Periodicity analysis of young stars in Taurus

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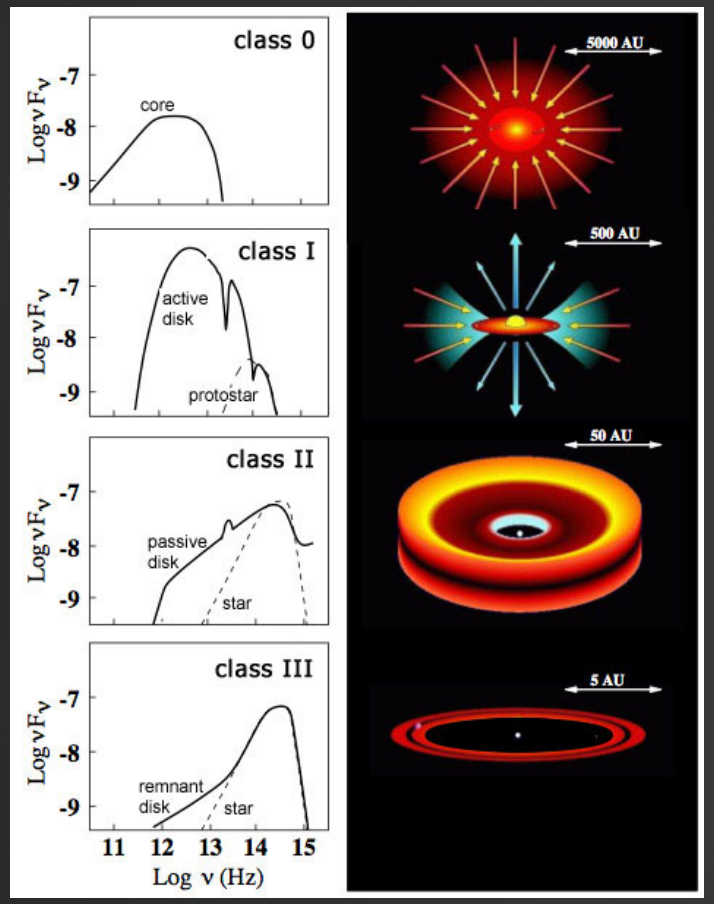
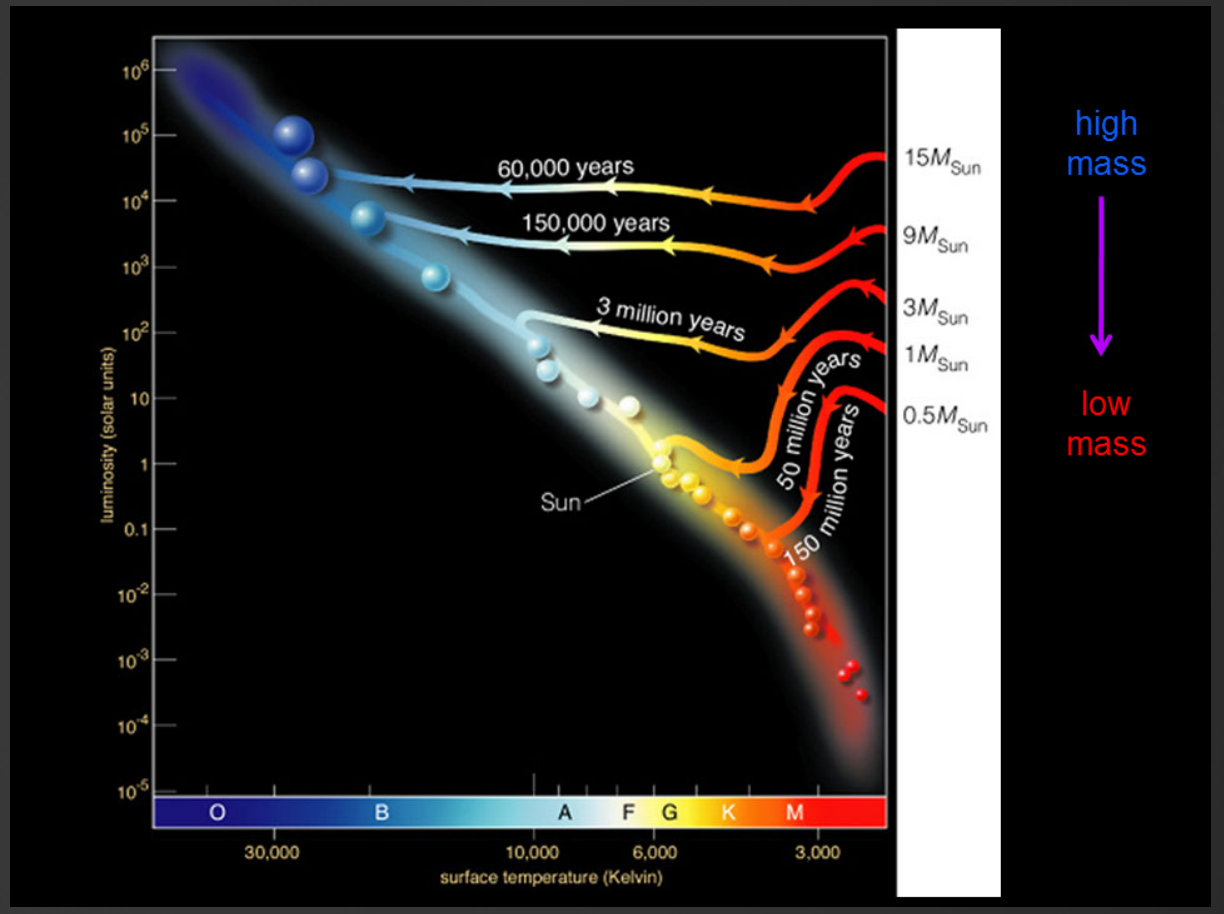
Photo: NASA

