Searching rotational splittings in δ-Scuti stars using pattern finding techniques

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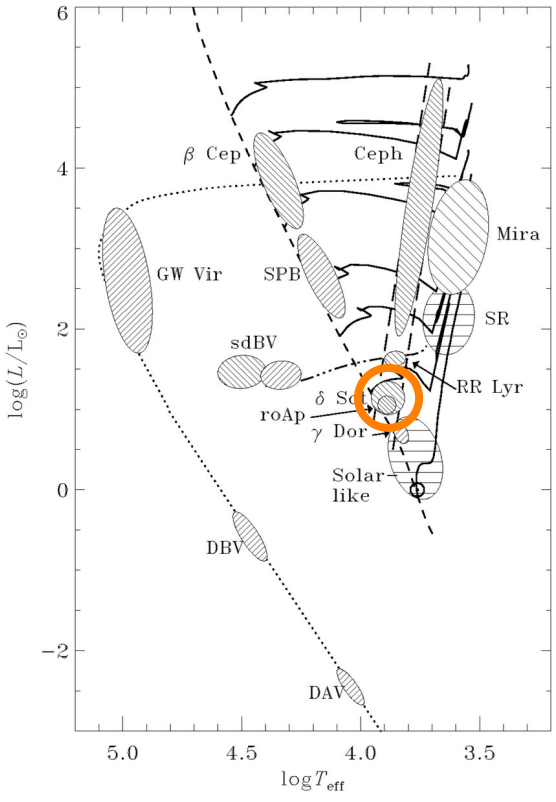
EXCELENCIA SEVERO OCHOA

Rotational splittings in δ-Scuti stars

δ-Sct stars



Christensen-Dalsgaard (2003)

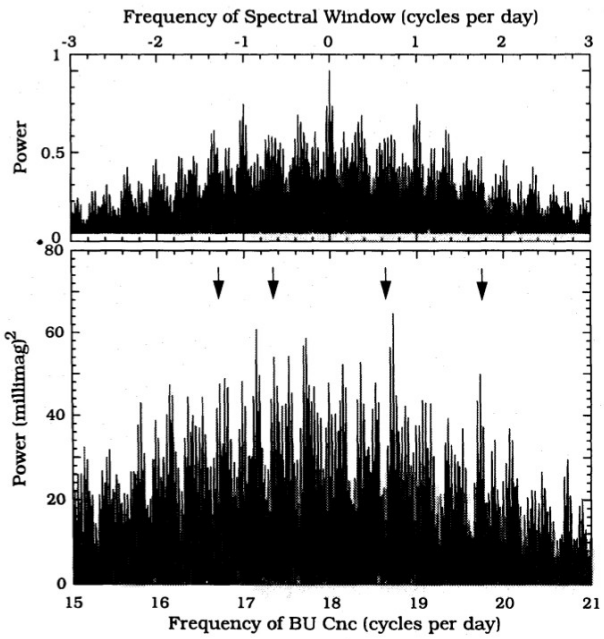


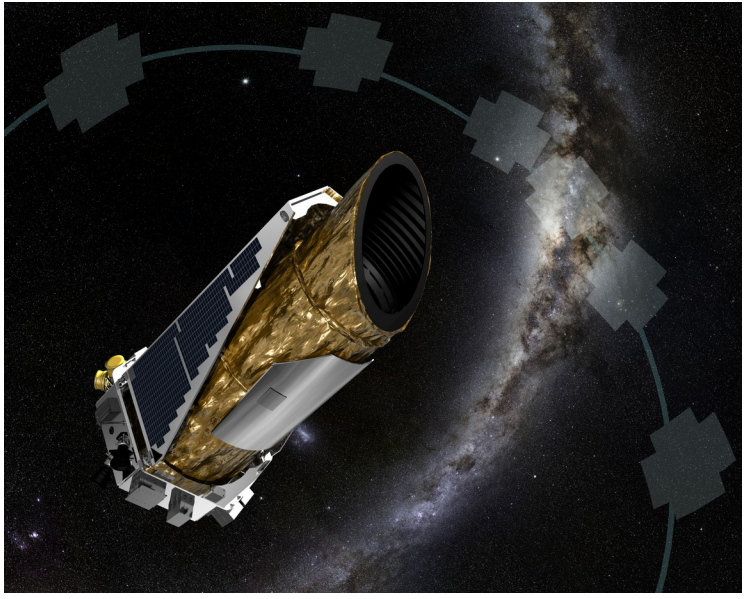
Fig. 3. Power spectrum of BU Cnc for the Bossi et al. 1977 - 1980 measurements in the literature. The four main frequencies found in the present multisite campaign are shown by arrows. The power spectrum already suggests that the 1977 - 1980 data alone would be insufficient to extract the frequencies Breger et al. (1998)

Rotational splittings in δ-Scuti stars

CoRoT (2006-2013)

