# MULTIFREQUENCY ANALYSIS OF QUASIPERIODICAL ASTROPHYSICAL SIGNALS

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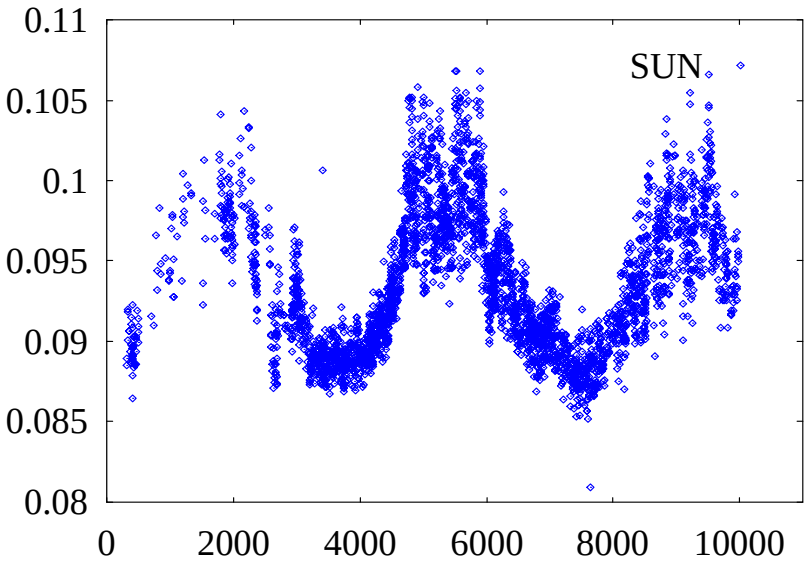
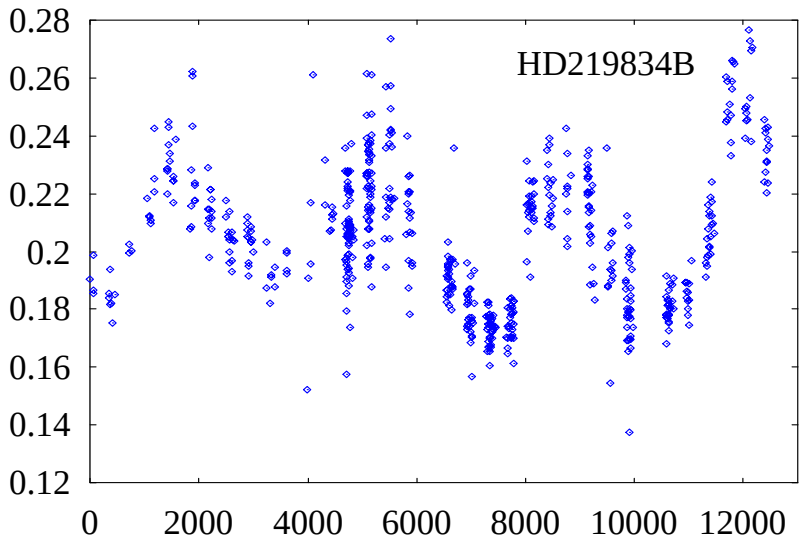
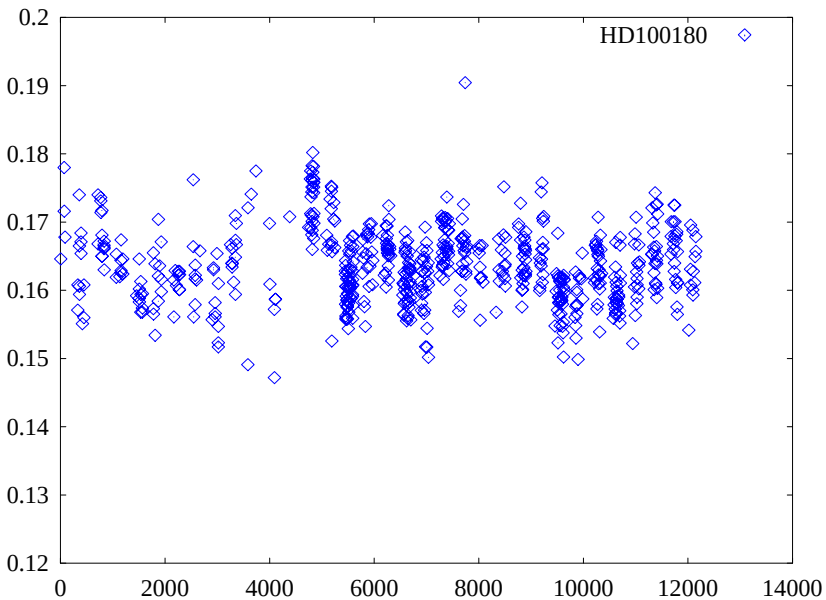
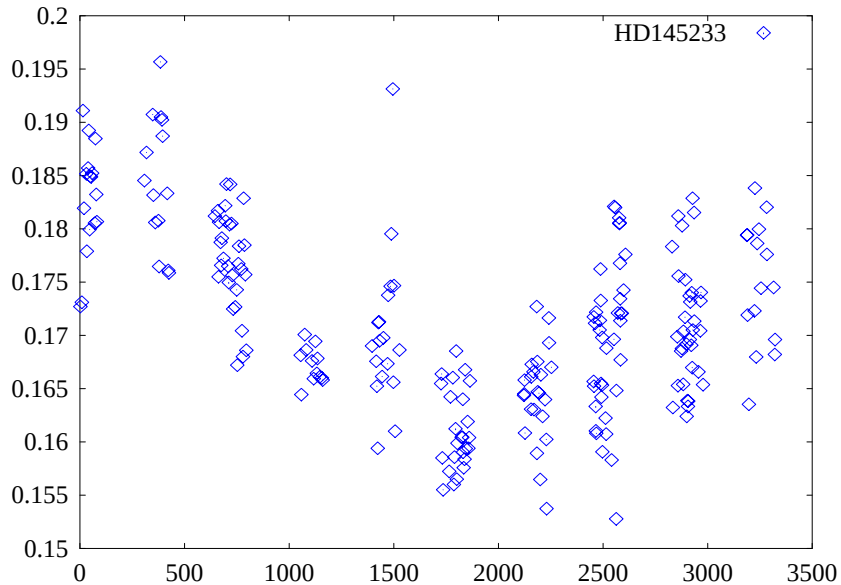
# Chromospheric activity time series for 2 stars: a) Sun; b) HD219883.