- **Introduction: what are dippers?**
- Wavelet analysis
- Results
- Outlook

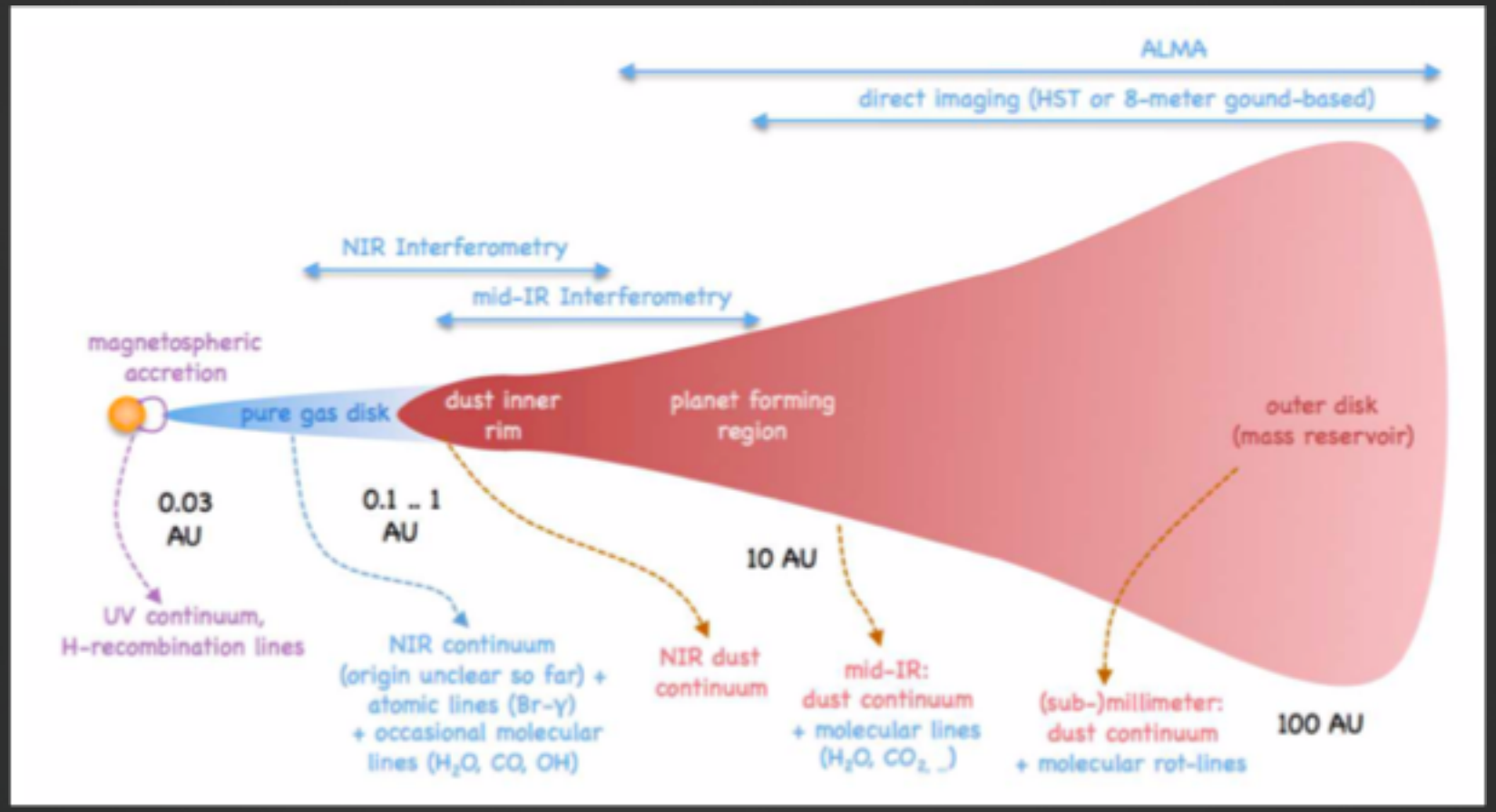
Low-mass star formation





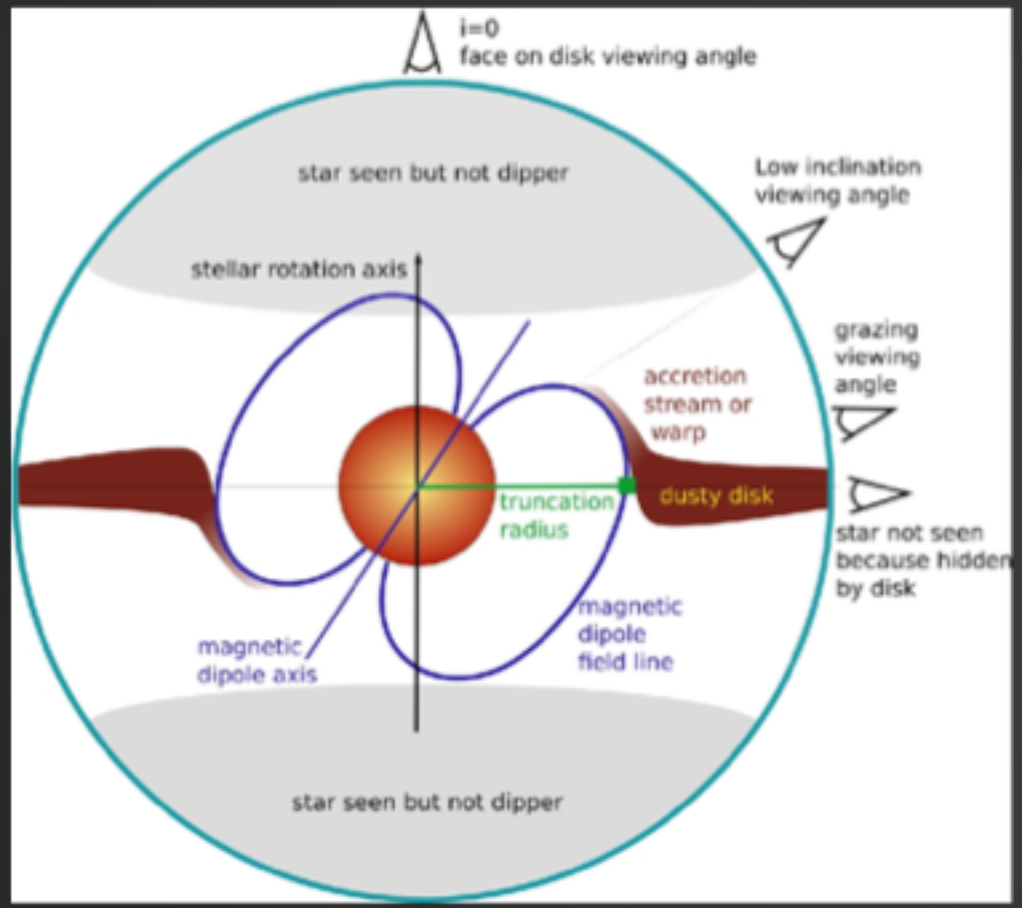
