Stellar spot modelling and differential rotation

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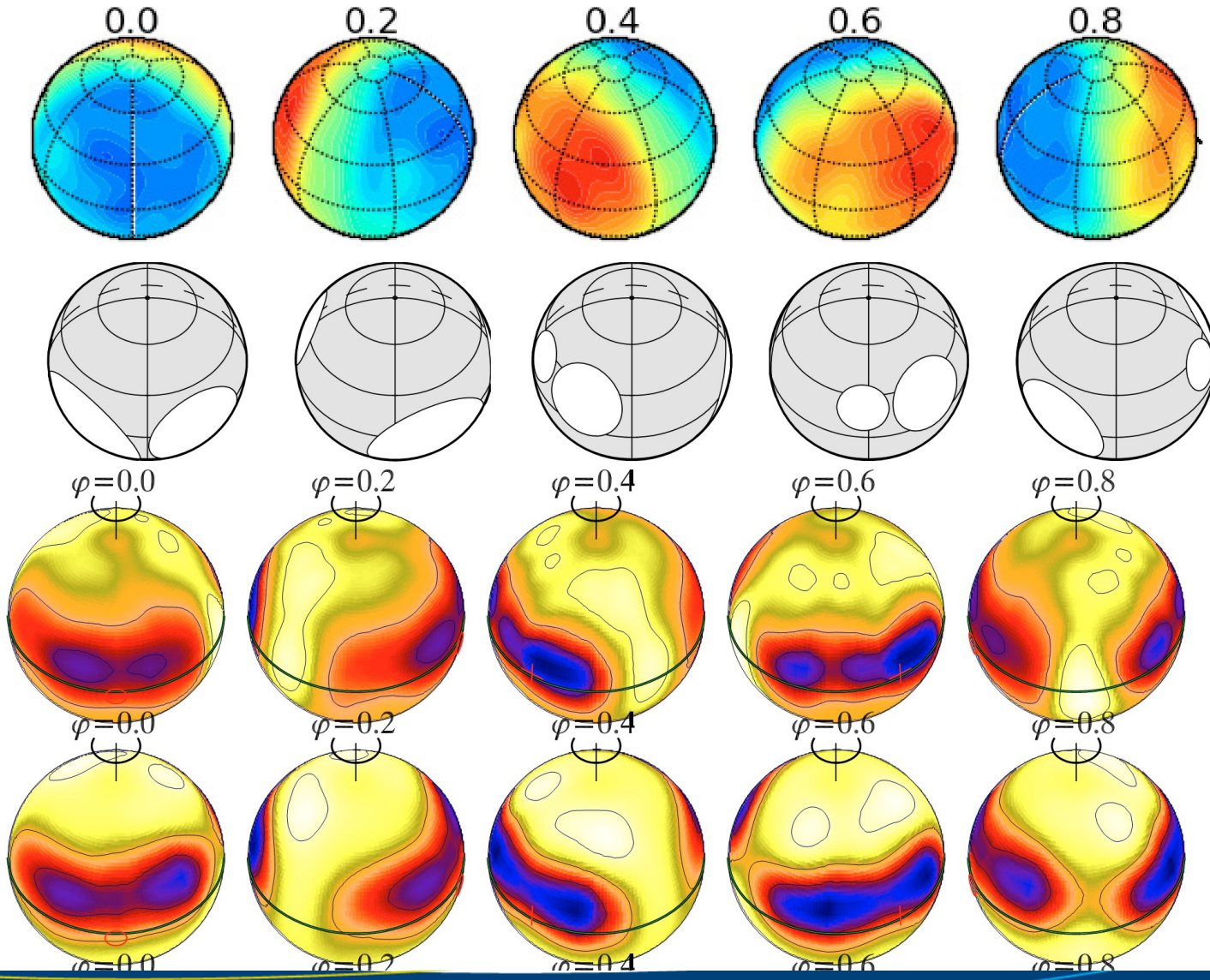
Corot star HD 50773, Ap2V, P_{rot} = 2.1 d

- B_r



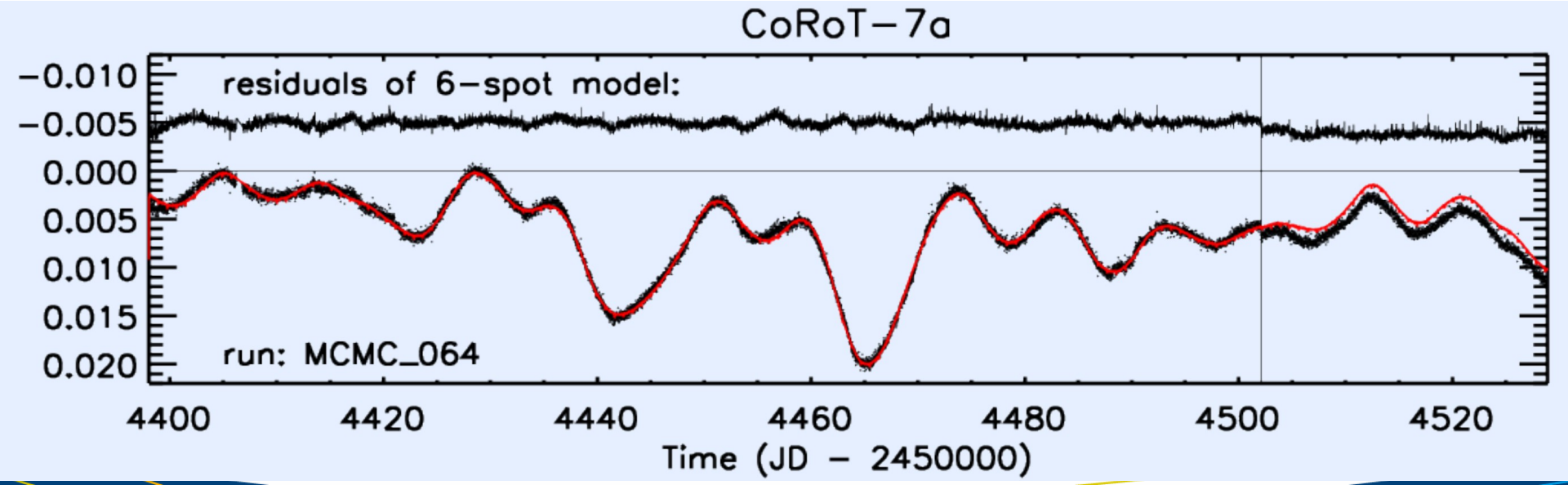
Lüftinger et al. (2010): photometry versus spectro-polarimetry

