Long-term monitoring of stellar activity

Goals:

Determination of activity cycles and differential rotation of a stellar sample

- The rotation period: key parameter
  - of the stellar dynamo
  - of stellar differential rotation (SDR)
- Monitoring of the rotation period: characteristics of (surface) SDR
  - Analogy to the solar butterfly diagram
  - Monitoring over a complete activity cycle required
- Concentration on low-active stars (sisters of the Sun)
- Volume-limited sample with TIGRE
  - Up to 25 pc from the Sun
  - Observable from La Luz and only during the winter season

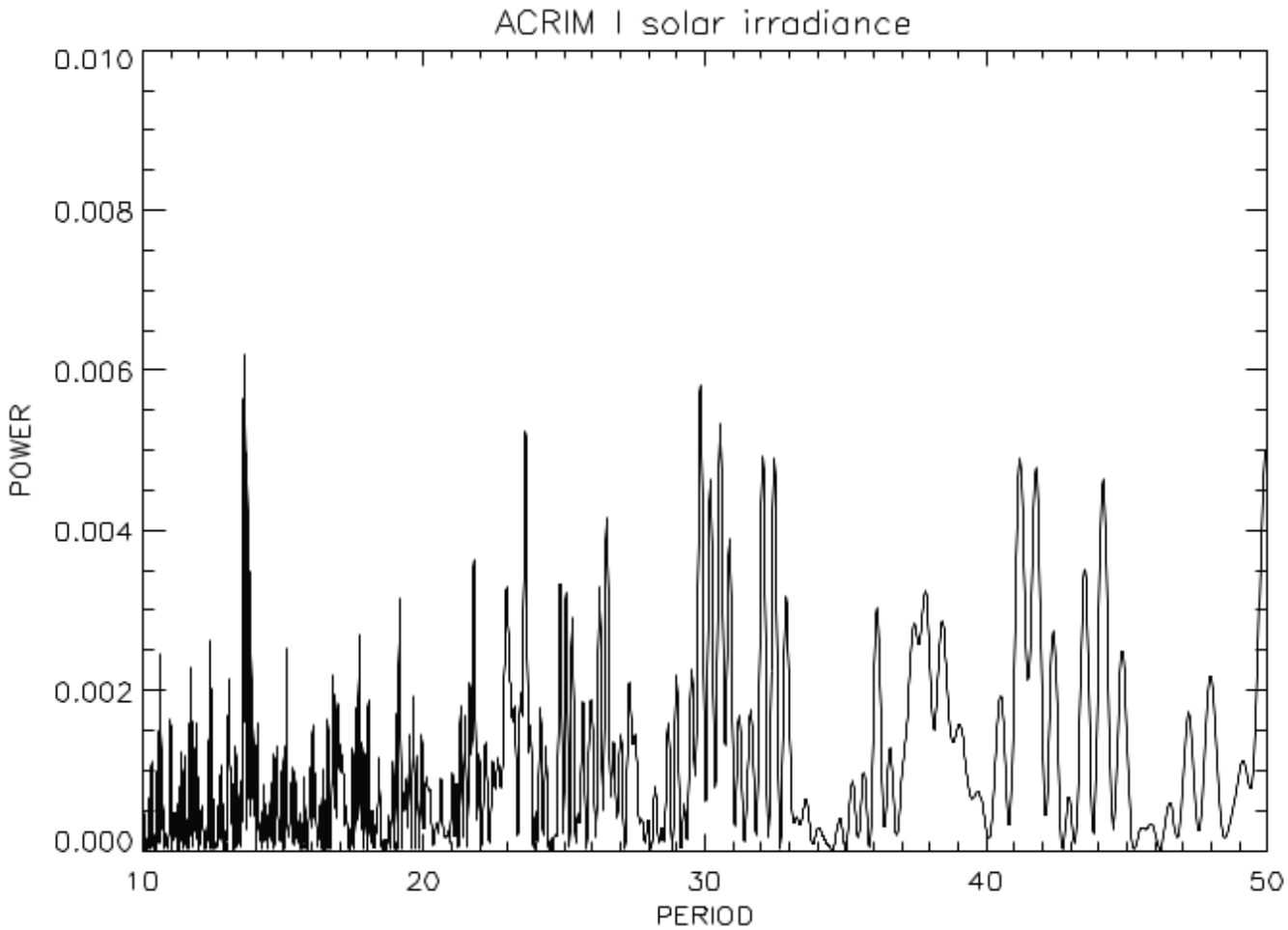
Search for Rotation Periods of low-active stars