A. Isella 2006

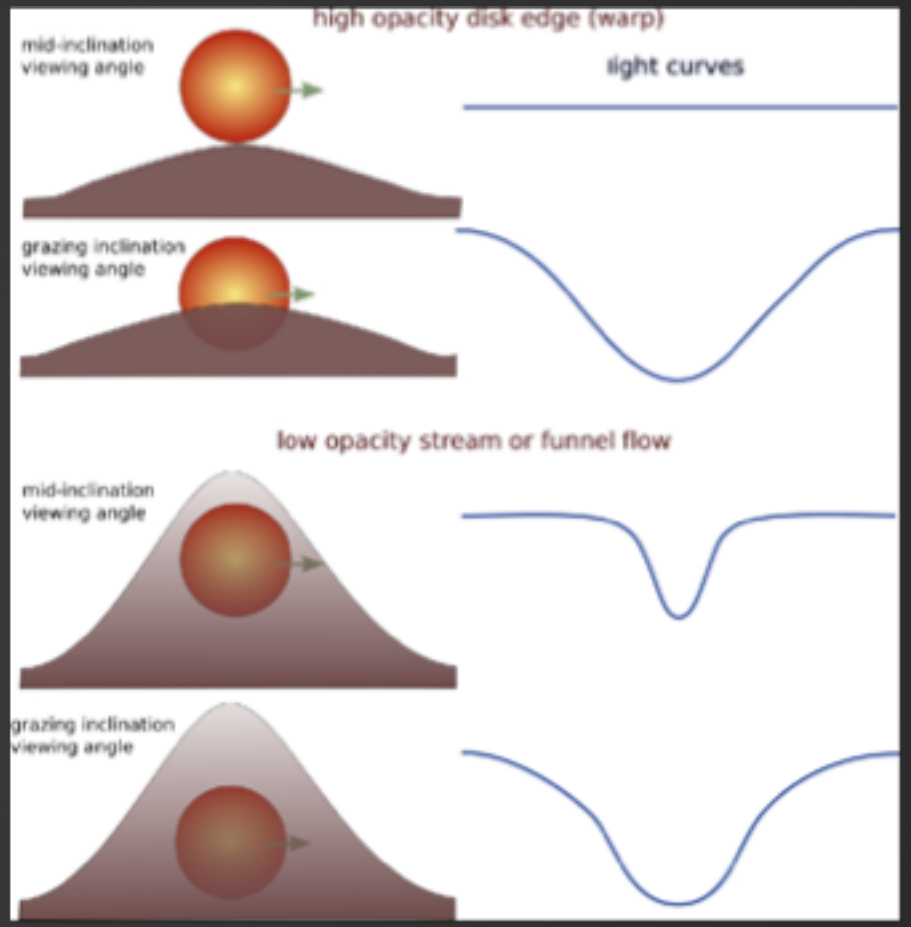
Protoplanetary disks



Dullemond & Monnier 2010

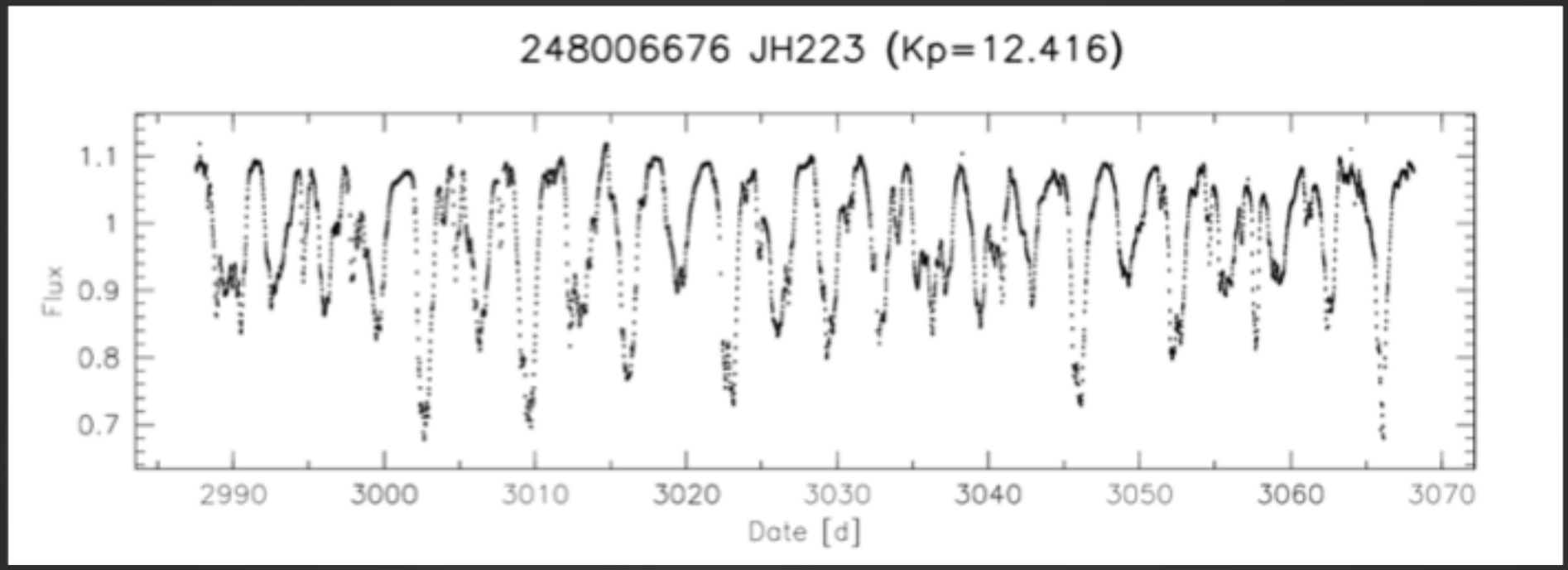
What causes dippers?