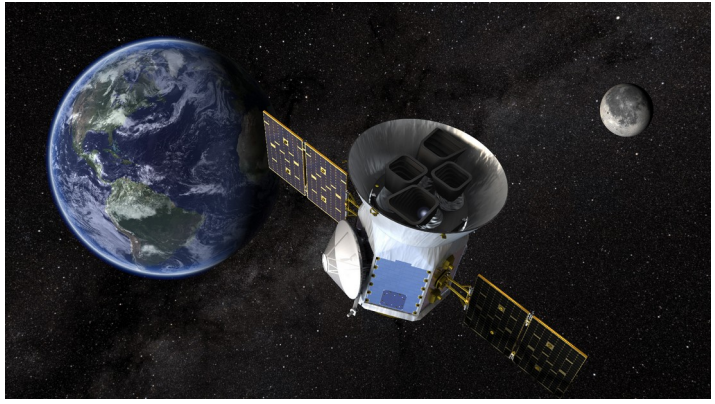
CNES – D. Ducros

Kepler / K2 (2009-2018)



NASA Ames/JPL-Caltech/T Pyle

TESS (2018-2020+)



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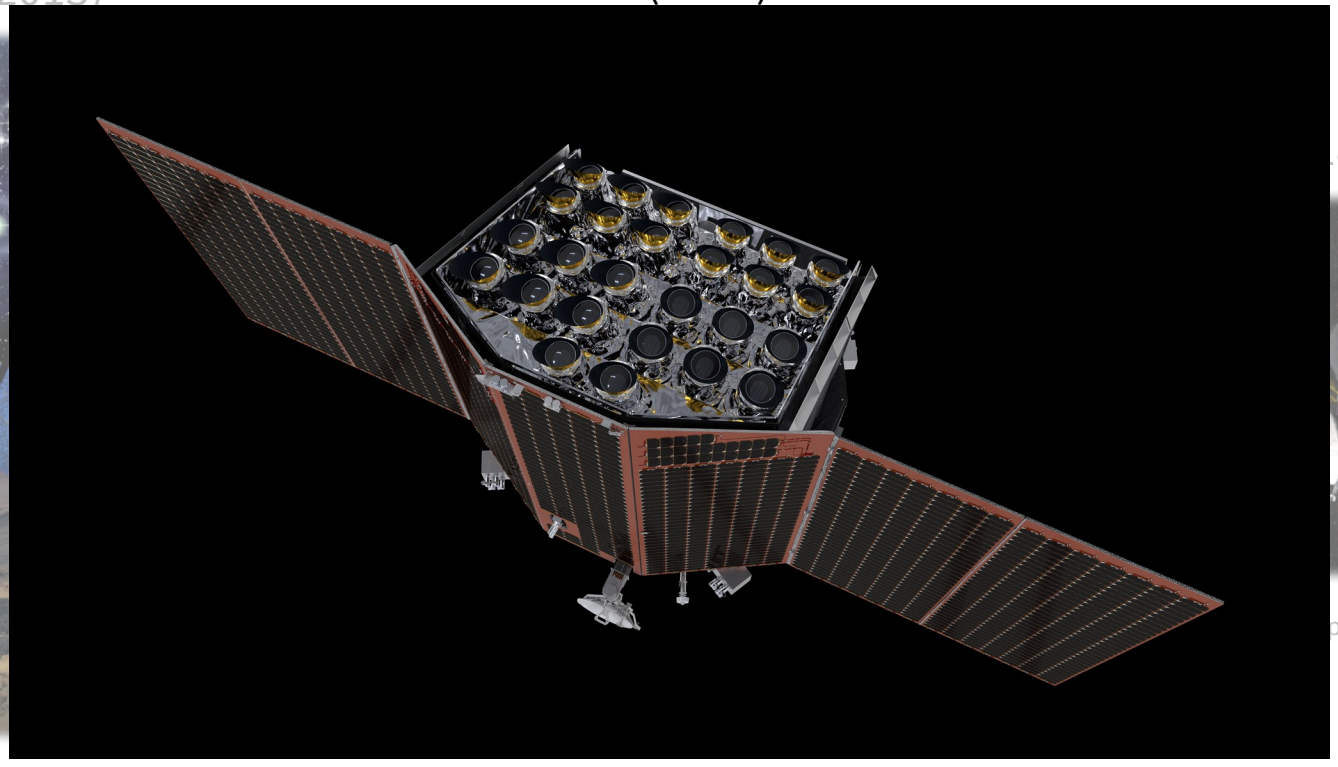
Rotational splittings in δ-Scuti stars

CoRoT (2006-2013)

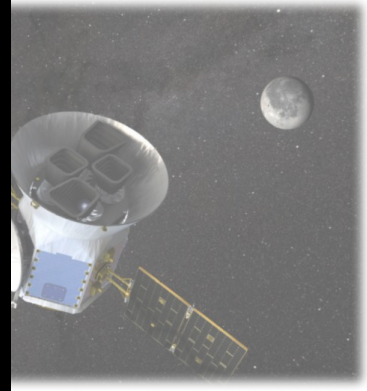
CNES – D. Ducros

PLATO (2026)