Method:

- (Space) photometry: probably not successful because
  - Bright stars! (CCD saturation)
  - complicated net balance of dark spots and bright faculae for low-active stars (see next 2 pages)
- Spectroscopy: only bright faculae determine the CaII H+K core emission
  - Was successful for many stars of the Mt. Wilson project
  - Even SDR was successfully investigated
- TIGRE AO0 and AO1: successful detections of rotation periods
  - See talk by Marco

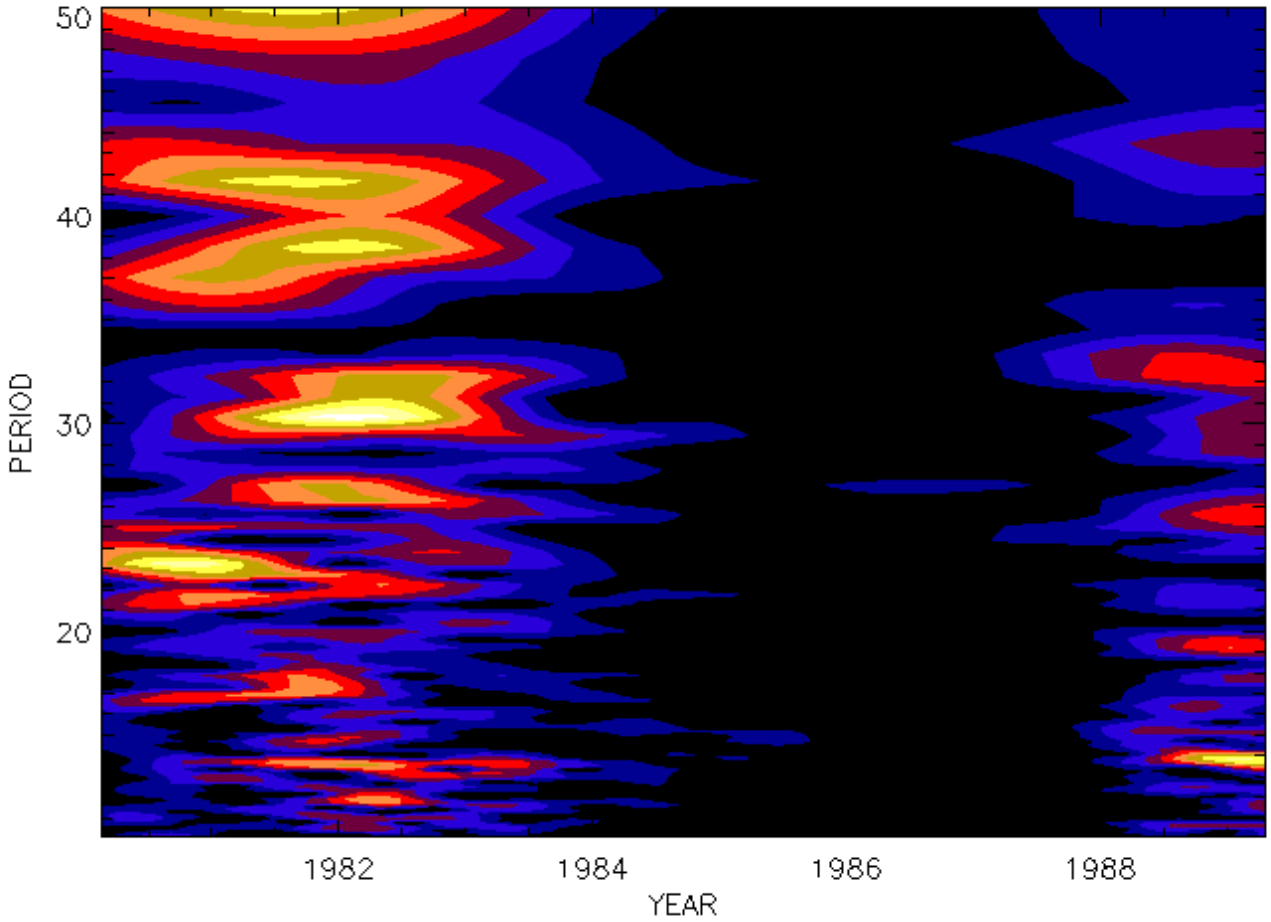
Fourier spectrum of the solar irradiance