Bodman et al. 2017

A prototypical dipper: JH223



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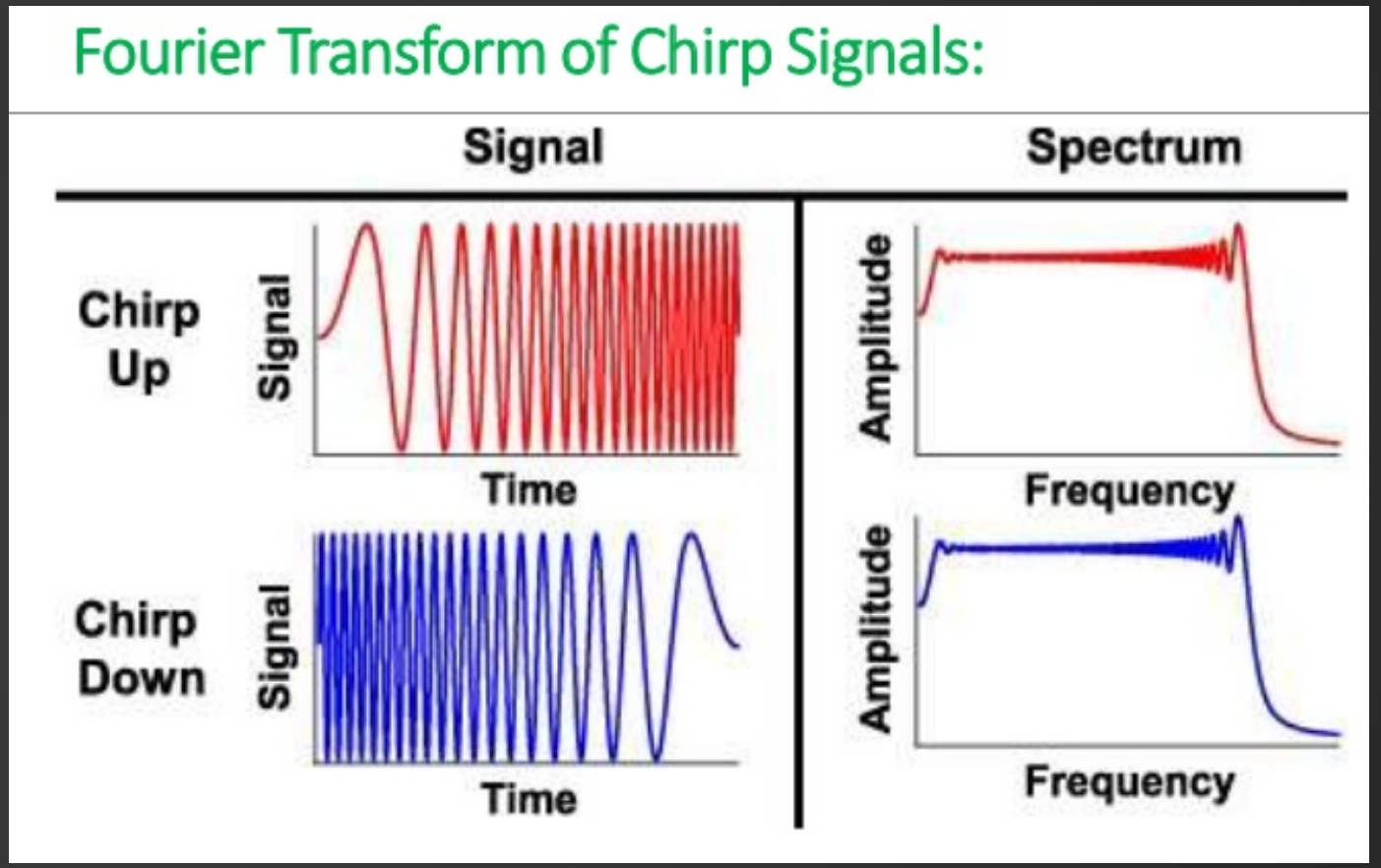
The Fourier transform

- Finds frequencies in the time series with high frequency resolution
- Problem: no time resolution for transient frequencies