# Wavelet Transform

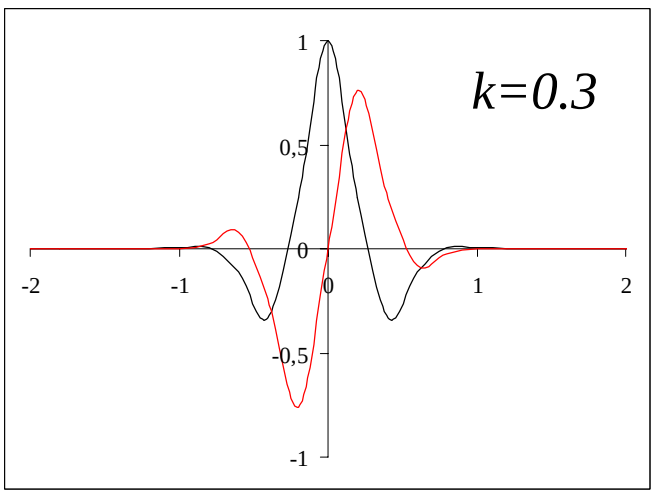
$$W_1(a,t) = a^{-1/2} \int f(t')\psi(\frac{t'-t}{a})dt' \qquad (1)$$

**Wavelet spectrum**

$$E(a) = \int |W_1(a,t)|^2 dt \qquad (2)$$

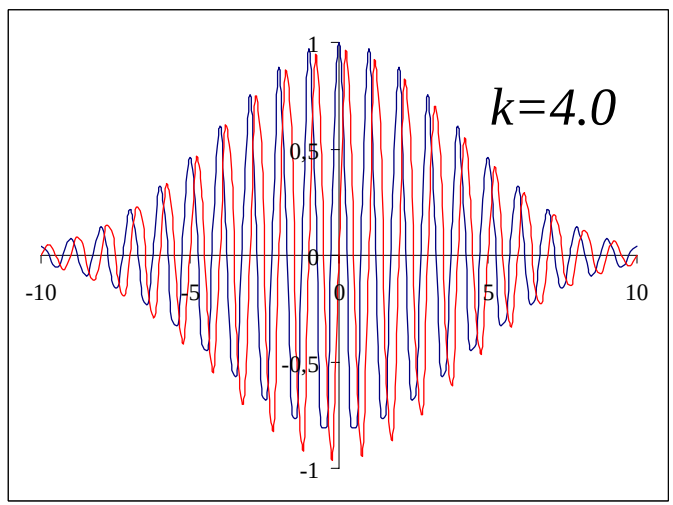
**Morlet Wavelet**

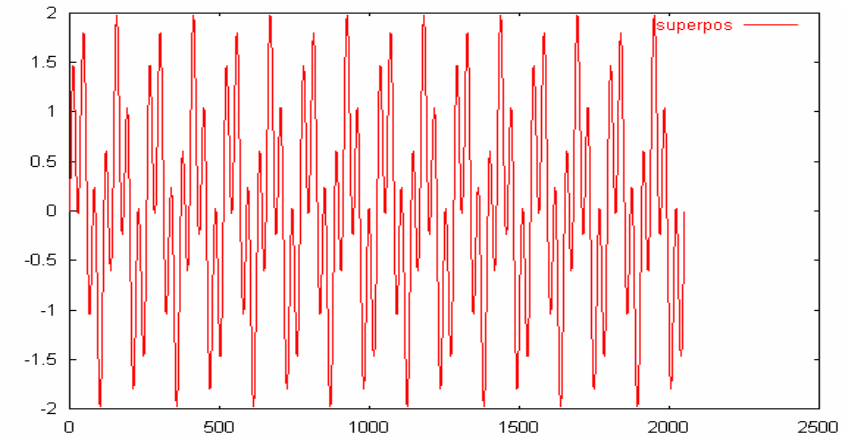
$$\psi(t) = e^{-t^2/2k^2} e^{i2\pi t} \qquad (3)$$