The model

- Circular spots
  (this assumption allows analytic formulae for change of brightness of the star)
- Can occupy any latitude
- Differential rotation described by
  - Either individual spot periods or
  - $\Omega(b) = \Omega_0 + \delta\Omega \sin^2 b$
- Spots should not move through each other
- Quadratic limb-darkening with constant coefficients

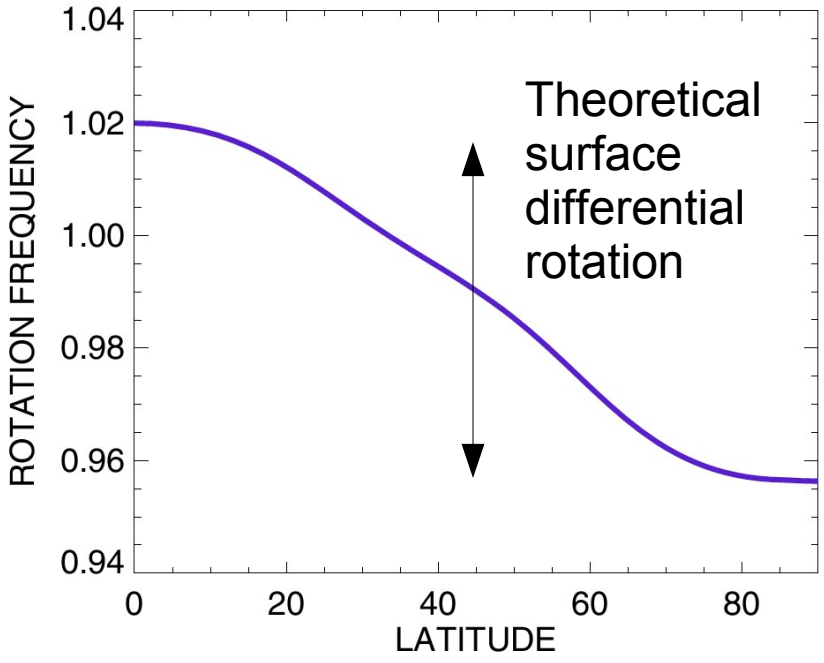
Corot-7a

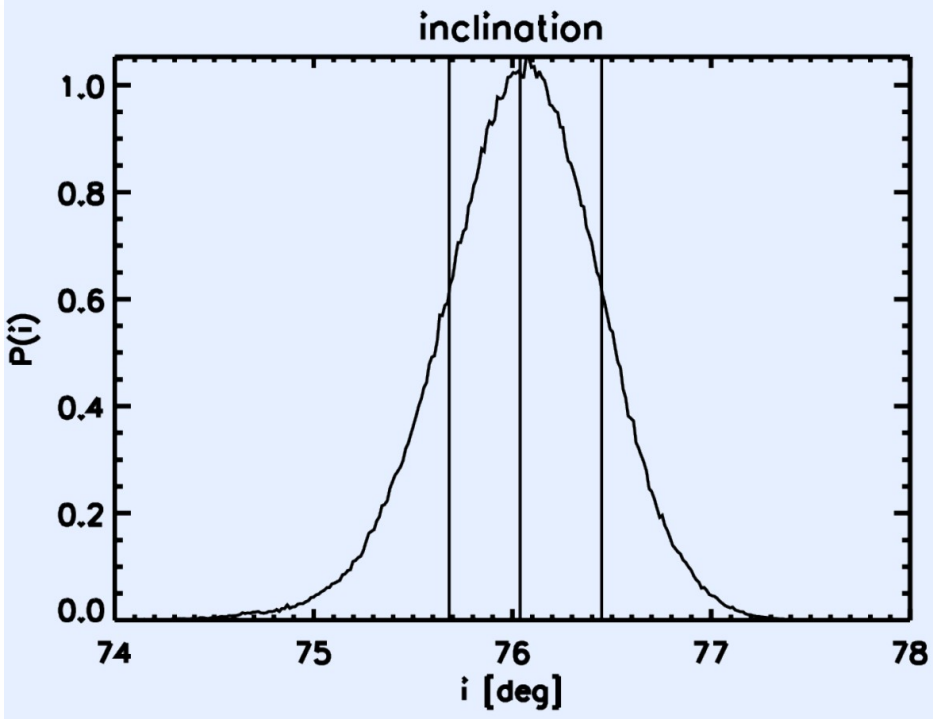
- Light curve with apparently irregular variations
- G9V star with P_{rot} = 20.2 days
- 131 days, about 6.5 rotation
- Can we measure the differential rotation?