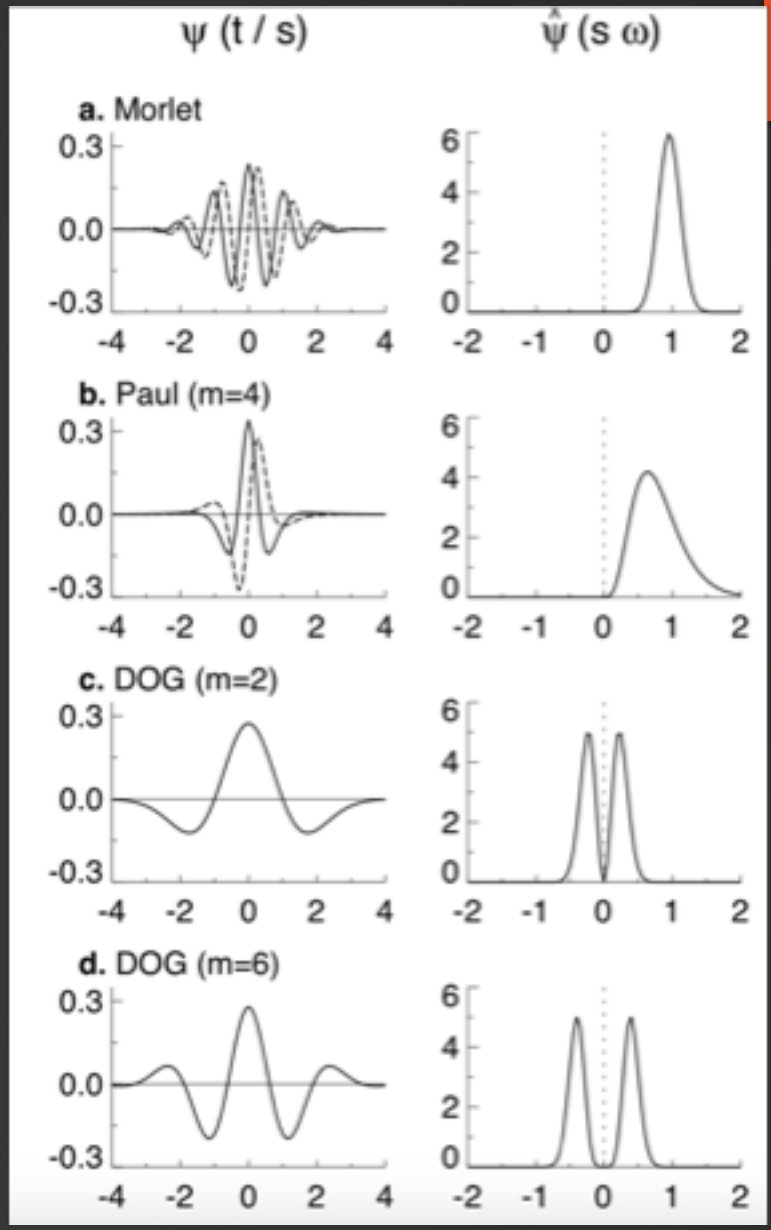


Source: Berkouk & Sadmi 2018

Wavelet transform

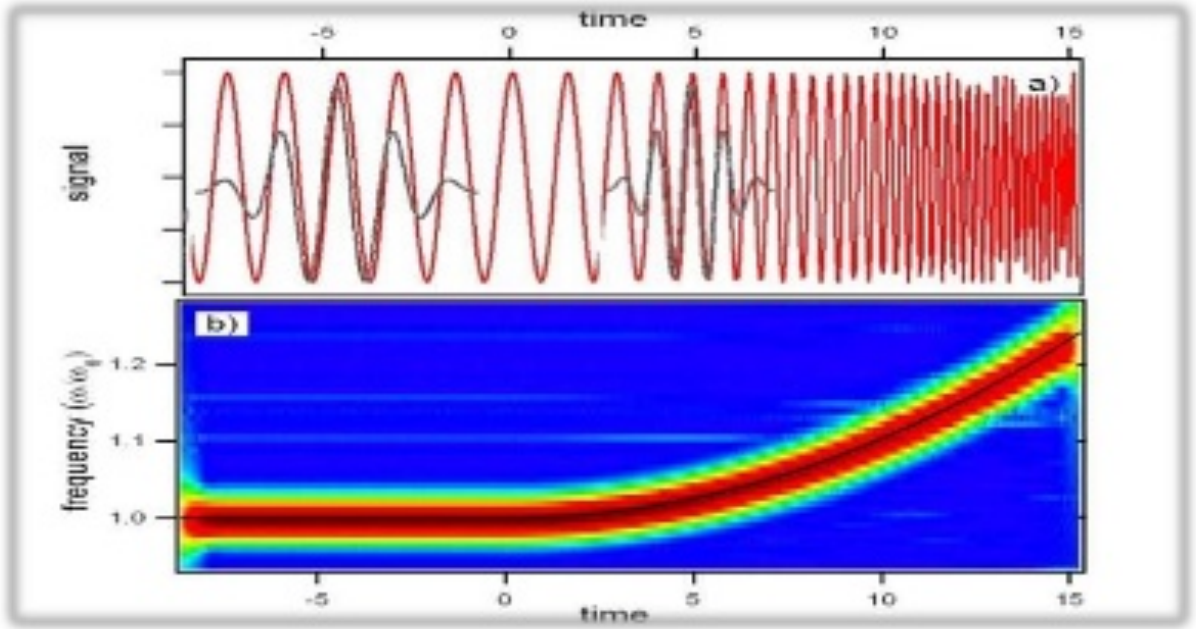
- Idea: consider a finite wave (instead of an infinite sinus) and shift it along the time series. The transform is the convolution of the signal and the wavelet at each position

Torrence&Compo 1998



