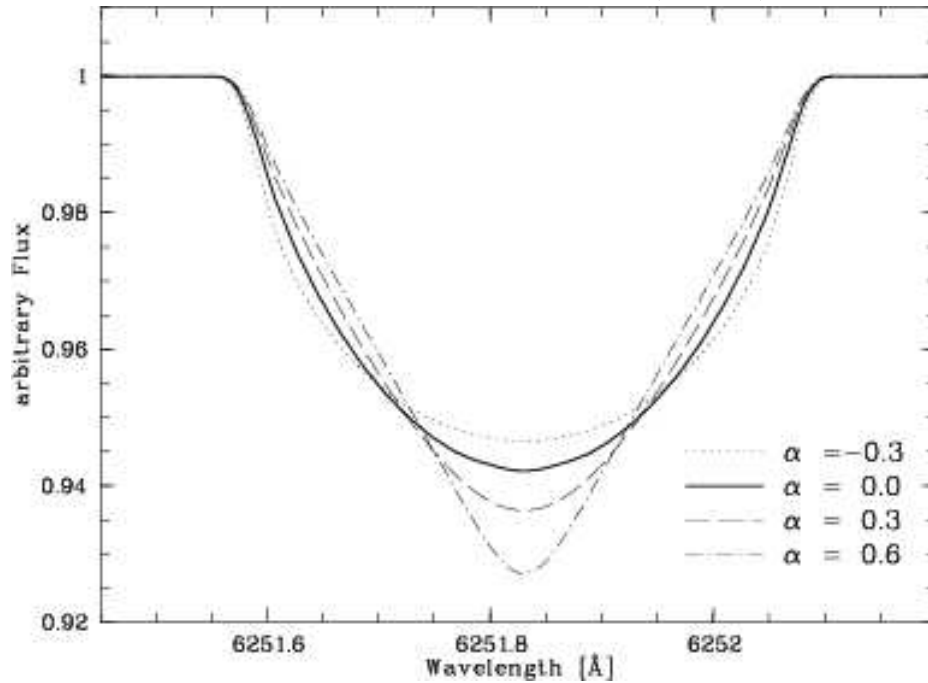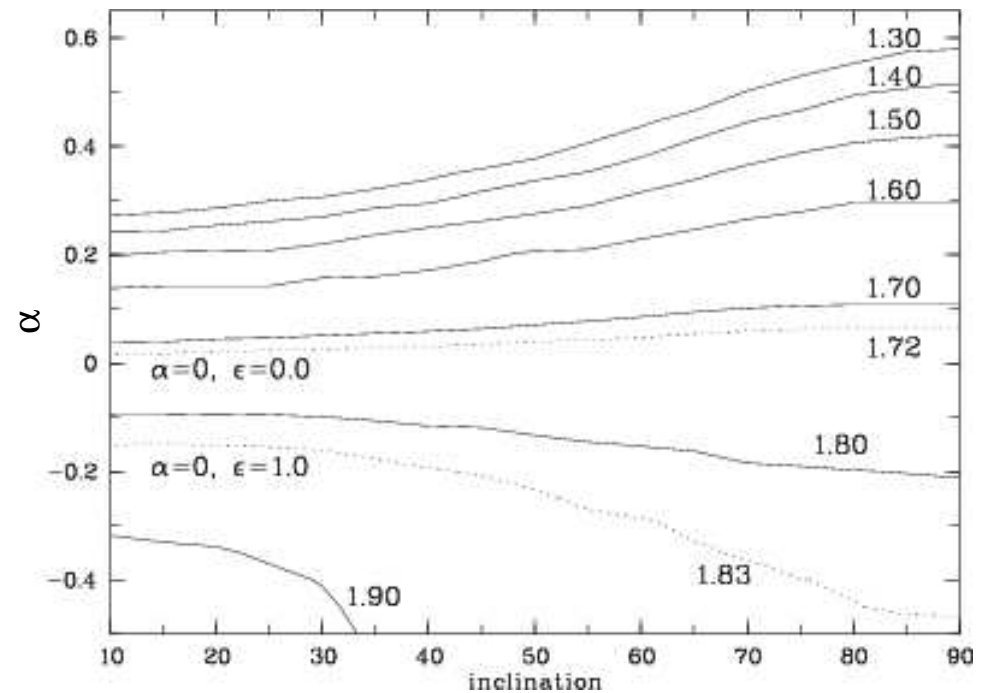

- **precision ~6 %**

poster BP1

Detection of differential rotation

Reiners & Schmitt (2002)