ESA/ATG medialab

8-2020+)



pace Flight Center

Rotational splittings in δ-Scuti stars

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CNES – D. Ducros

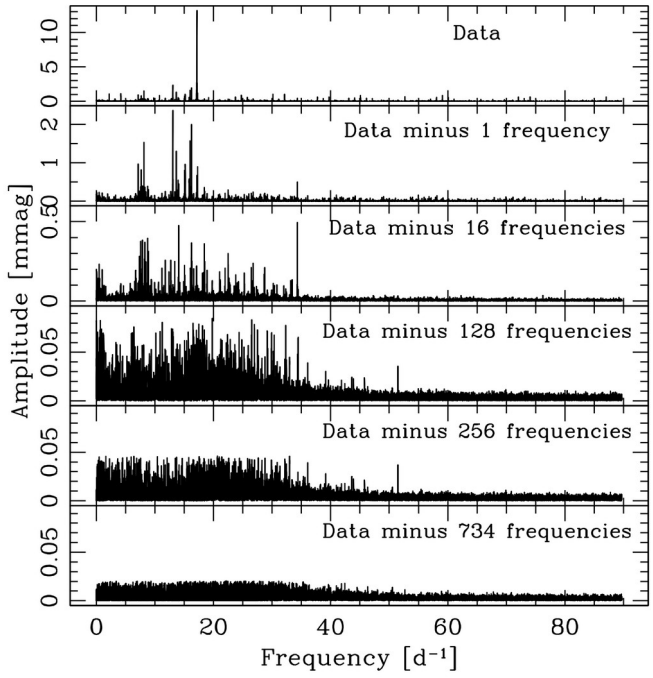
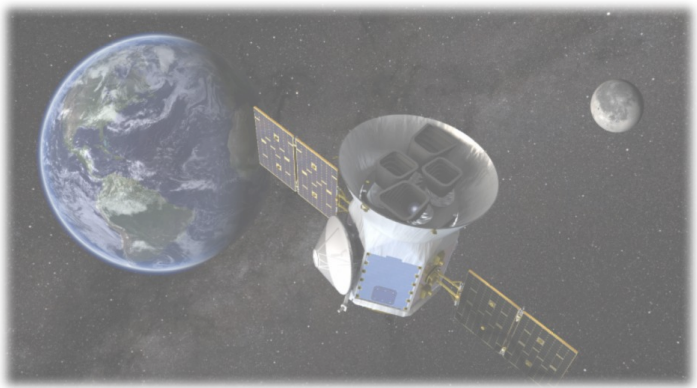


Fig. 5. Fourier amplitude spectra at different stages of the analysis. The flat plateau below about 35 d^{-1} appears after the detection of about 250 frequencies. The highest peak in the third panel from top is the second harmonic of the dominant frequency, while its third harmonic is the peak at the highest frequency in 4th and 5th panel.

Mantegazza et al. (2012)

TESS (2018-2020+)



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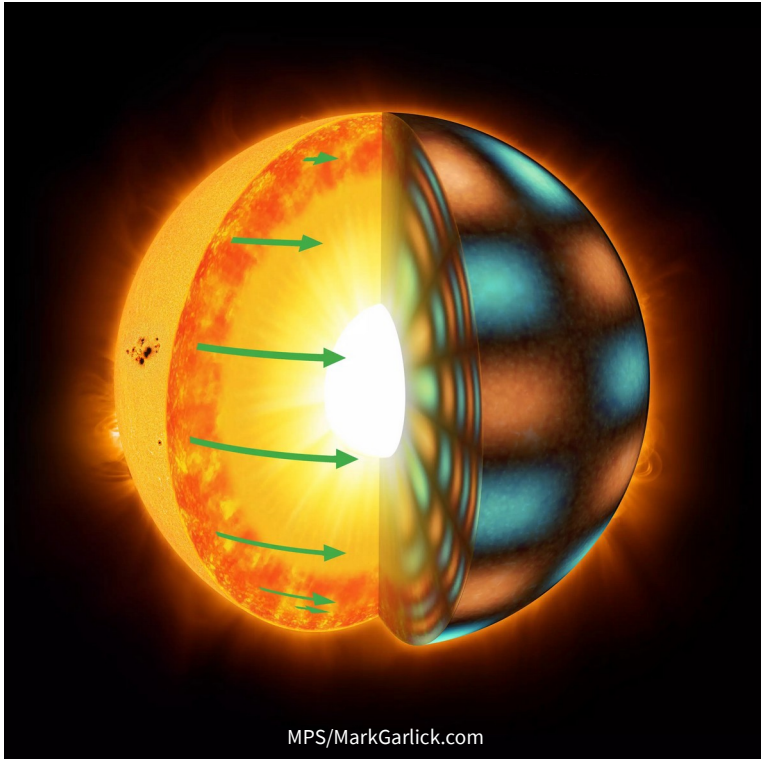
Rotational splittings in δ-Scuti stars