Hempelmann (2003)



Wavelet picture of the solar irradiance

Hempelmann (2003)

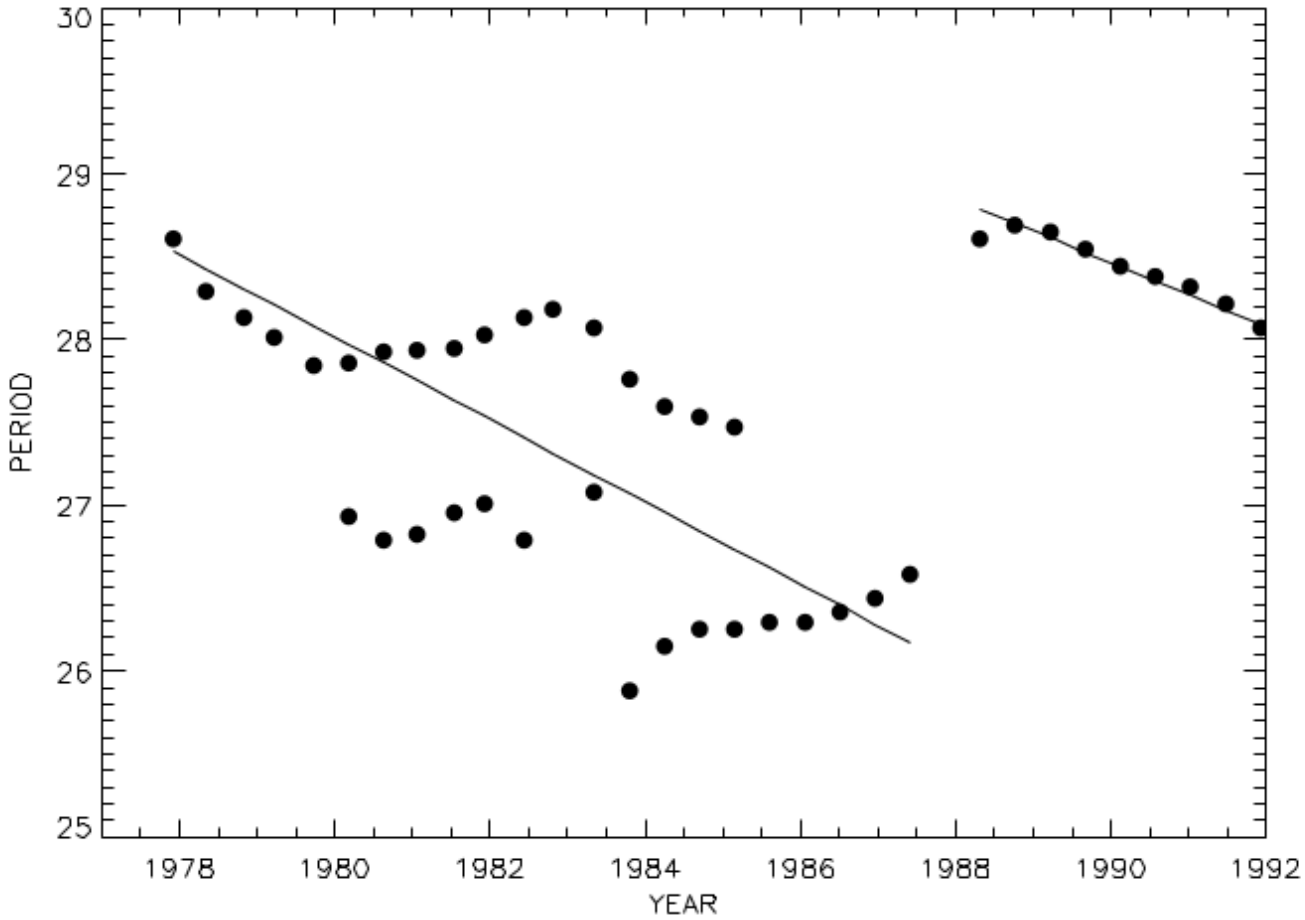


Differential rotation

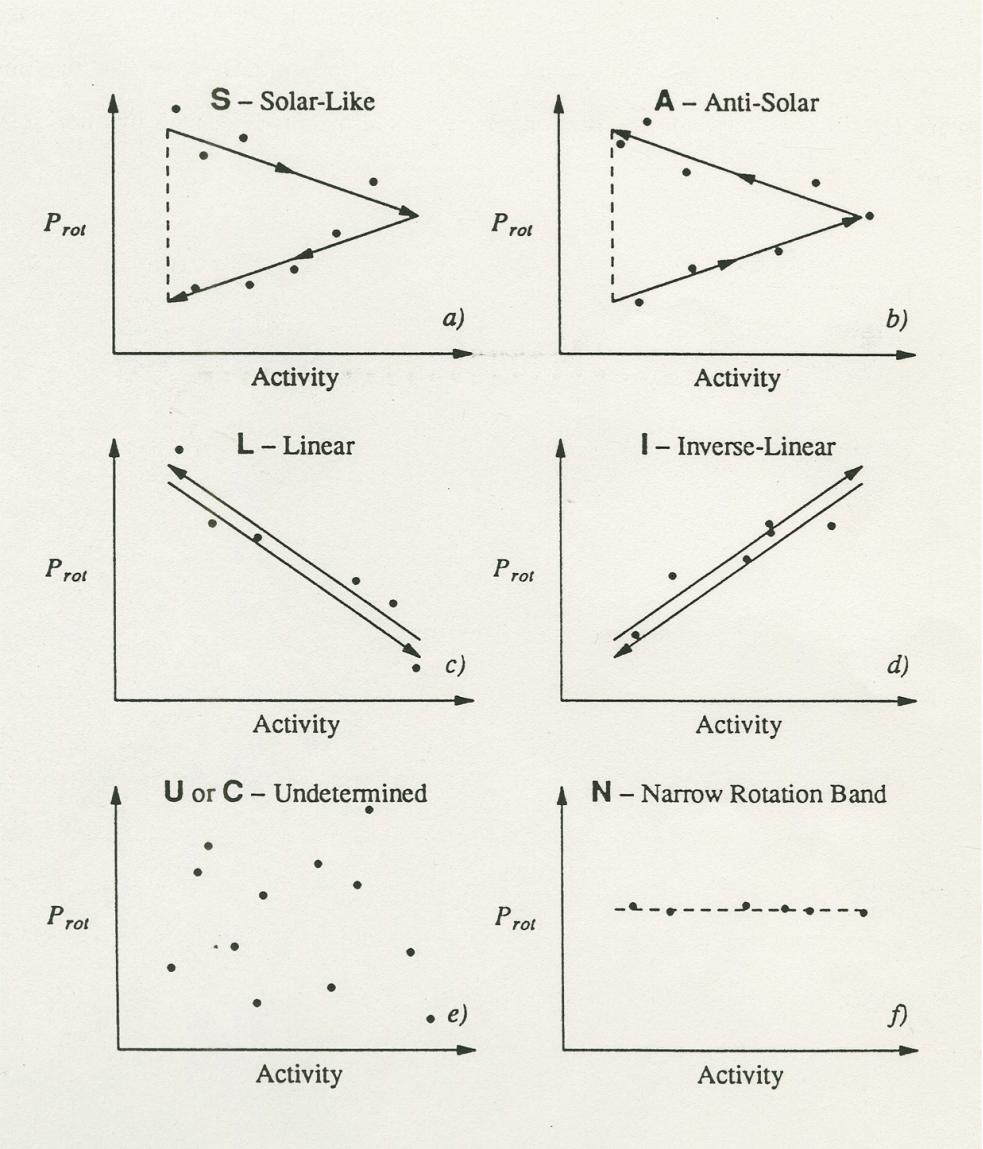
- Stellar differential rotation (SDR) and active region migration (ARM)
  - Surface differential rotation: The Sun rotates faster at the equator than at the poles
  - AR migration: Equatorwards during the activity cycle on the Sun
  - The combination of both effects allow to sample the SDR/ARM over the cycle
  - Method: Time-frequency analysis, c.f. wavelet analysis
  - Yields always an ambiguous solution: the signs of SDR and ARM are exchangeable
  - Test with Ca II K observations of the Sun (Hempelmann & Donahue 1997)
    – Qualitative correct result, but
    – Hampered by period splittings/shifts caused by ARGD (phase jumps)
- Results for a sample of 37 stars by Donahue (PhD thesis)
  - He finds six (!) types of SDR/ARM, only one of solar-type