- Use of the first two zeroes of the FT:
  q_1 and q_2

- q_2/q_1 ratio can be used as a signature
  of differential rotation

- solar–like differential rotation

$$\Omega(l) = \Omega_{equator} (1 - \alpha \sin^2 l)$$

Data analysis

- Sample: 158 A0–F1 stars

    $60 < v \sin i < 150$ km/s   (follow the FT to the second zero)

- Least Square Deconvolution

    - δ–template from the150 strongest lines (VALD)

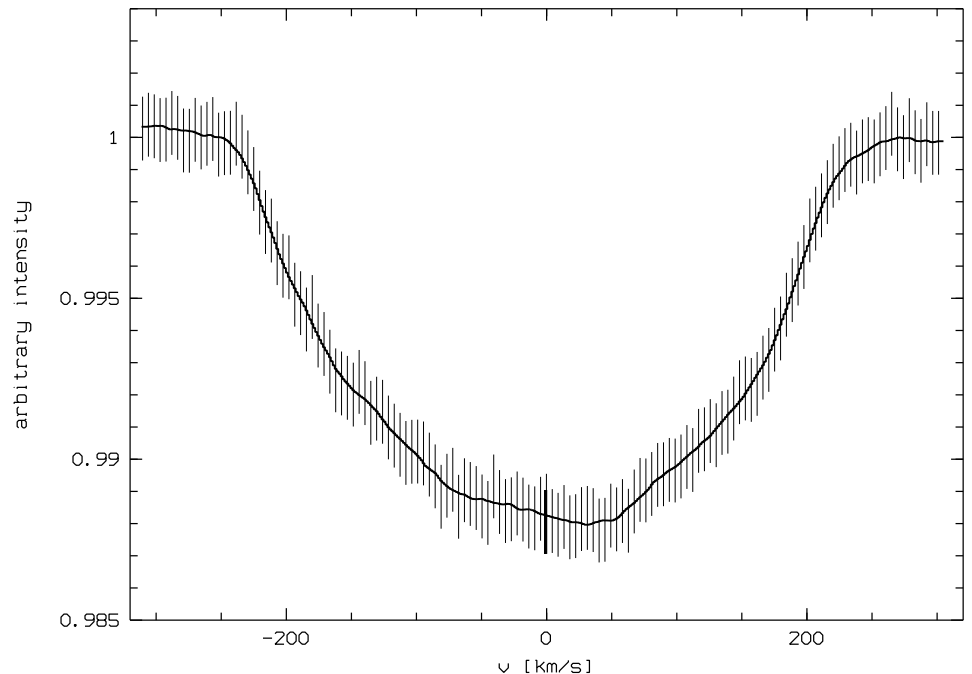   - deconvolution: broadening function

    - adjustment of equivalent widths   ⎫ few iterations