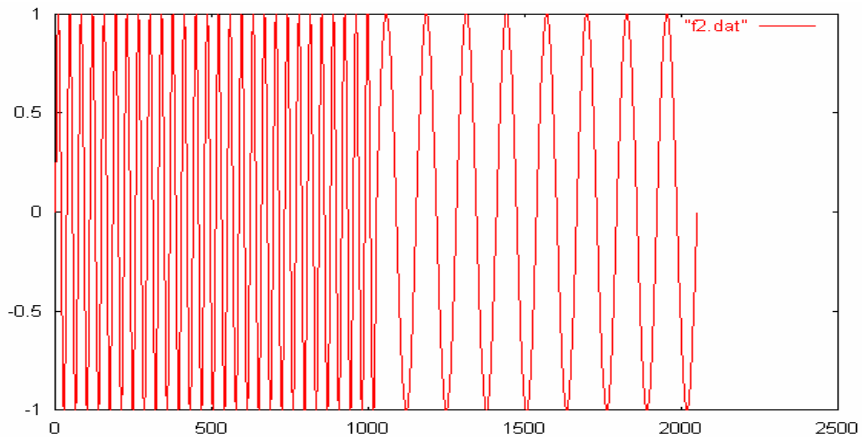


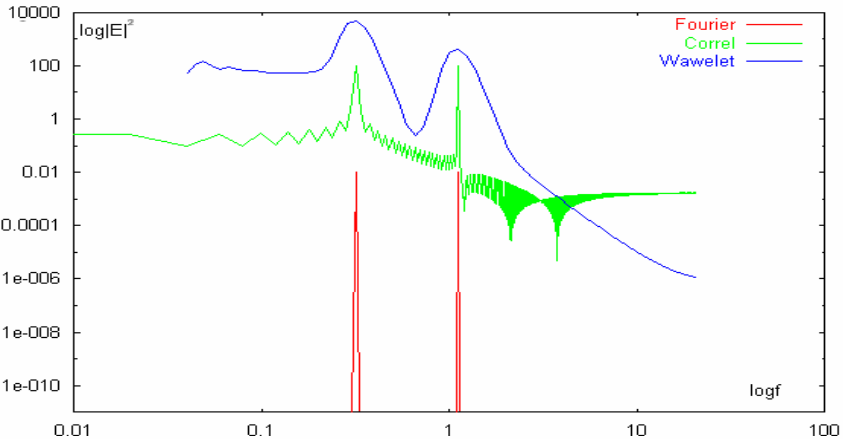

$$\delta t = cka$$

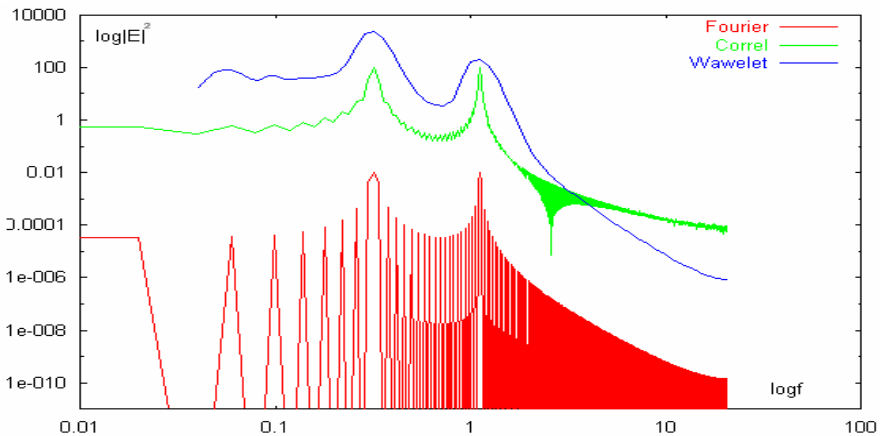
$$\delta\omega = \frac{c}{ka}$$




superpos


"f2.dat"


log|E|²
Fourier
Correl
Wawelet
logf


log|E|²
Fourier
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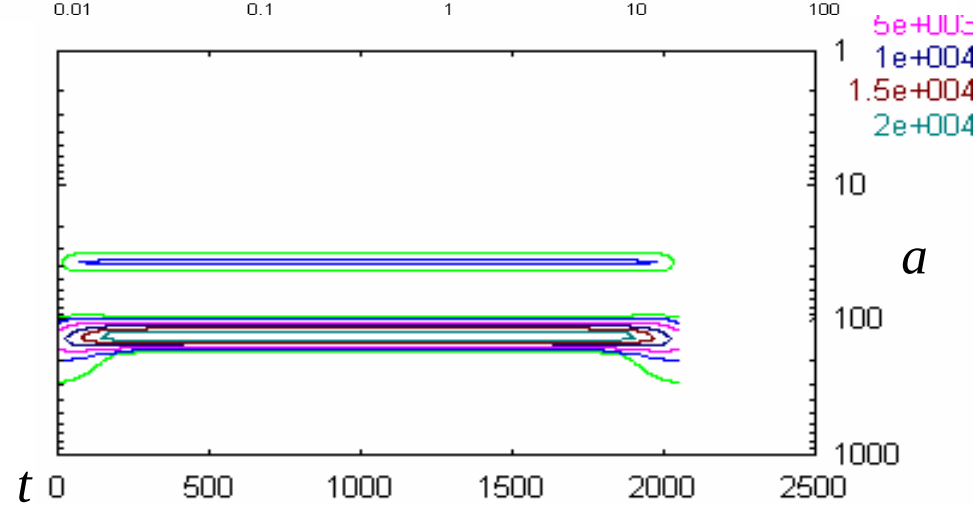
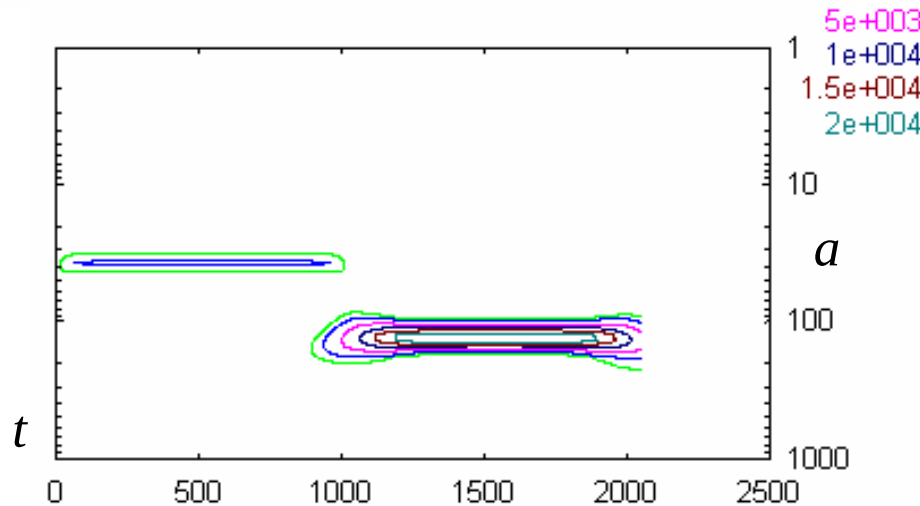