Example: wavelet transform of the chirp signal

Time-frequency representation of « up-chirp » signal using CWT :



Source: Berkouk & Sadmi 2018

- Introduction: what are dippers?
- Wavelet analysis
- **Results**
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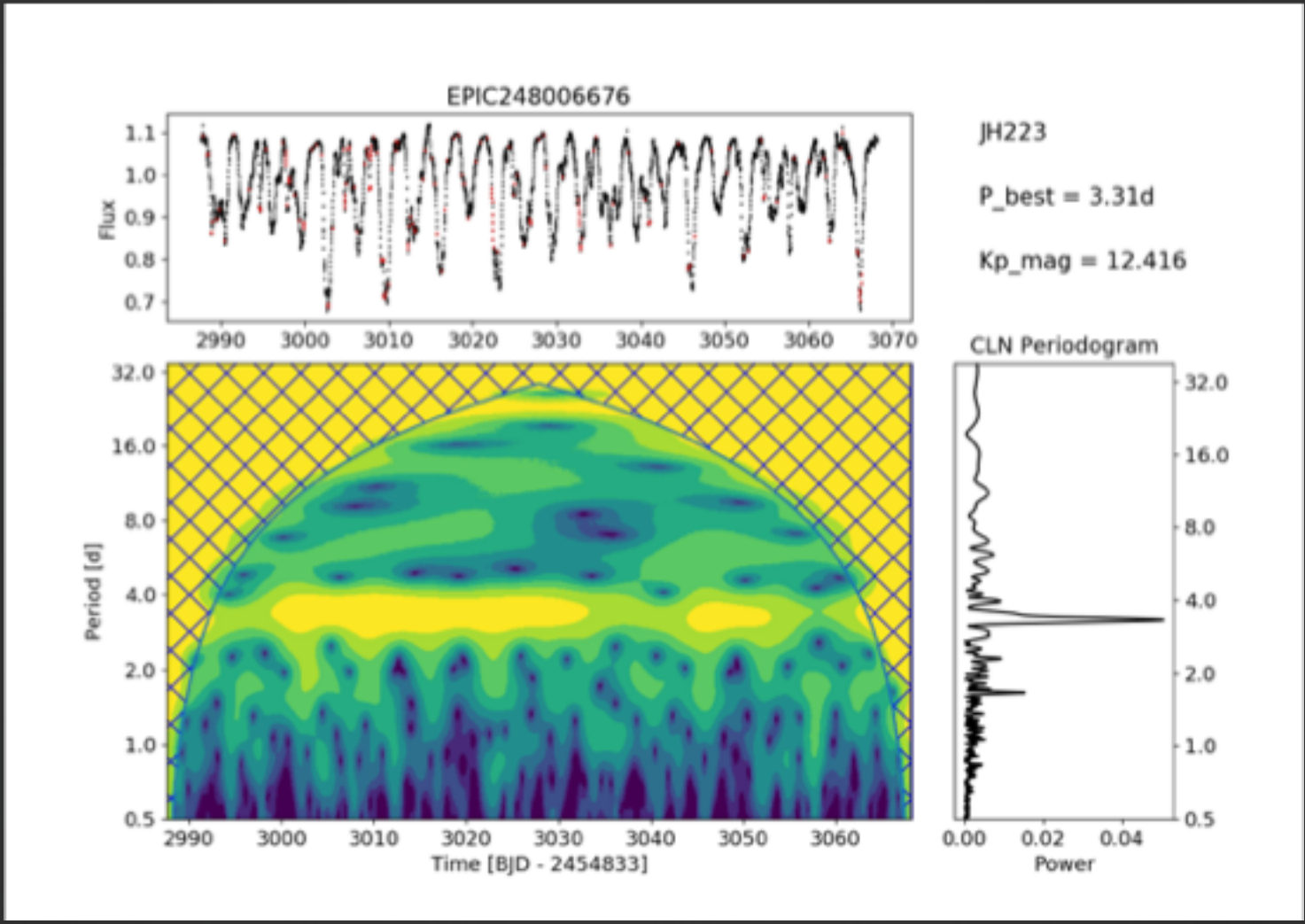
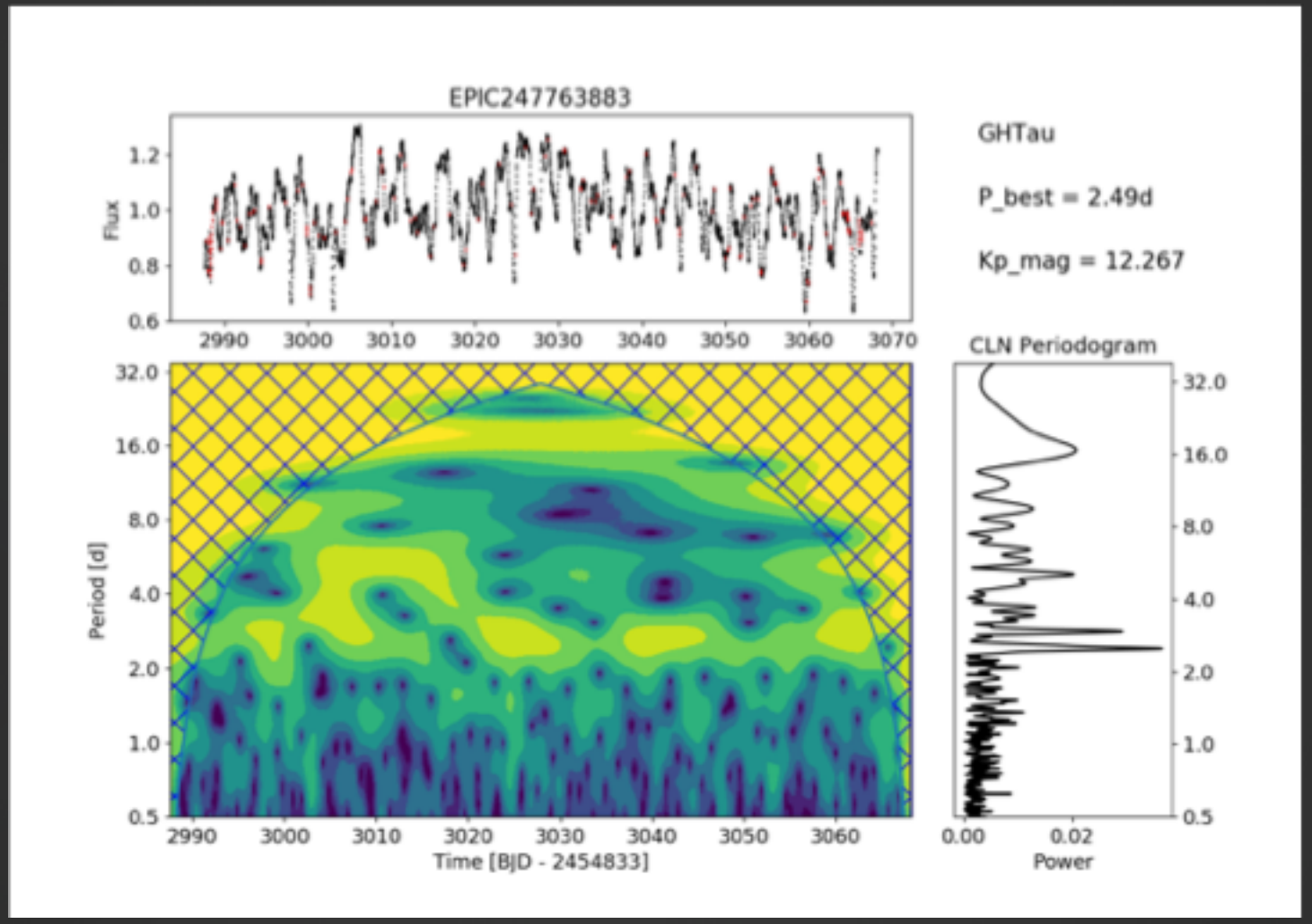
Data set