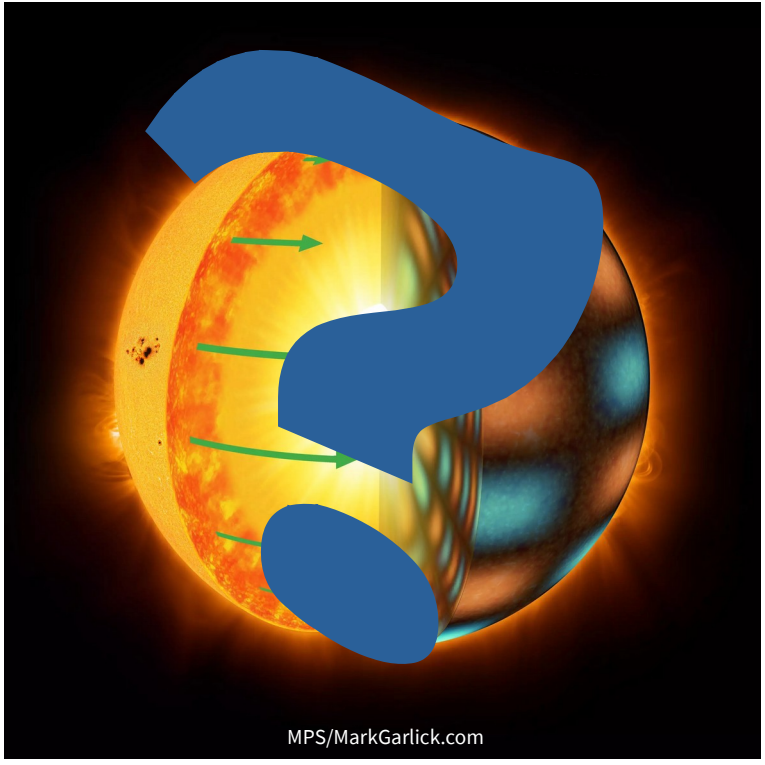
Surface rotation observed in solar-like stars



Rotational splittings in δ-Scuti stars

Surface rotation observed in solar-like stars

But for most δ-Sct stars it remains a mystery...



Rotational splittings in δ-Scuti stars

The Sample

Star	T_{eff} (K)	log g	M ($M_\odot$)	R ($R_\odot$)	$\Delta\nu$ (μHz)	$v \sin i$ (km s^{-1})	i (°)	δr (μHz)	ν_{orb} (μHz)	$\Delta\nu/\delta r$	No. of freqs
KIC 3858884[a]	6606(70)	3.74(1)	1.86(4)	3.05(1)	29(1)	25.7(1.5)	88.176(2)	1.9(1)	0.445980(1)	15.3	400
KIC 10080943[a]	7480(200)	4.1(1)	1.9(1)	2.1(2)	52(1)	14.4(1.4)	68(3)	1.7(2)	0.75468(1)	30.6	321
KIC 4544587[b]	7750(180)	4.33(1)	1.61(6)	1.57(3)	74(1)	76(15)	88(3)	11(2)	5.28715(1)	6.7	16
KIC 9851944[b]	6902(100)	3.69(3)	1.79(7)	3.16(4)	26(1)	72.1(9)	74.52(2)	5.3(1)	5.348706(2)	4.9	52
KIC 8262223[b]	9128(130)	4.28(2)	1.96(6)	1.67(4)	77(1)	50.7(9)	75.178(2)	7.2(2)	7.17542974(4)	10.7	60
HD 172189[c]	7750(-)	3.48(8)	1.8(2)	4.0(1)	19(1)	78(3)	73.2(6)	4.6(2)	2.02983(1)	4.1	50
CID 105906206[c]	6750(150)	3.53(1)	2.24(4)	4.22(2)	20(2)	47.8(5)	81.42(13)	2.61(3)	3.13272(1)	7.7	202
KIC 10661783[d]	7764(54)	3.938(4)	2.10(3)	2.56(2)	39(1)	78(3)	82.4(2)	7.0(3)	9.399407(2)	5.6	12
HD 159561[d]	8047(154)	3.9(2)	2.4(4)	2.69(1)	38(1)	239(12)	87.5(6)	19(1)	0.0036762(1)	2.0	40
HD 15082[d]	7430(100)	4.3(2)	1.49(3)	1.43(4)	80(2)	90(10)	87.7(1.8)	14(2)	9.48798(1)	5.7	64
CID 100866999[e]	7300(250)	4.1(1)	1.8(2)	1.9(2)	56(1)	—	80(2)	—	4.12069(3)	—	8
HD 174966[e]	7555(50)	4.22(1)	1.515(15)	1.58(3)	65(1)	126.1(1.2)	62.5(+ 7.5-17.5)	18(-)	—	3.6	172
HD 174936[e]	8000(200)	4.1(2)	1.65(26)	1.97(32)	52(-)	169.7(-)	—	—	—	—	422

Ramón-Ballesta et al. (2021)