5e+003
1e+004
1.5e+004
2e+004
a
t


5e+003
1e+004
1.5e+004
2e+004
a
t

# DWA-Double Wavelet Analysis

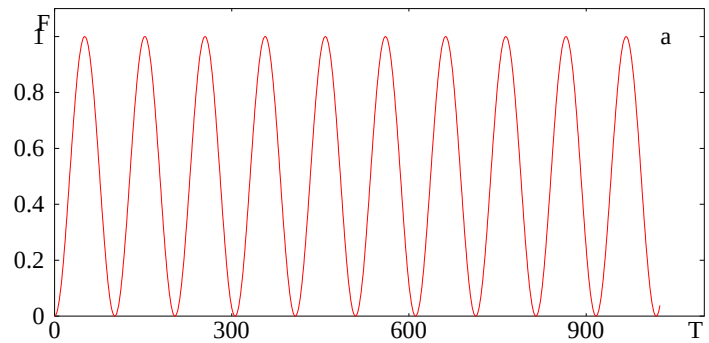
$$W_1(a,t) = a^{-1/2} \int f(t')\psi(\frac{t'-t}{a})dt' \qquad (2)$$

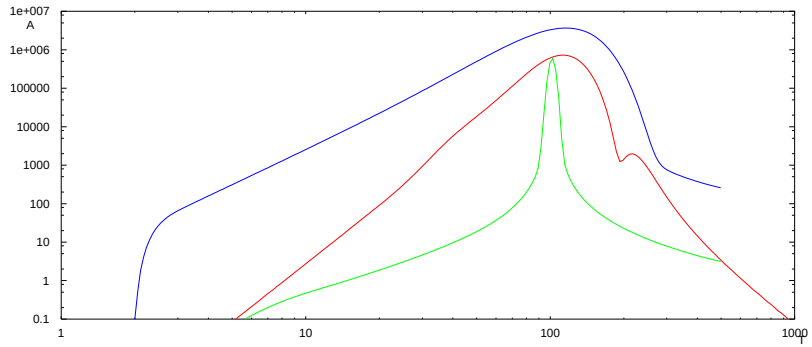
$$W_2(a,t) = a^{-1/2} \int |W_1(a,t')|\psi(\frac{t'-t}{P_c})dt' \qquad (4)$$

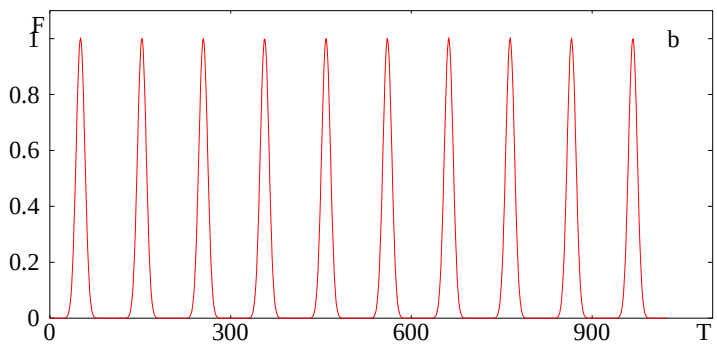
$$M_2(a) = \int |W_2(a,t)|^2 da \qquad (5)$$