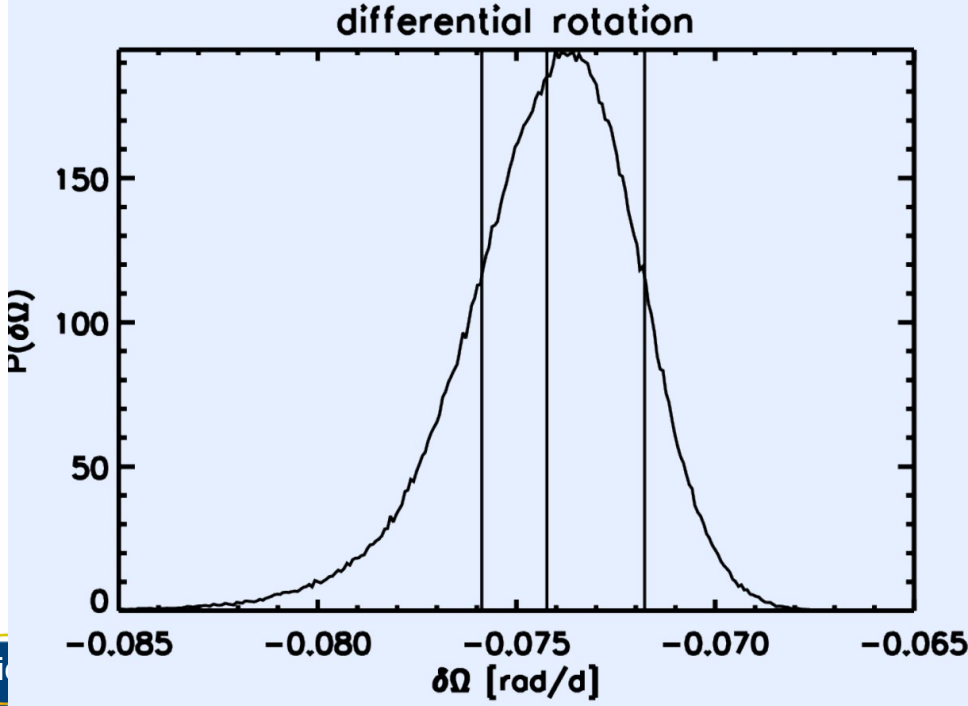


Corot-7a

- Sharp definition of the inclination of the star
- Differential rotation: -0.074 rad/d
- Prediction by M. Küker: -0.07