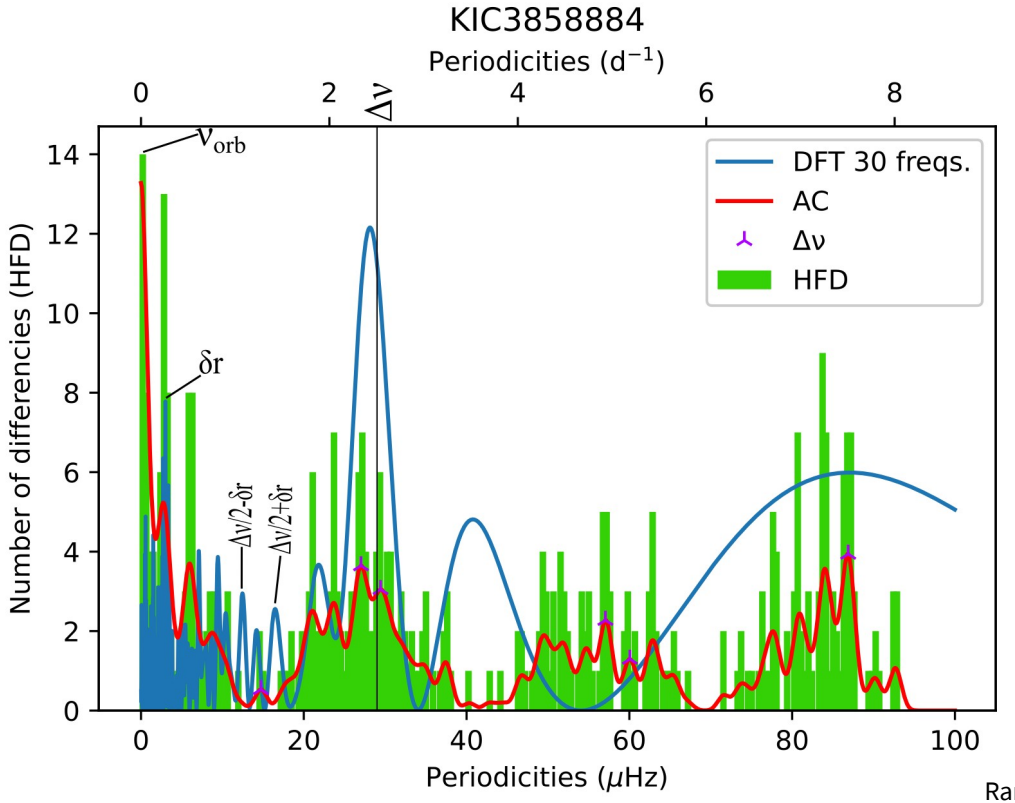
Rotational splittings in δ-Scuti stars

Three well known techniques:

- Discrete Fourier Transform
- Autocorrelation Function
- Histogram of Frequency Differences

Rotational splittings in δ-Scuti stars

Favourable cases



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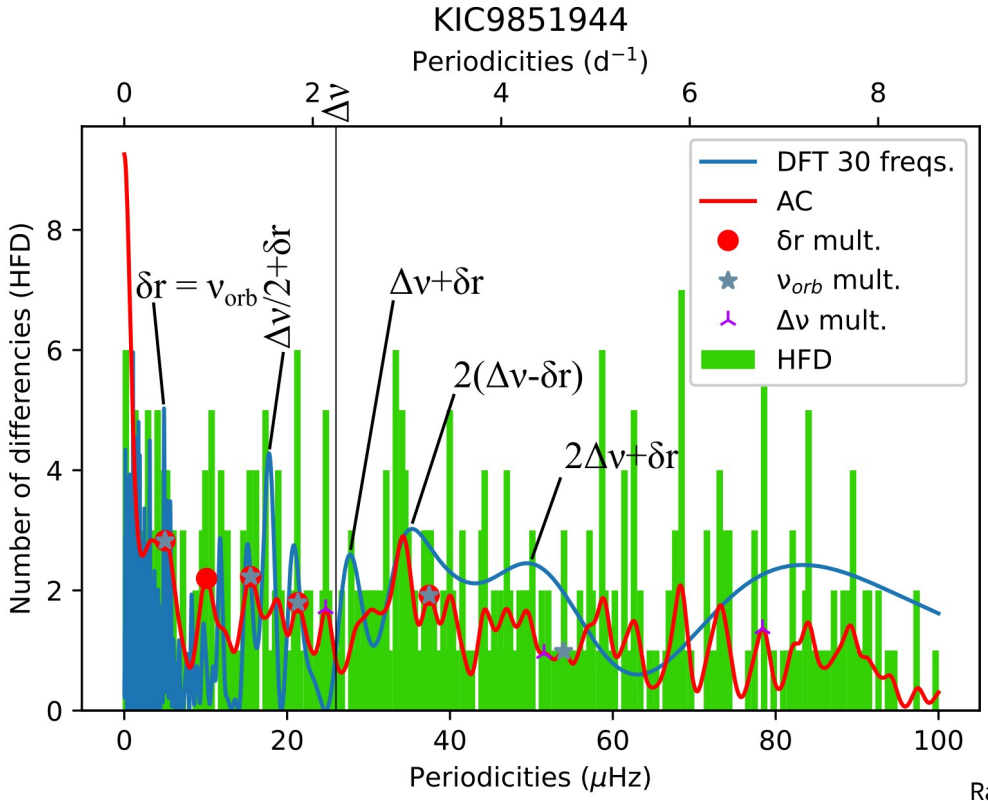
Rotational splittings in δ-Scuti stars