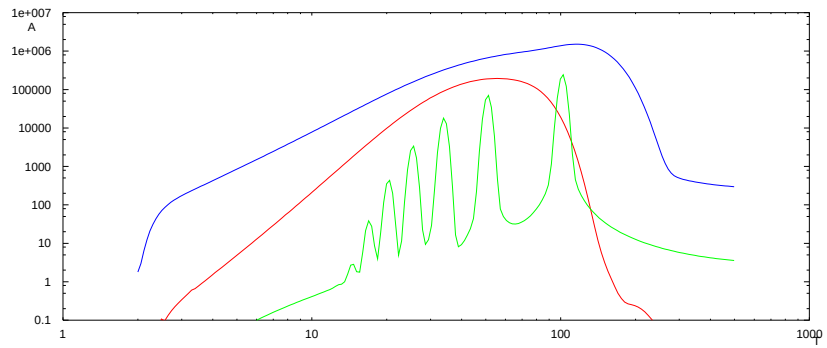
$$A = \frac{P_c}{a^*} \qquad (6)$$

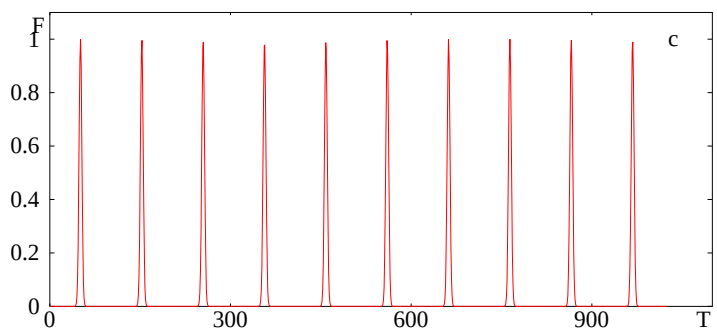
Test functions (left) $f_n = [\sin(2\pi\upsilon t)]^{2n}$ : n=1 (a), n=10 (b), n=100 (c).
Spectra (right) : k=4.0 (green ) , k=0.3 (blue), DWA (red).

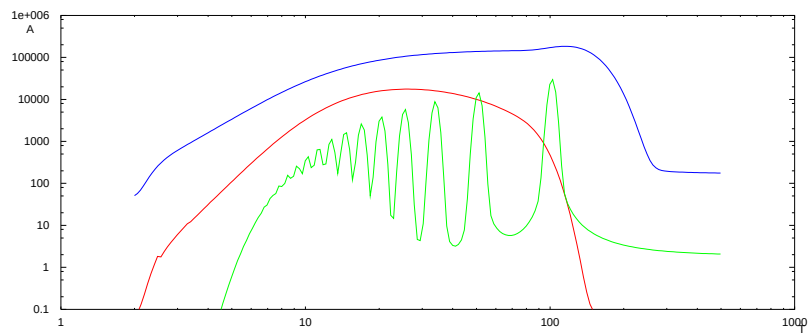


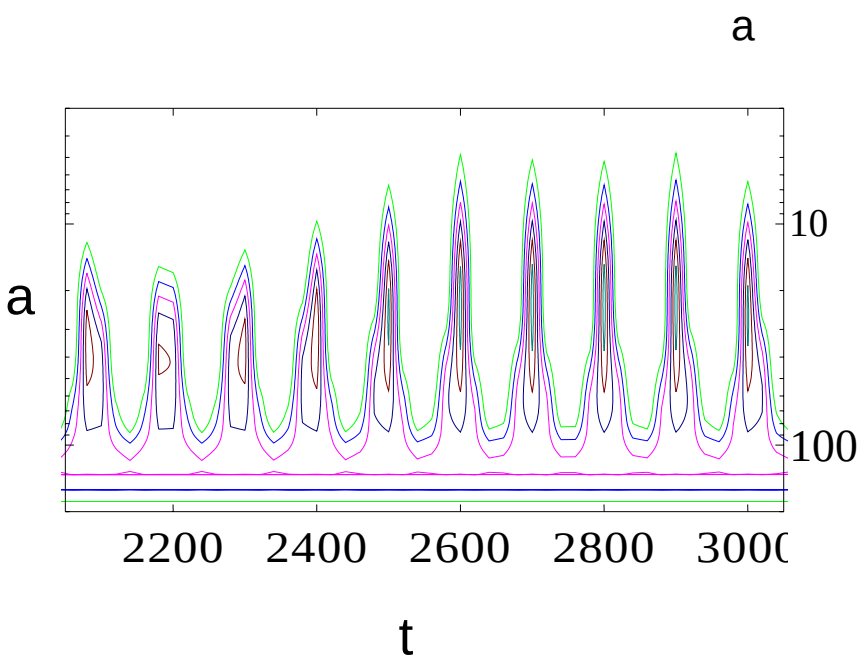



Wavelet plan $W_1(a,t)$ for the test function at n=100.
a) k=0.3; b) k=4.0



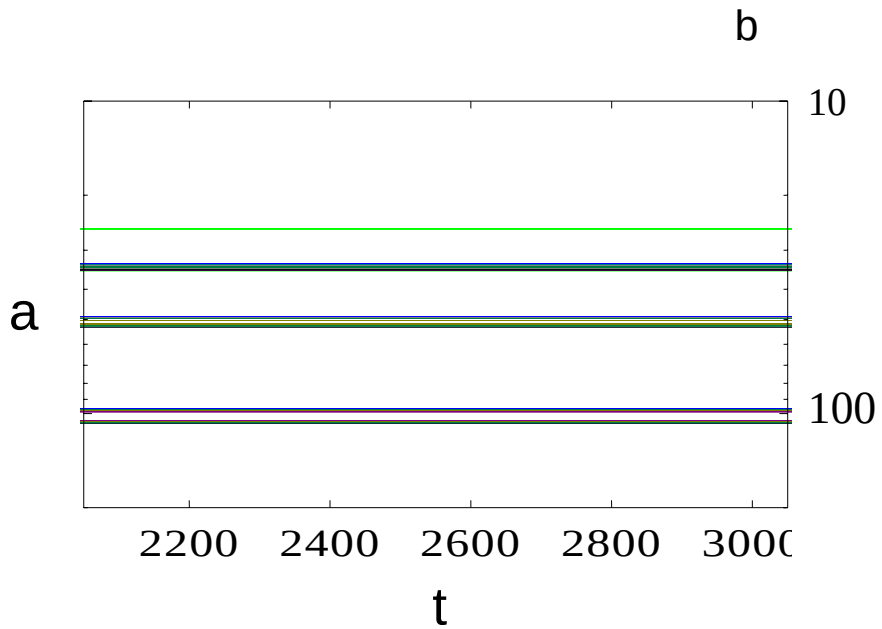



Table 1. Anharmonisity for test signals.