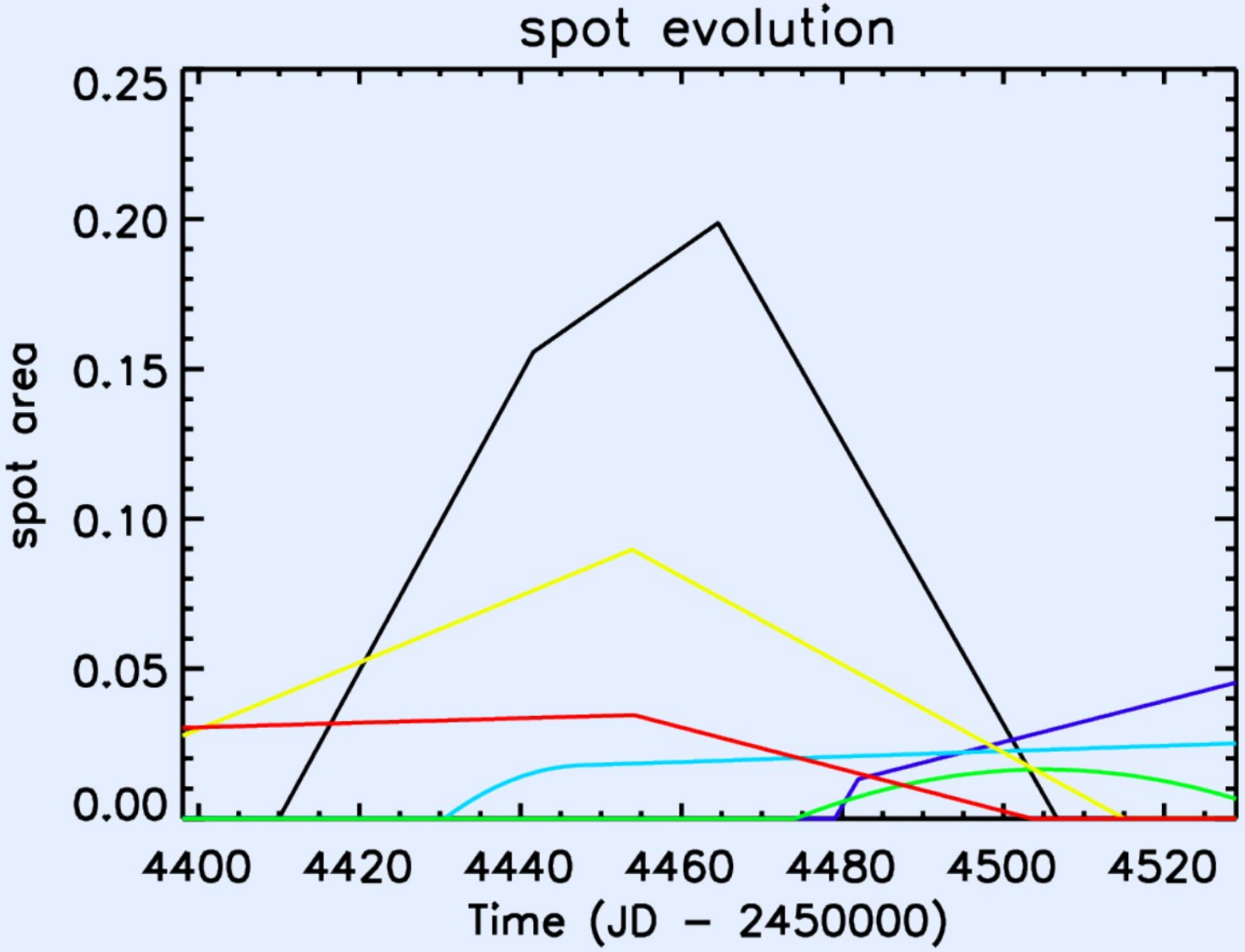




Corot-7a

- 6 spots
- 4*6 slopes
- 2*6 coords
- 6 sizes
- Omega
- Diff. Rot
- Inclination

- ~50 parameters



Too many parameters?

- Full-surface maps:

> In the present model, the stellar surface is subdivided into elements, i.e., into 200 squares of side 18°, with each element containing unperturbed photosphere, dark spots, and facular areas. The fraction of the kth element covered by dark spots is indicated by its filling factor f_k, the fractional area of the faculae is $Q f_k$, and the fractional area of the unperturbed photosphere is $1 - (Q + 1) f_k$. The contribution to the stellar flux coming from

Bonomo & Lanza (2012)

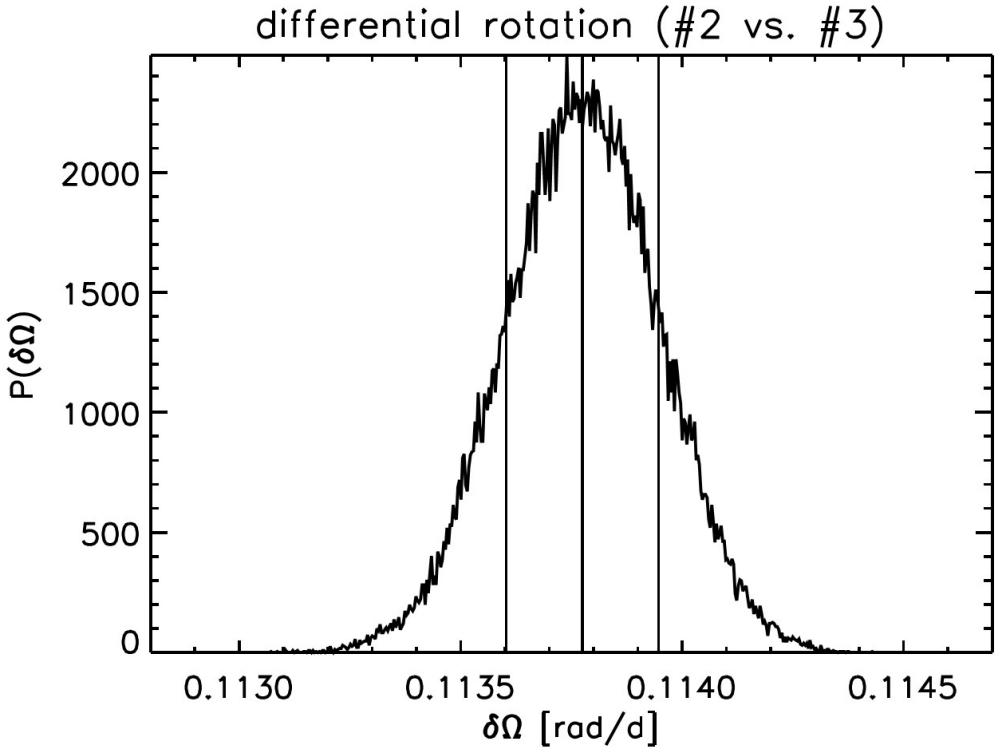
- Spot modelling is still a way of reducing the number of parameters considerably

More Bayes recipes

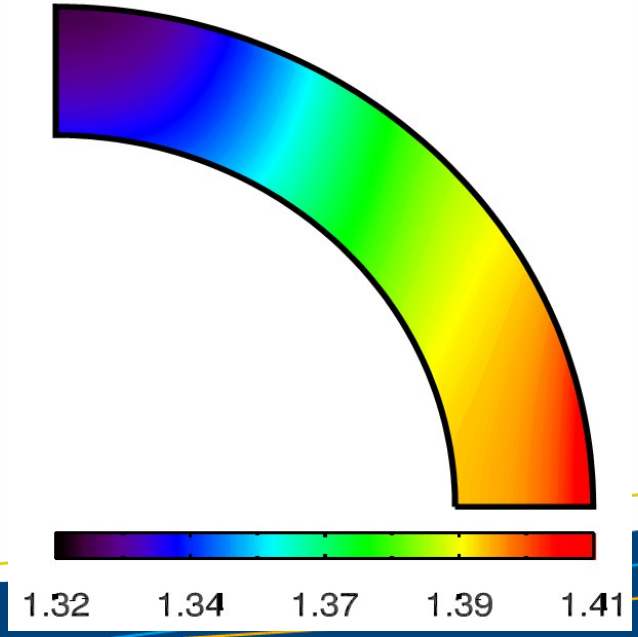
- Use sin *b* instead of *b*
- Use cos *i* instead of *i*
- Modelling should be independent of choice of uniquely related parameters
  - Period versus frequency
  - Spot area versus spot radius
- Use log(area) or log(Period), then the results are identical