Orbital synchronisation



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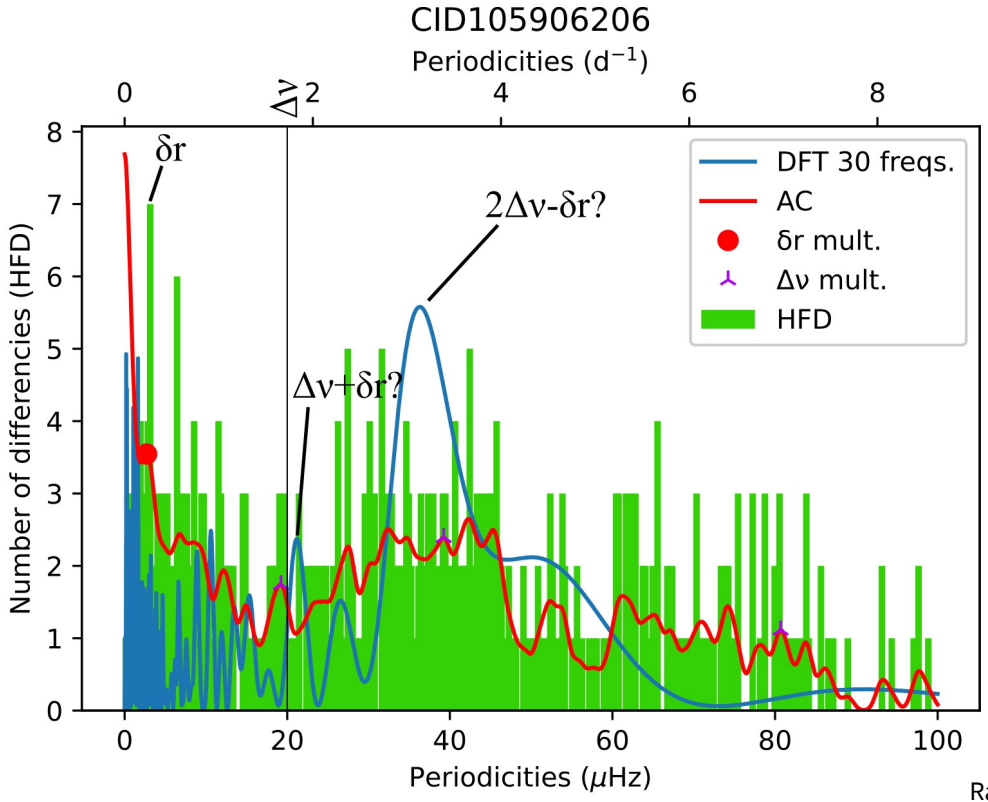
Rotational splittings in δ-Scuti stars

Evolved stars



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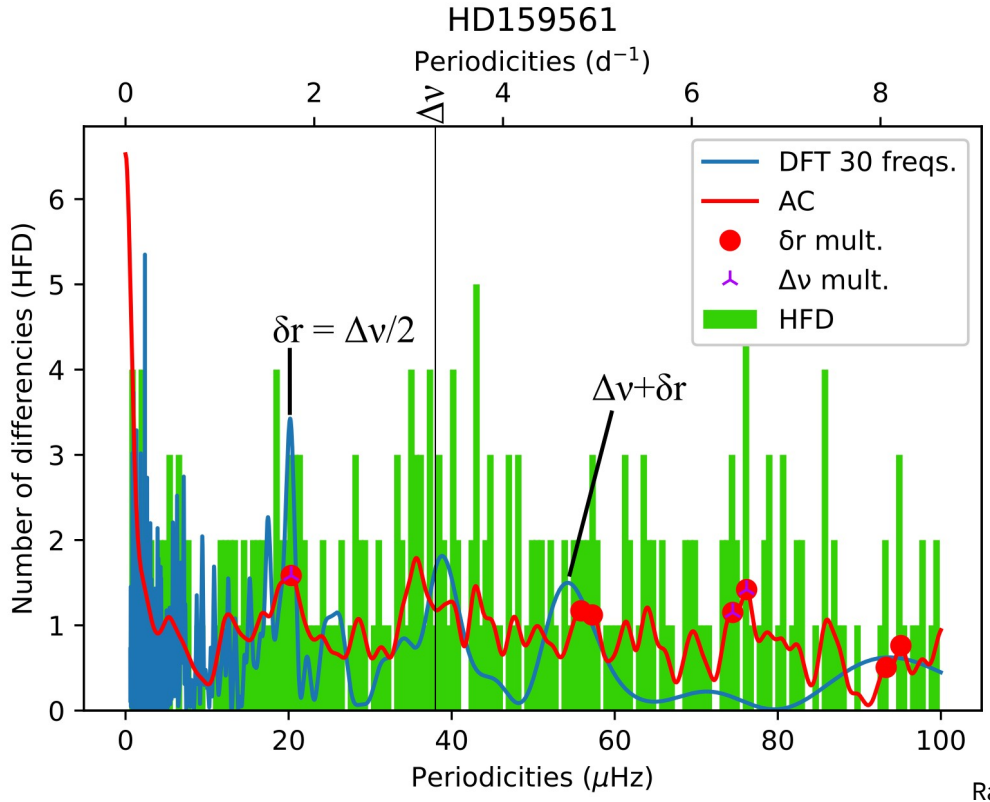
Rotational splittings in δ-Scuti stars