| signals | $\sin^2 t$ | $\sin^4 t$ | $\sin^{10} t$ | $\sin^{20} t$ | $\sin^{200} t$ |
|---|---|---|---|---|---|
| A | 1.05 | 1.49 | 1.60 | 1.83 | 3.92 |
| $M_2 / M_1$ | 0.0 | 0.06 | 0.29 | 0.49 | 0.97 |

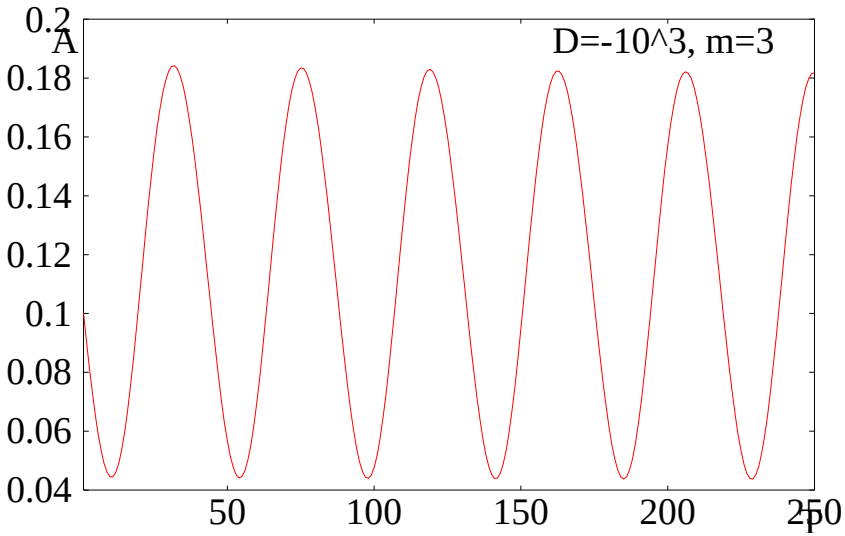
# Model (D. Moss)

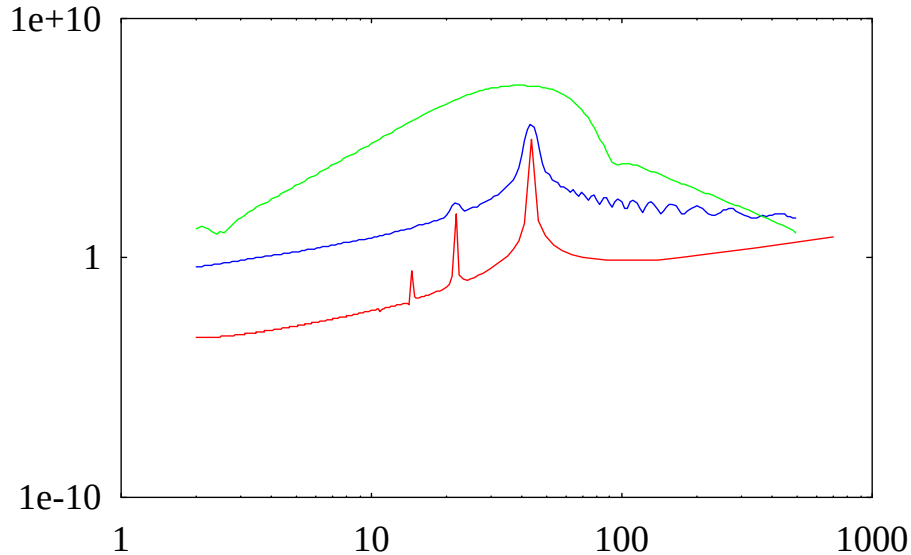
$$\frac{\partial B}{\partial t} = D\sin\theta\frac{\partial A}{\partial \theta} + \frac{\partial^2 B}{\partial \theta^2} - \mu^2 B \quad (1)$$

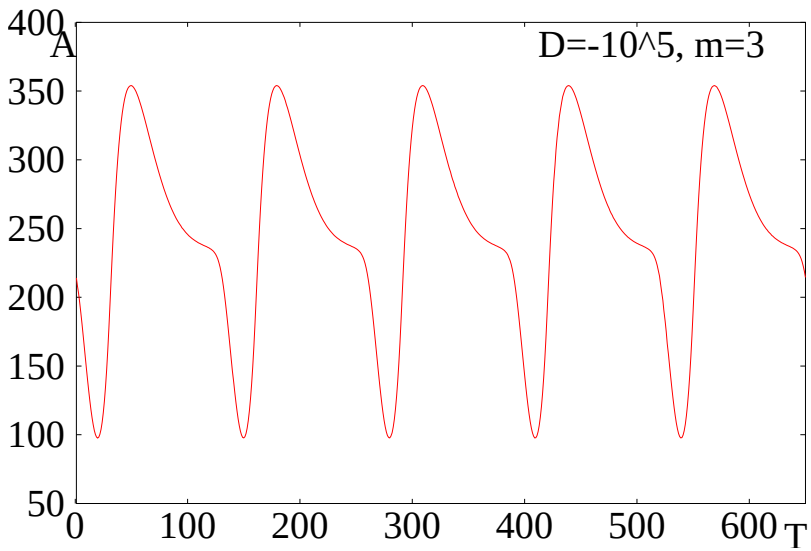
$$\frac{\partial A}{\partial t} = \alpha B + \frac{\partial^2 A}{\partial \theta^2} - \mu^2 A \quad (2)$$