Corot-2a

- G7V, <0.5Gyr, P_{rot} = 4.5 days
- Diff. Rot. -0.11 rad/day
- Theory -0.09 rad/day

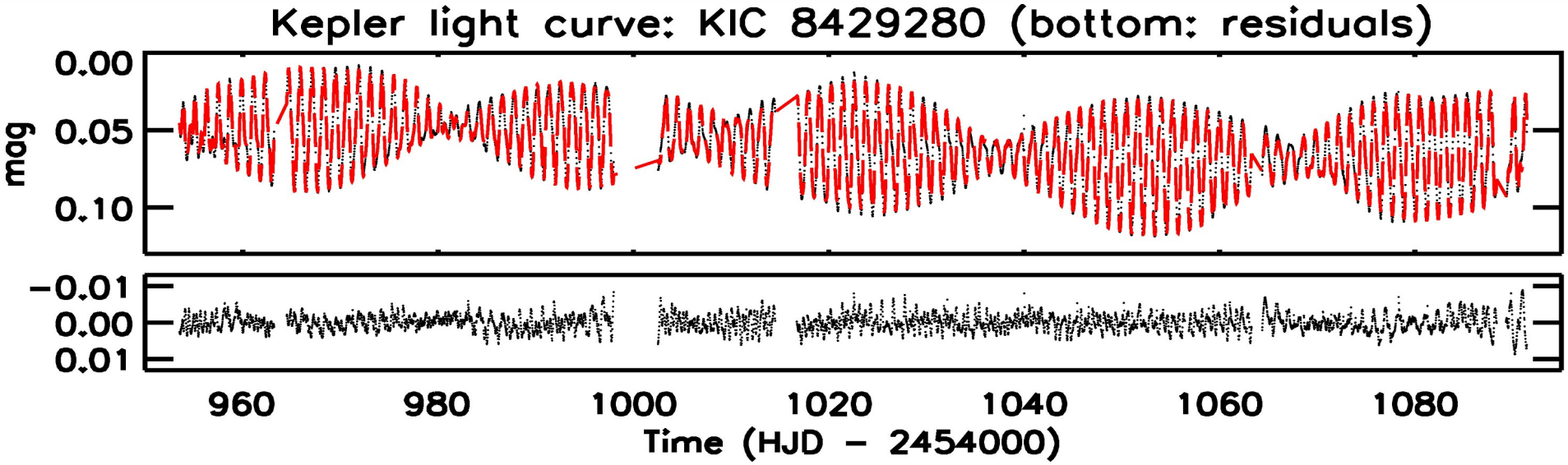


Küker et al. (2011) for Corot-2a



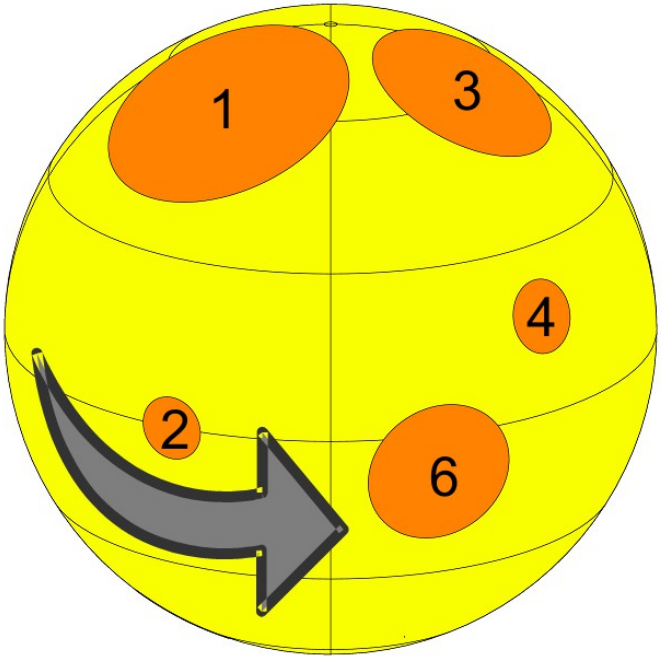