SDR of the Sun

The (synodic) rotation of the Sun as seen in CaII H+K (Hempelmann and Donahue, 1997)

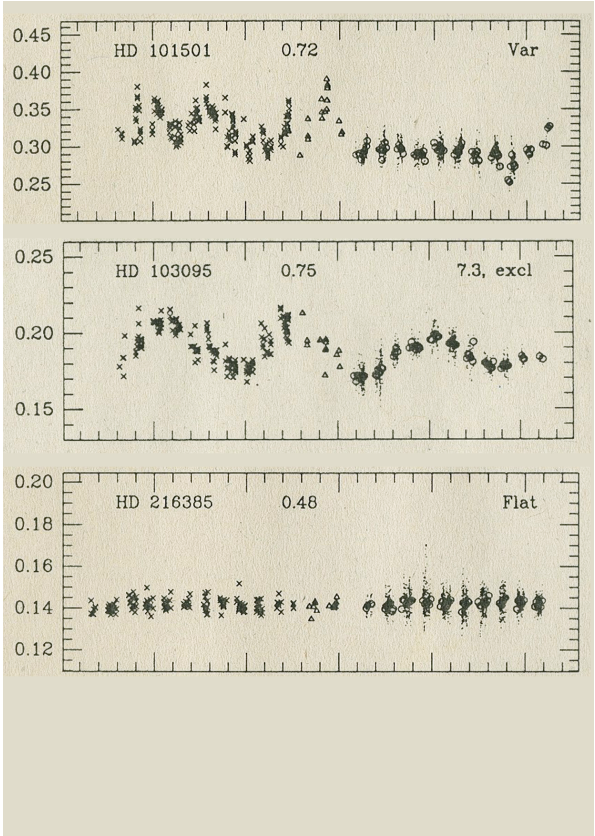


SDR/ARM: Donahue's 6 classes



Long-term cycles

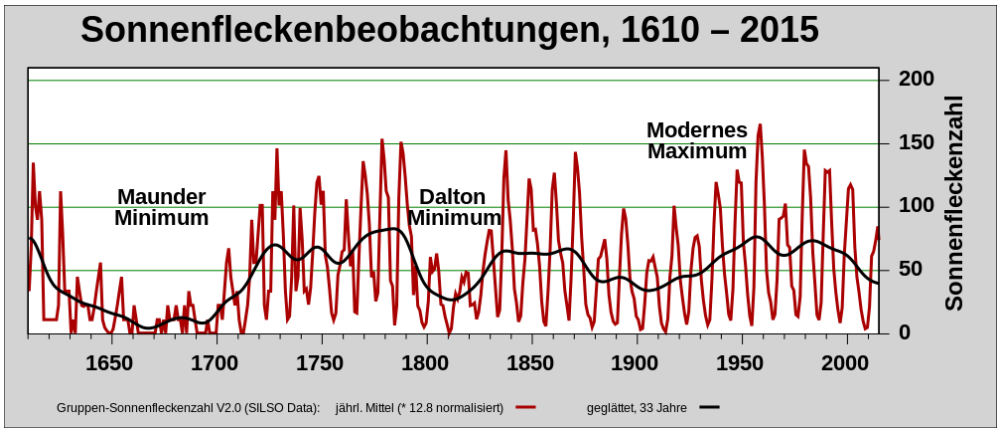
- Activity cycles
  - Results from the Mt. Wilson Ca HK project
  - There are constant, cyclic and irregular stars (Baliunas et al. 1995)
  - Constant: lowest active; cyclic: low active; irregular: high active



Very long cycles

- Grand minima: how frequent, how long?
- Long cycles of the Sun
  - Yoshimura: 55y
  - Gleissberg: 85y
  - De Vries / Suess: $\approx$ 200y
  - Hallstatt: $\approx$ 2000y

$\longrightarrow$ The three decades of Mt. Wilson can only be the beginning of a monitoring



Continuation of monitoring

- The Mt. Wilson project was finished
- Possible successors:
  - The solar-stellar spectrograph at Lowell: yes, but limited sample
  - STELLA: no, because of cocentration on Doppler imaging
  - TIGRE: yes
- TIGRE is the main successor at present