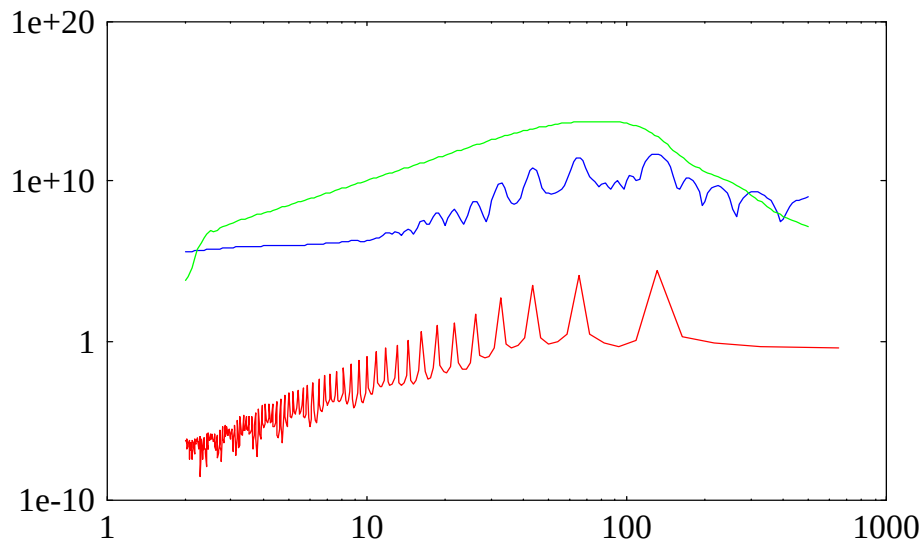
$$\alpha(B) \propto f(B)\cos\theta, \qquad f(B) = 1/(1+B^2) \quad (3)$$

# Time series from numerical simulations of the Parker migratory dynamo model (left) and Fourier (red), wavelet k=4 (blue) and DWA (green) spectra