- 230 accreting YSOs in Taurus are observed in the K2 campaign (2017)
- Duration of the campaign: ~3 months, cadence 30min
- ~35 objects are dippers or show the dipper phenomenon together with another variability (bursts, spots etc.)
- In previous studies, 20-30% of CTTSs were classified as dippers (Cody et al. 2014, Alencar et al. 2010)

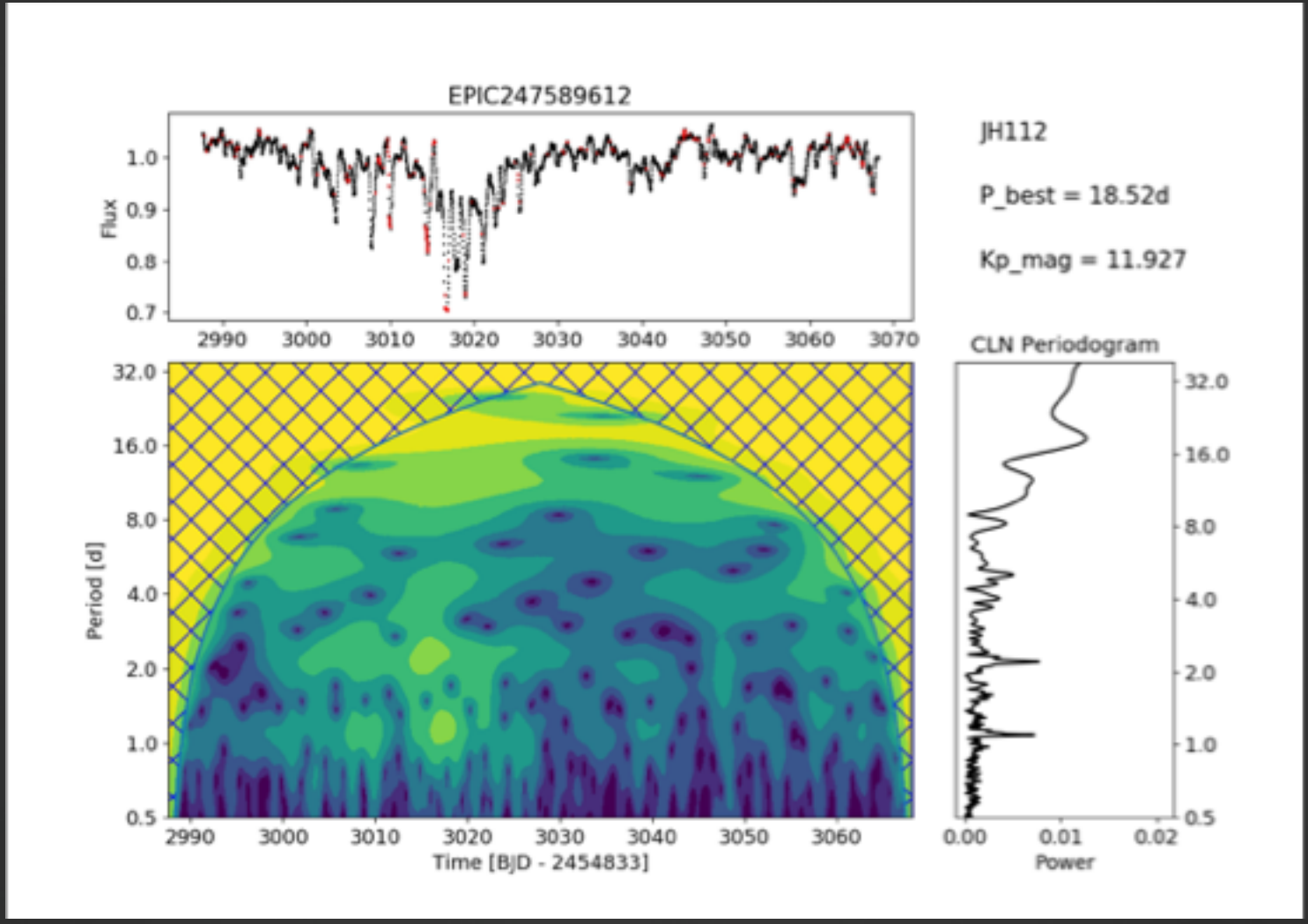
JH223: a dipper example



The case of multiple periodicities

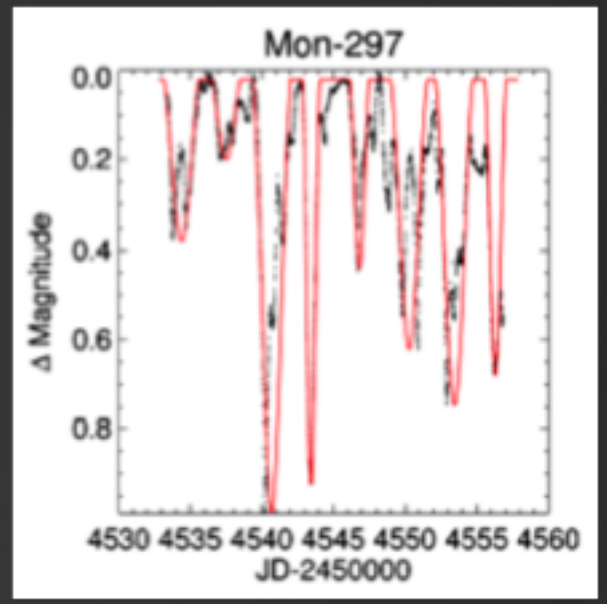


Transient dippers



Outlook

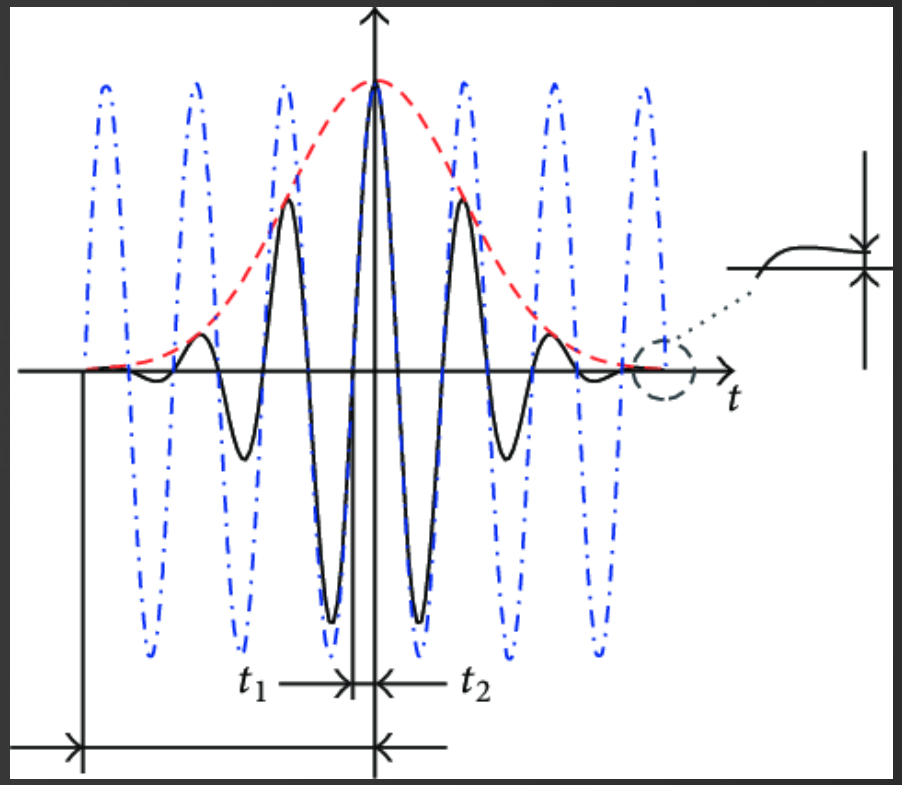
- It is possible to fit dippers with a simple occultation model
- Aim of the project: full radiative transfer modeling with the MCFOST code (Pinte et al. 2006)
- Search for planet signatures with simulations



McGinnis et al. 2015

Morlet Wavelet

- $\psi(x) = \frac{1}{\sqrt{\pi T_b}} e^{-\frac{x^2}{T_b}} e^{2\pi i F_c x}$
- Gaussian with width defined by T_b + complex wave
- To investigate all frequencies, the wavelet is stretched according to a scale *s*