Peculiar stars



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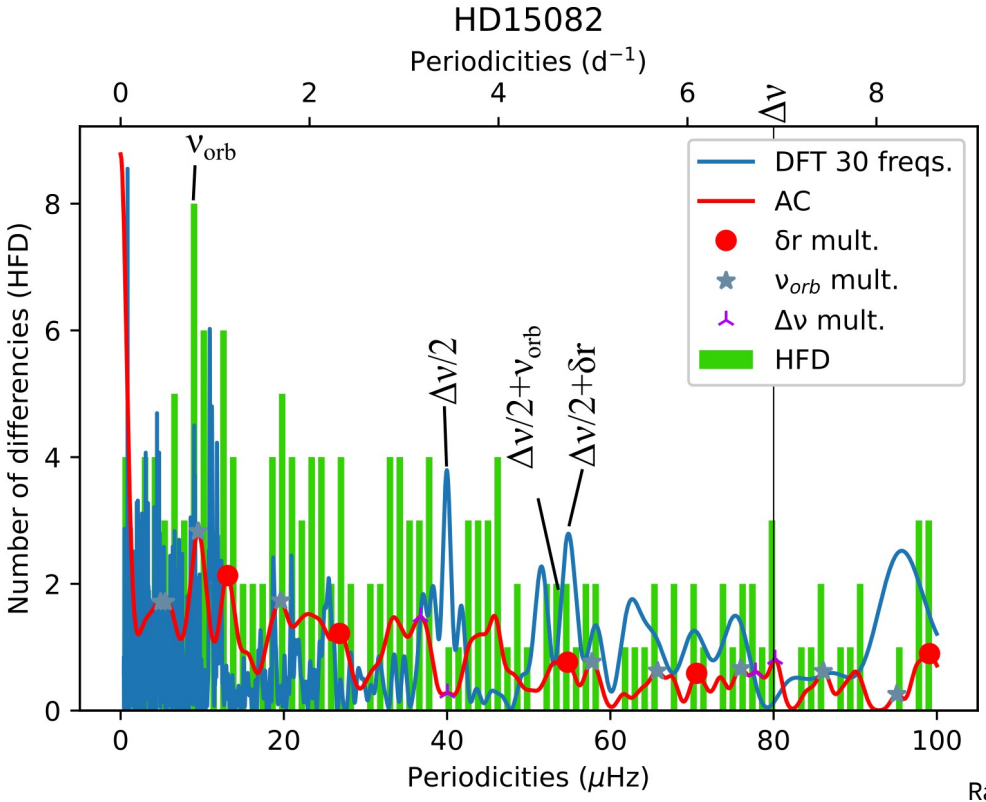

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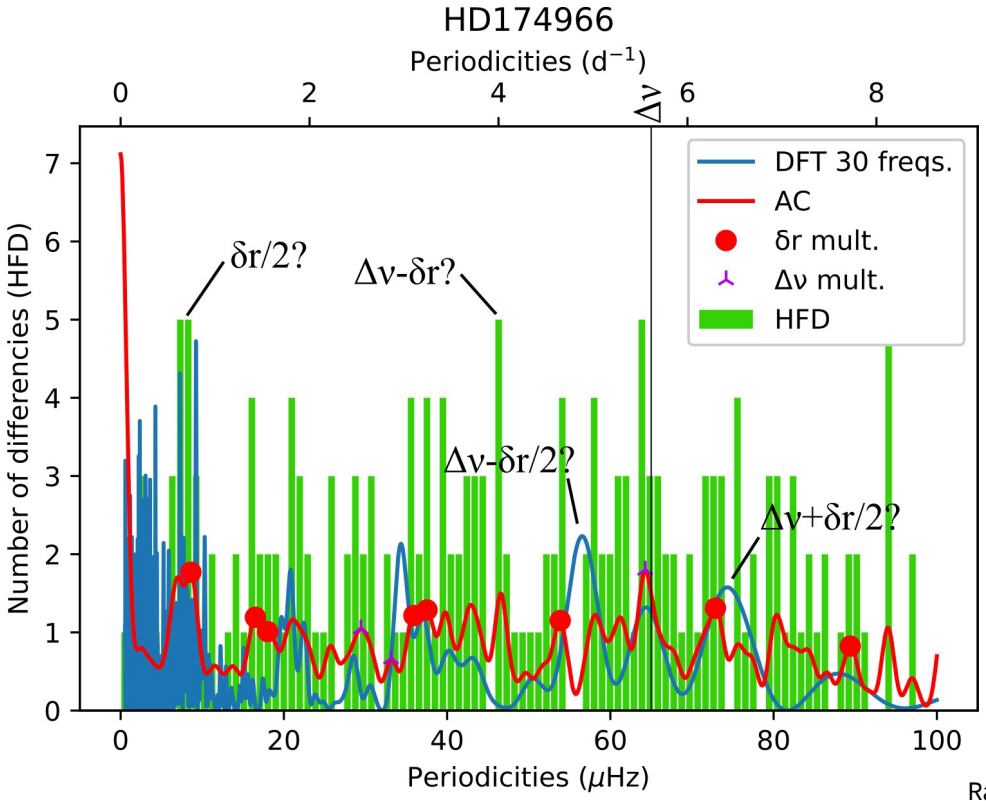
Rotational splittings in δ-Scuti stars