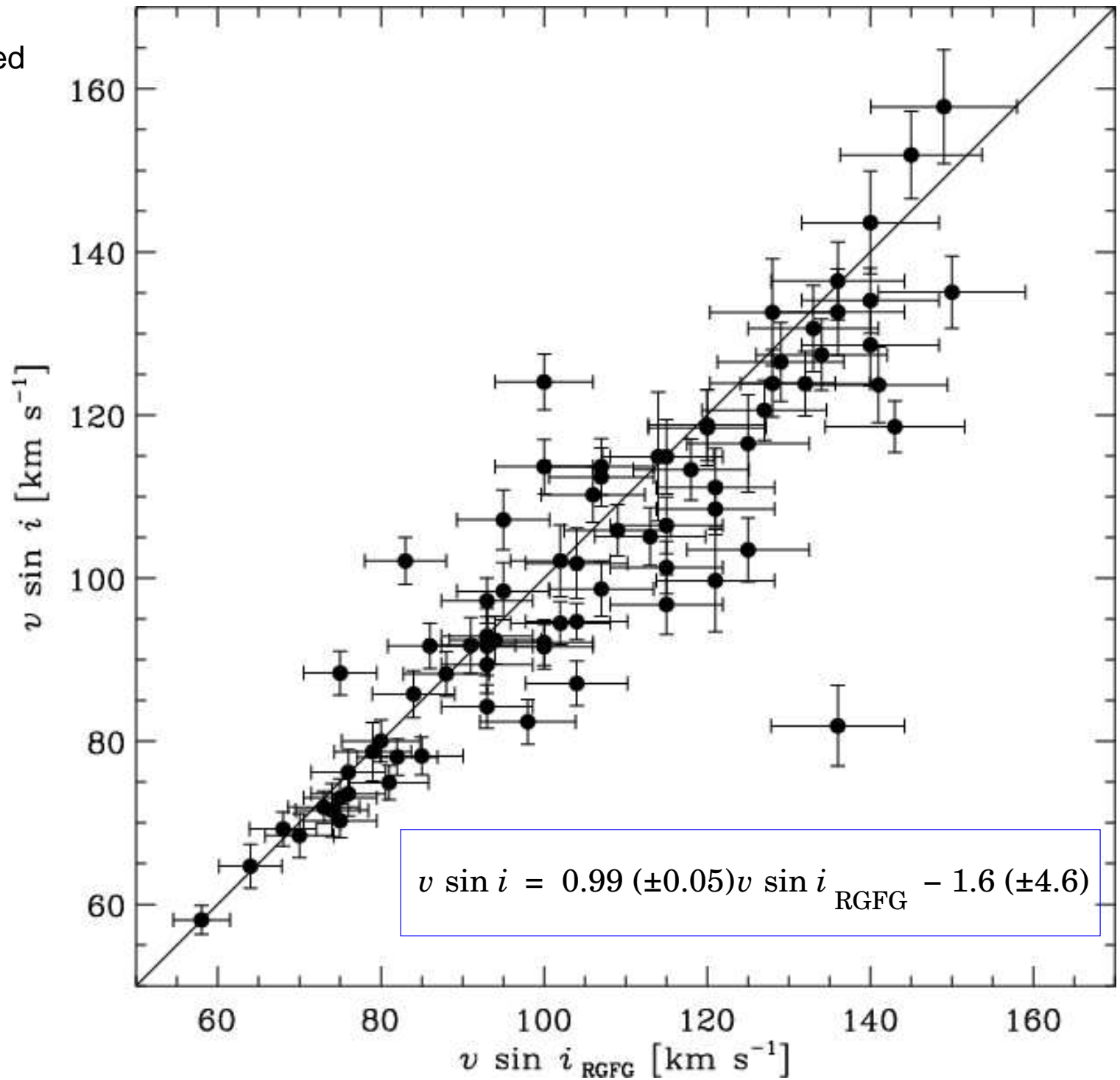
    - use of every lines, enhancement of SNR

- Fourier Transform of
    the broadening function

Results

q_2/q_1 could be determined for 78 stars

Figure axes: $v \sin i$ [km s^{-1}] (vertical) vs $v \sin i_{\mathrm{RGFG}}$ [km s^{-1}] (horizontal)

$$v \sin i = 0.99 \, (\pm 0.05) v \sin i_{\mathrm{RGFG}} - 1.6 \, (\pm 4.6)$$

Results

- Linear limb darkening law, ε from 0.5 to 0.75

- $\Delta q_2 / q_1 \sim 0.1$

- Rigid rotation expected for q_2 / q_1 between 1.72 and 1.83
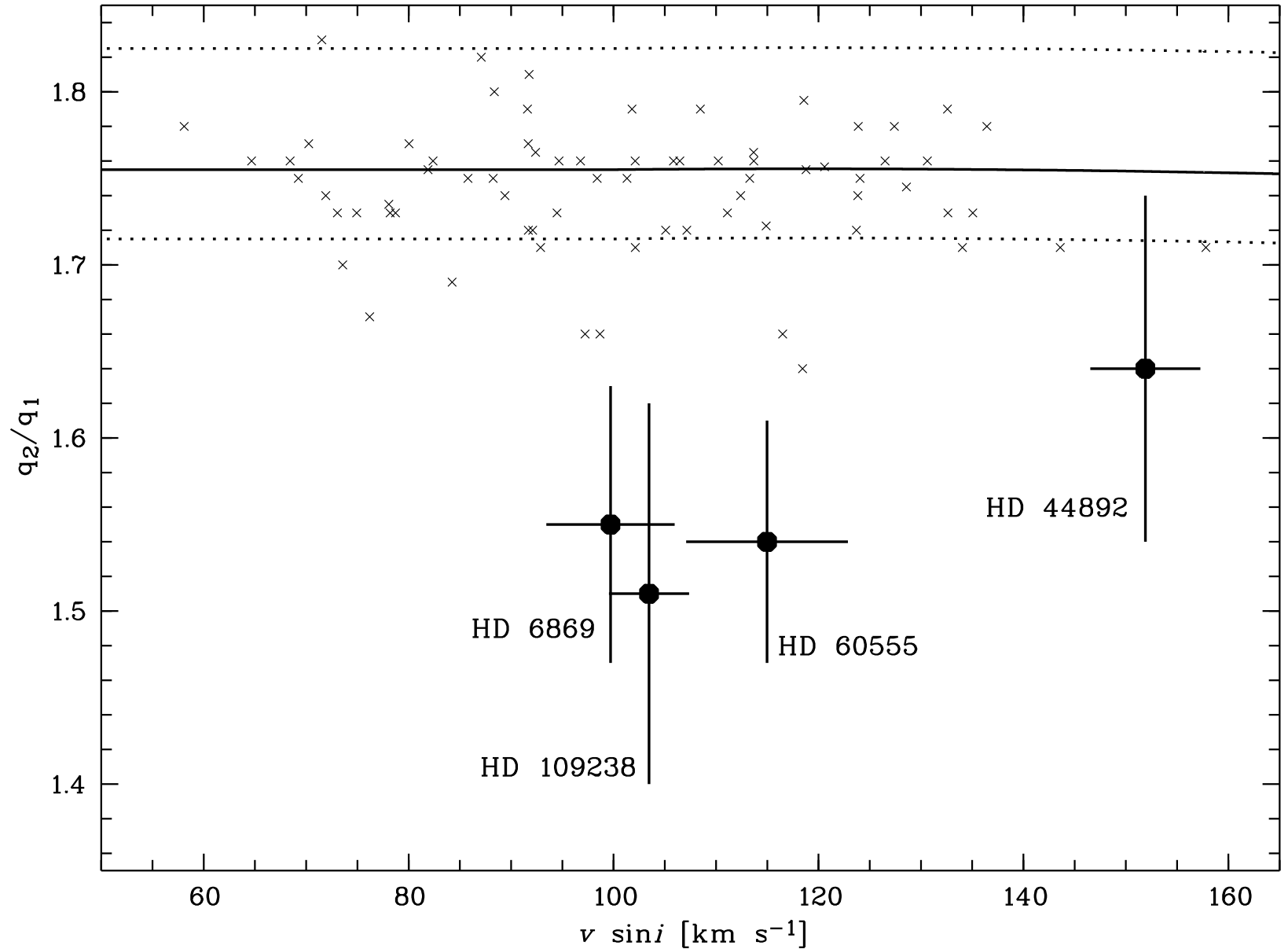
Candidate stars