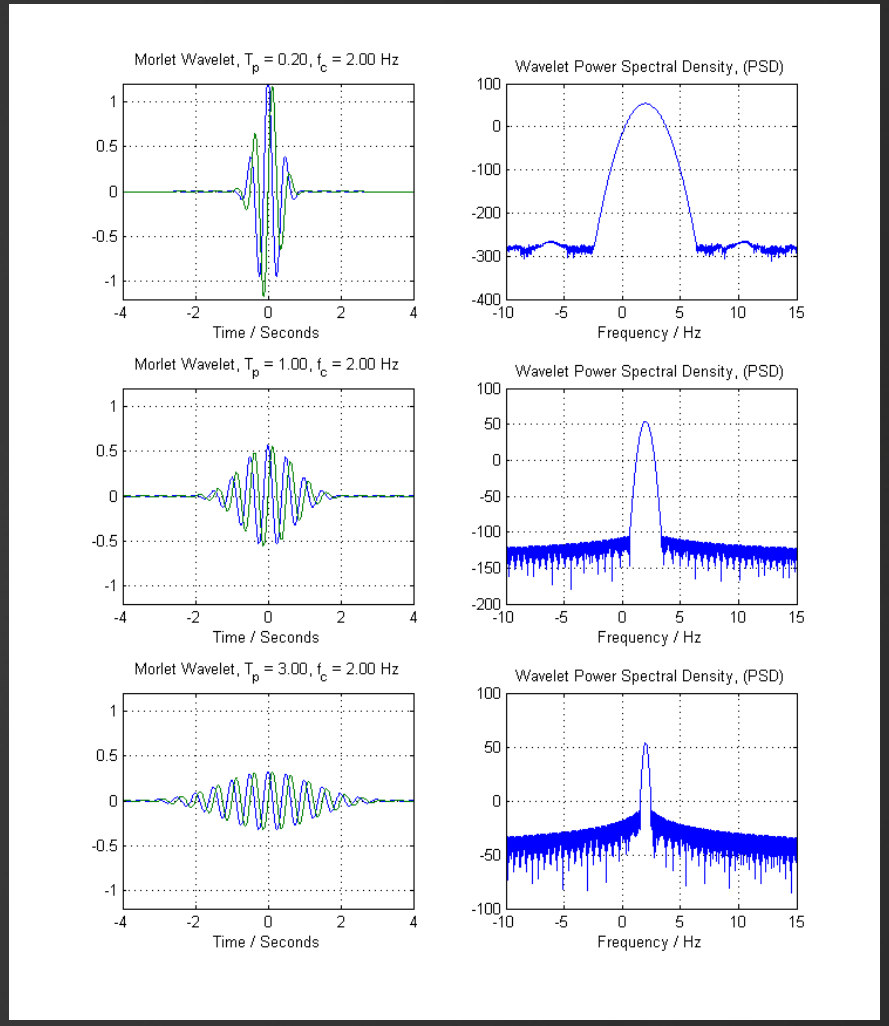
Time vs. frequency resolution

- Increasing the width of the Gaussian increases the frequency and worsens the time resolution

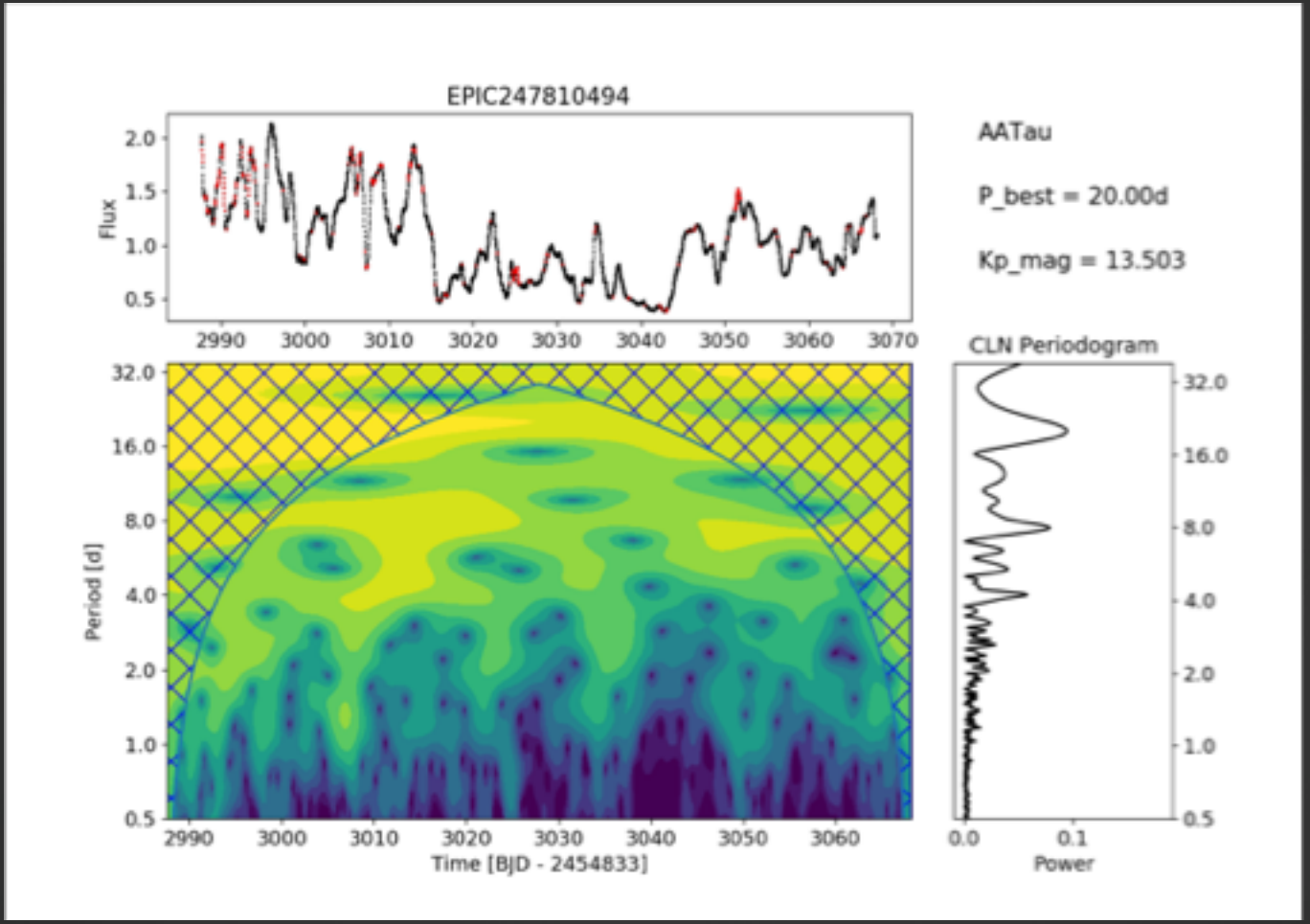
-> uncertainty principle

- Remember:

$$\hat{\psi}(\omega) = e^{-\frac{\pi^2 (f - F_c)^2 T_b}{2}}$$



AA Tau


EPIC247810494
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1.5
1.0
0.5
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3000
3010
3020
3030
3040
3050
3060
3070
AATau
P_best = 20.00d
Kp_mag = 13.503
CLN Periodogram
Period [d]
32.0
16.0
8.0
4.0
2.0
1.0
0.5
Time [BJD - 2454833]
0.0
0.1
Power