Unknown rotation



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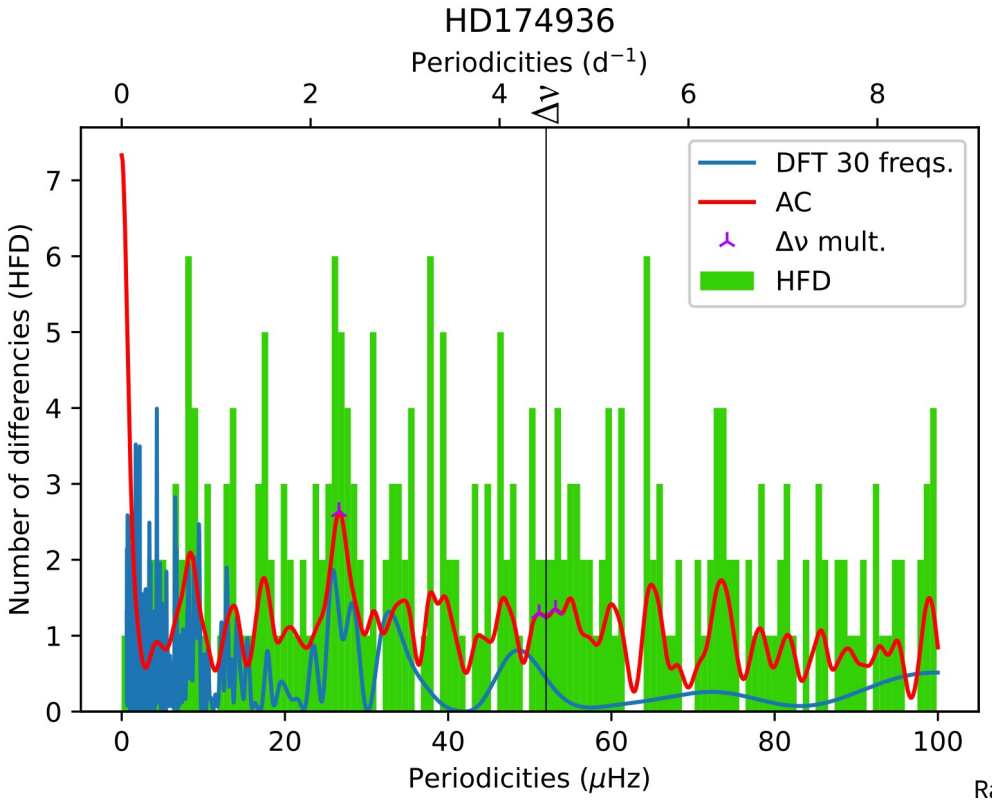

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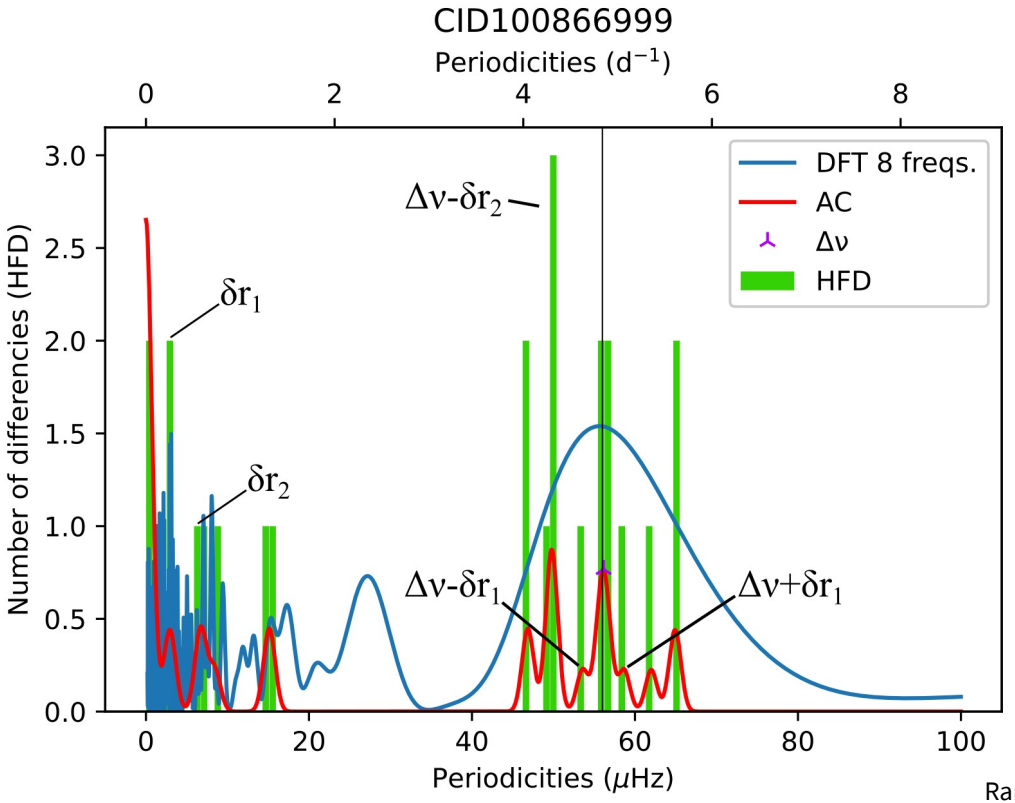

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Rotational splittings in δ-Scuti stars

Conclusions:

- **The signature of δr is present and identifiable using asteroseismological data only.**

Rotational splittings in δ-Scuti stars

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- **Best results using the combined analysis of the Fourier transform and the autocorrelation function.**

Rotational splittings in δ-Scuti stars

Conclusions:

- **The signature of δr is present and identifiable using asteroseismological data only.**
- **Best results using the combined analysis of the Fourier transform and the autocorrelation function.**
- **The primary identification of Δν is crucial for a successful determination of δr.**

The End