KIC 8429280

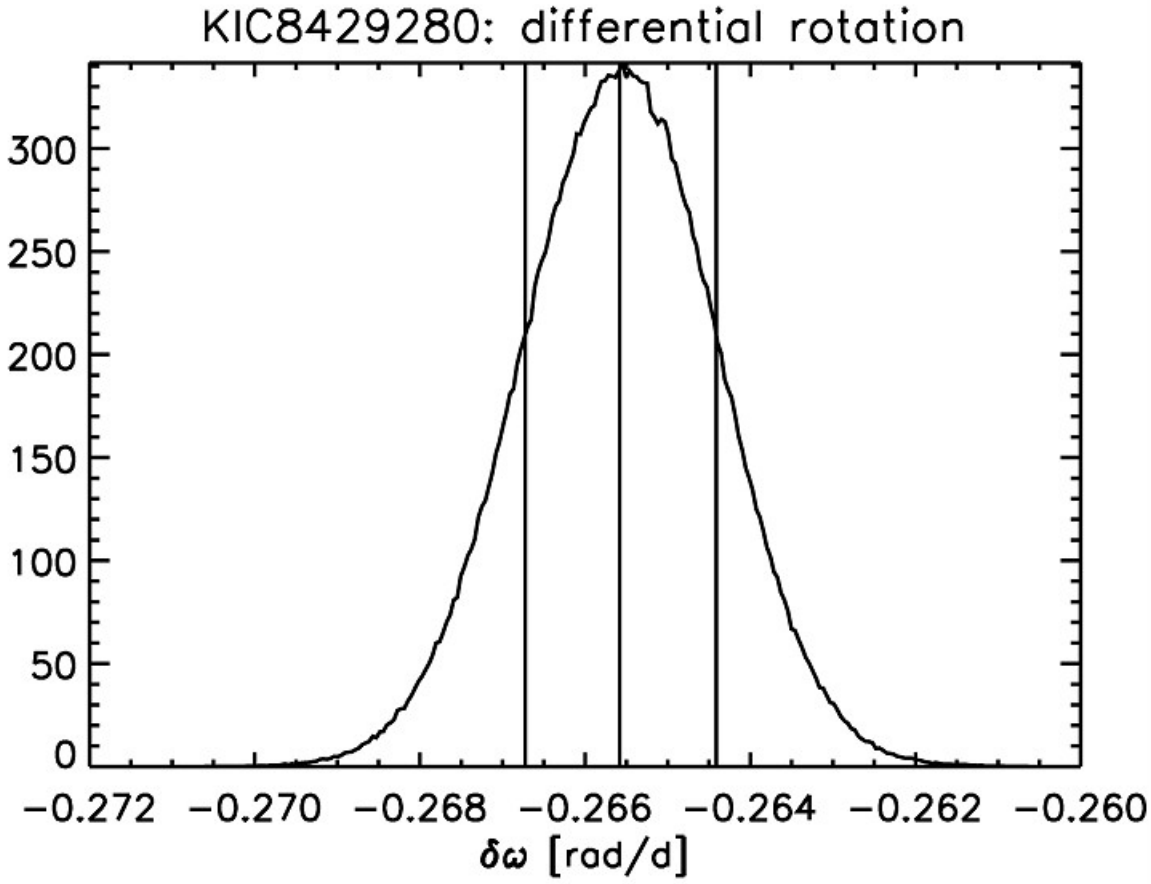
- Young active K2V star, < 50 Myr
- Light curve 138 d
- Very prominent beating



KIC 8429280

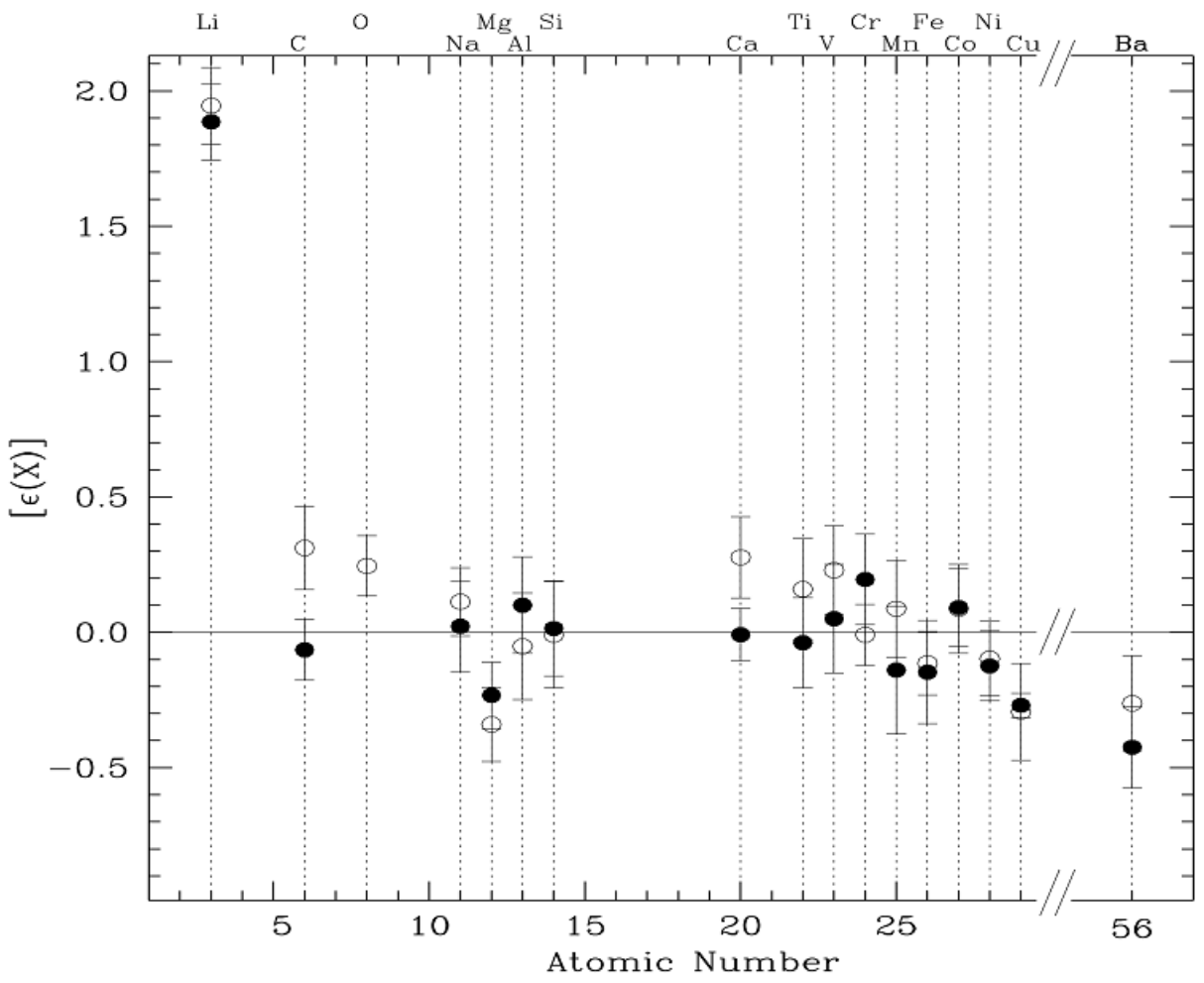
- Diff. Rot.
  -0.266 rad/d!