|	Type	$v \sin i$	q_2/q_1	α	v_e	i
HD 6869	A9 V	100 ± 6	1.55 ± 0.08	0.28 ± 0.10	460	13°
HD 60555	A6 V	115 ± 7	1.54 ± 0.07	0.29 ± 0.08	470	14°
HD 109238	F0 IV/V	103 ± 4	1.51 ± 0.11	0.32 ± 0.13	500	13°
HD 44892	A9/F0 IV	152 ± 5	1.64 ± 0.10	0.16 ± 0.16	400	22°

■ **extremely fast rotation ?**

  ○ q_2/q_1 also affected by very rapid rotation and gravity darkening

  ○ q_2/q_1 only depends on equatorial velocity v_e (Reiners 2003)

  ○ HD 44892 also consistent with gravity darkening effect

■ **binarity ?**

   no signature in spectra nor in FTs

Fourier Transforms of
        HD 6869, 60555 and 109238

■ No evidence of binarity in the FT
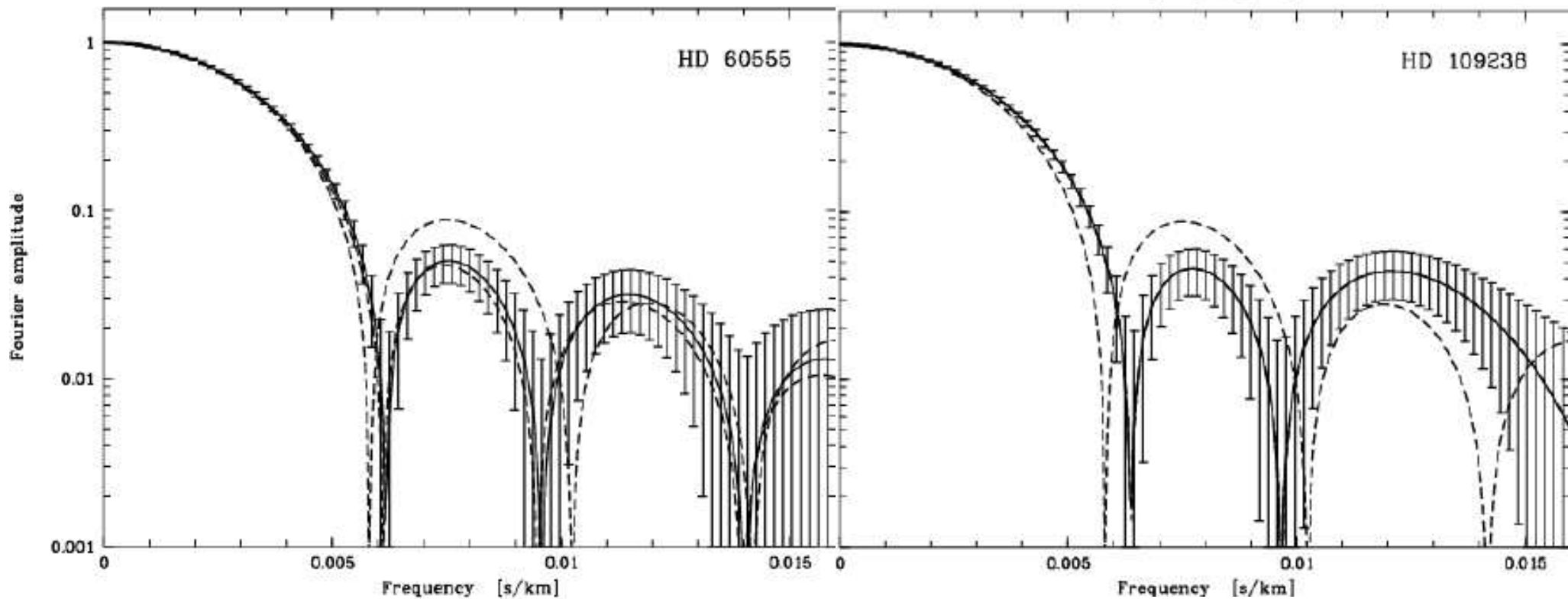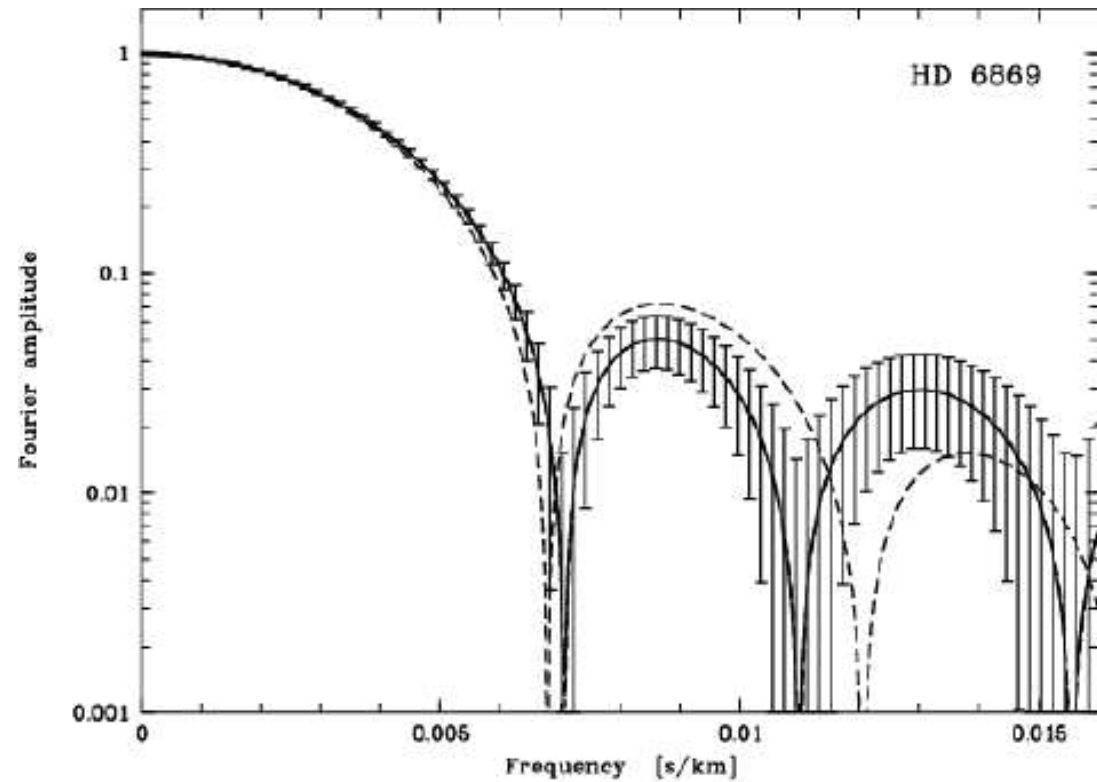
Conclusions

- 158 A0–F1 stars $60 < v \sin i < 150$ km/s

  78 stars with measurable q_2/q_1

  4 stars with signature of differential rotation

  (1 marginal)

- in these objects: equator rotates ~30% faster than pole

- Altair high SNR observations

  no evidence of differential rotation

  gravity darkening effect: determination of i