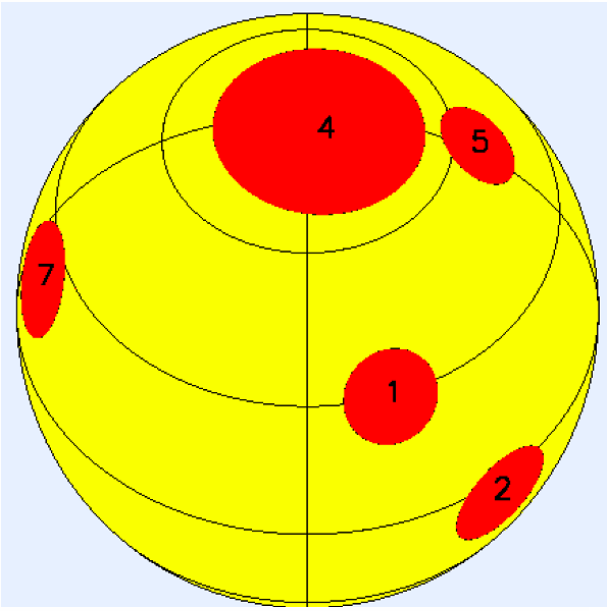
KIC 7985370 and KIC 7765135

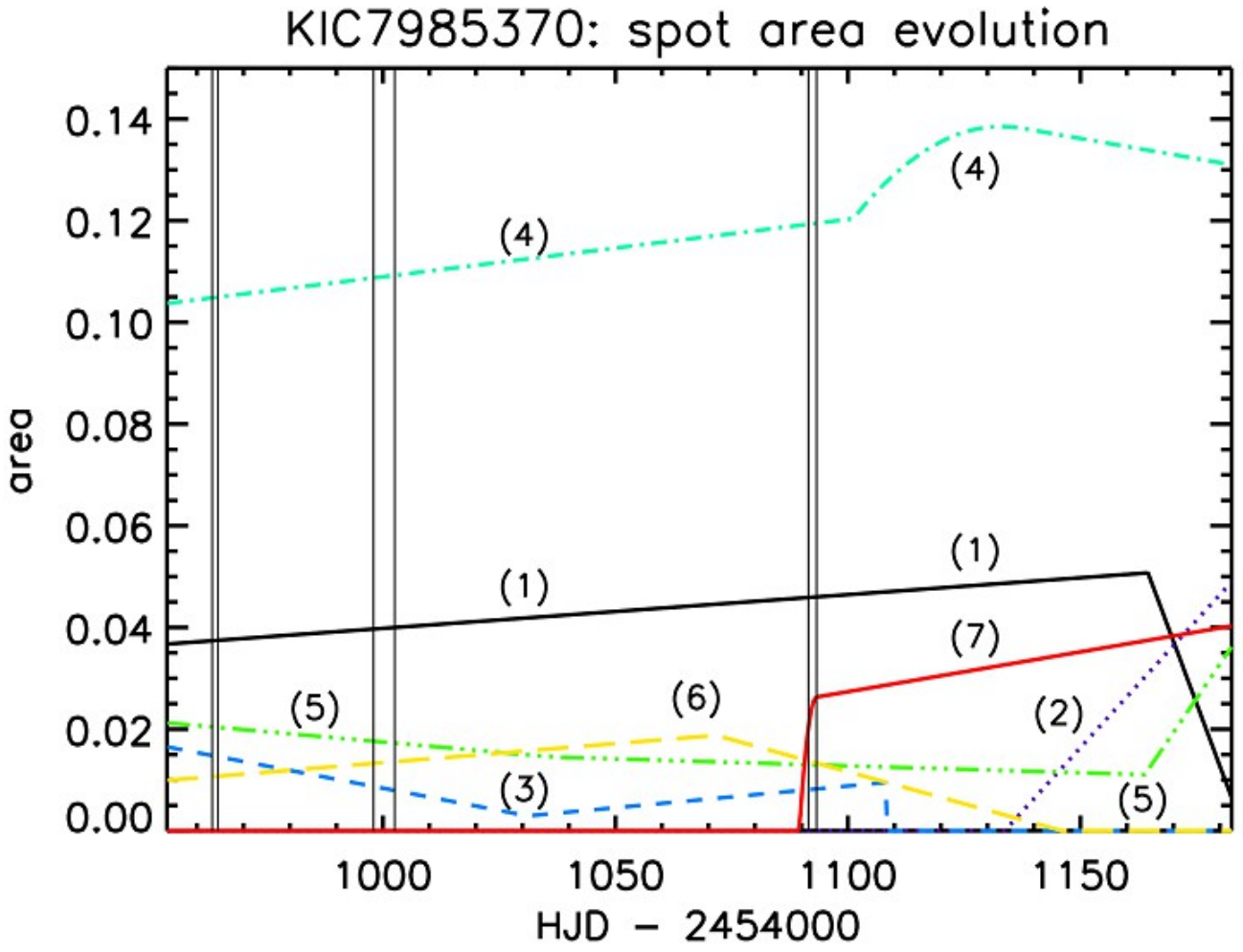
- Estimated age: 100-200 Myr



KIC 7985370

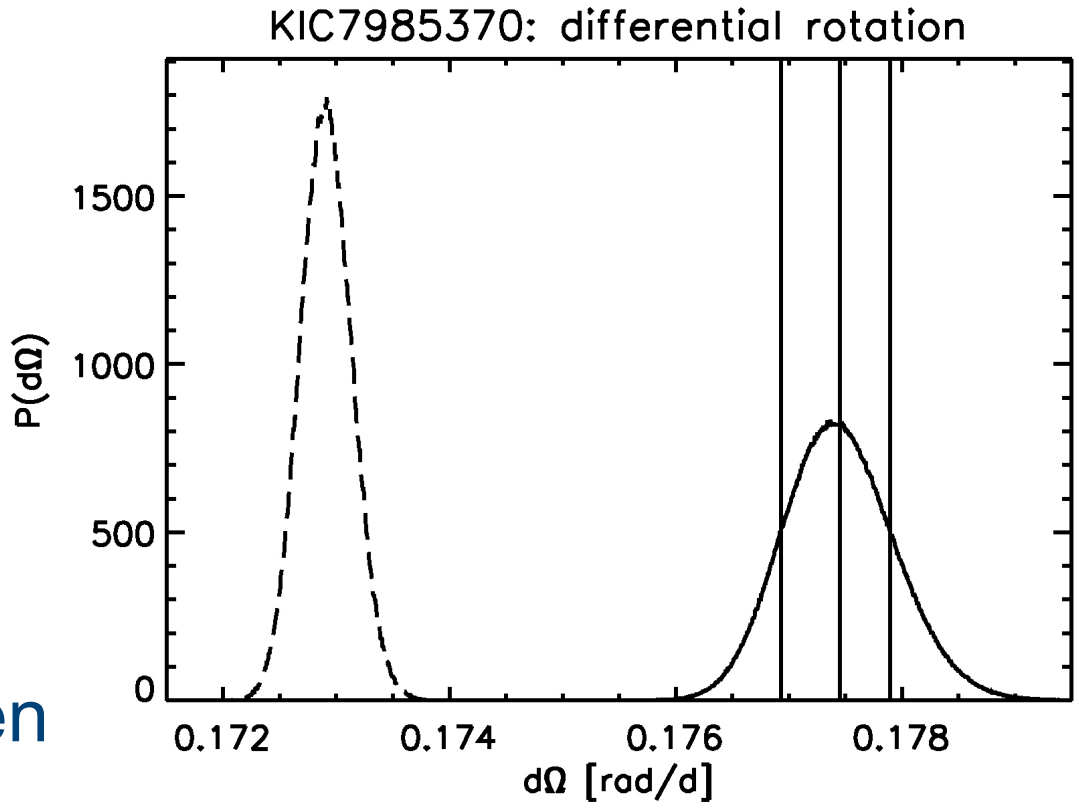
- P_{rot} = 2.9 d
- G1.5V





KIC 7985370

- Solid line: original data
- Dashed line: detrended Kepler data

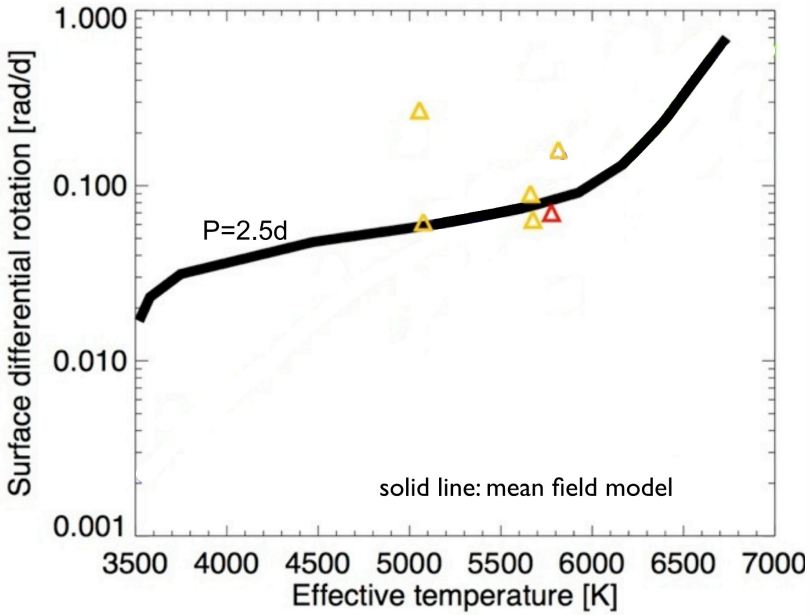


- Note the small difference between the two

- Bayesian modelling is fairly robust

Summary

- Spot modelling with circular spots of constant brightness (typically darkness)
- Promising results from MOST and CoRot data



- Kepler stars higher differential rotation than theoretical values <=> in contradiction with Reinhold picture
- Kepler data are very accurate! Bayes Information Criterion (BIC) indicates even more parameters are allowed to model the light curves