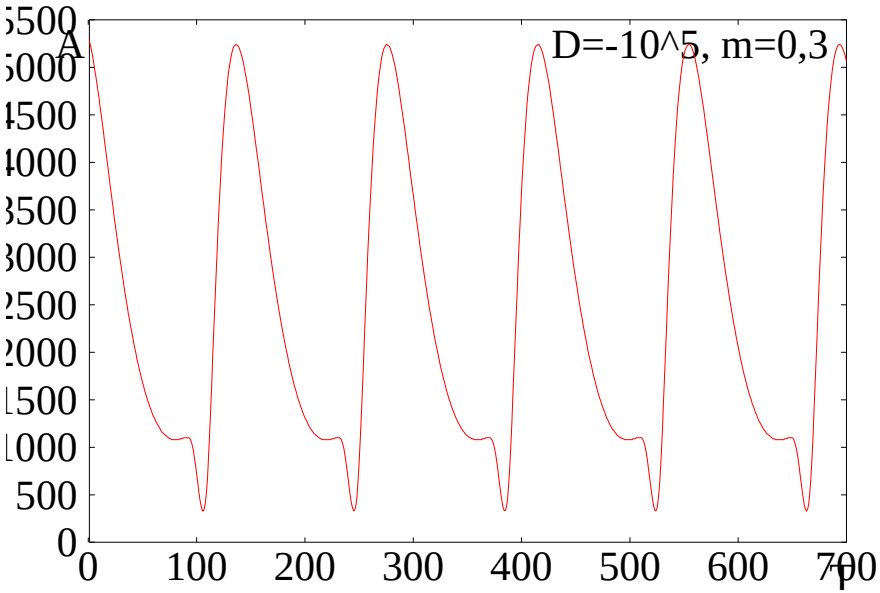


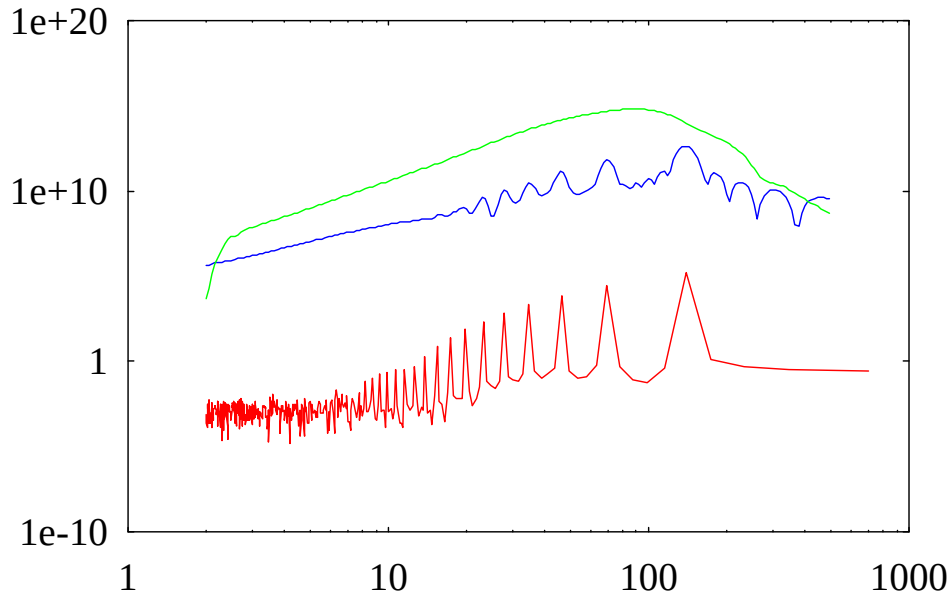



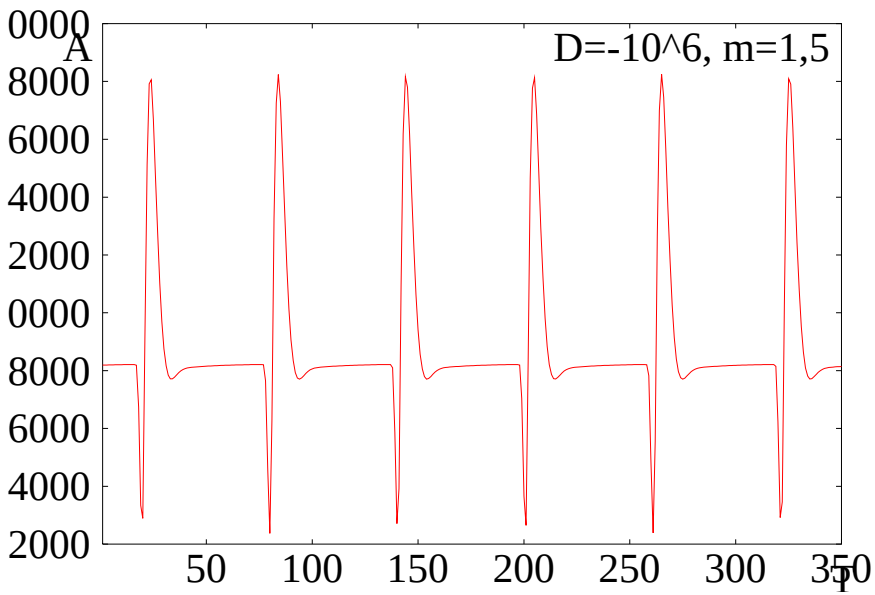



# Time series from numerical simulations of the Parker migratory dynamo model and wavelet, fourier and DWA spectra
# (green line-DWA, blue line-wavelet spectra k=4.0, red line-fourier spectra)



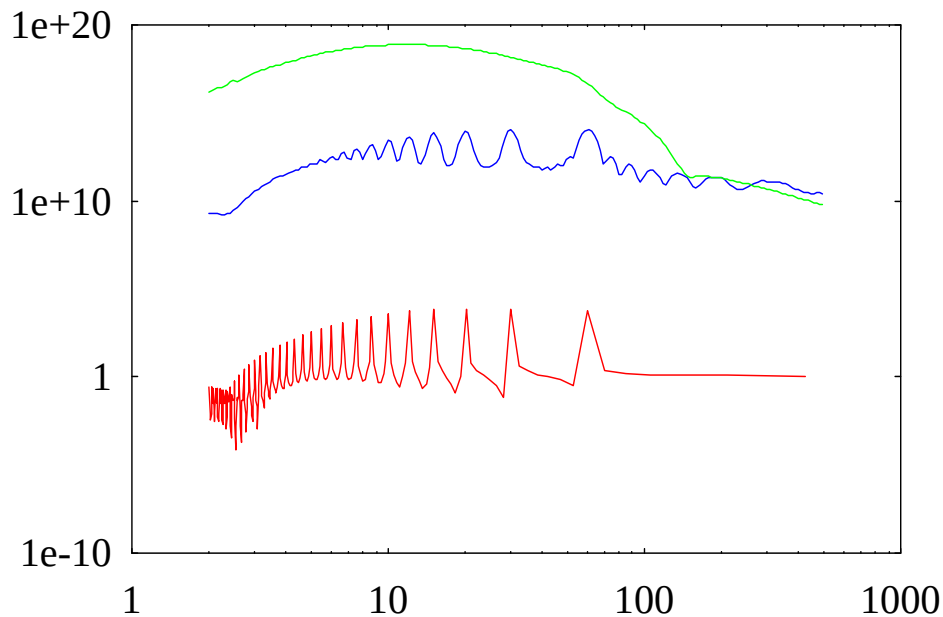



Table 2 .Anharmonicity measures for the Parker migratory dynamo (Ds=-10^3 and ms=3) the first entry (left) in each main box is A the second (right) is M2/M1

| *D/Ds* | *μ/μs* | | | | |
|---|---|---|---|---|---|
| | 0 | 0.1 | 0.5 | 1.0 | 2.0 |
| 0.1 | decays | decays | decays | decays | decays |
| 0.3 | 1.48/0.05 | 1.13/0.04 | 0.93/0.01 | decays | decays |
| 1 | 1.58/0.11 | 1.53/0.08 | 1.51/0.06 | 1.1/0.001 | decays |
| 10 | 1.56/0.16 | 1.59/0.2 | 1.62/0.25 | 1.49/0.002 | 0.94/0.001 |
| 100 | 1.5/0.18 | 1.56/0.16 | 1.84/0.36 | 1.65/0.6 | 0.96/0.003 |
| 1000 | 1.57/0.21 | 1.58/0.15 | 5.01/1.2 | aperiodic | 0.9/0.01 |

Table 3. Two measures of anharmonicity of stellar cycles for various stars ('y' denotes a young star) derived from recorded daily Ca II h and K time series of the Mount Wilson HK Project

| Object | $P_c$ (years) | A | $M_2/M_1$ |
|---|---|---|---|
| HD16160 | 12.3 | 1.0 | 0.02 |
| HD146233 | 8 | 1.0 | 0.14 |
| HD26913 (y) | 5.8 | 1.0 | 0.17 |
| HD160346 | 7.1 | 1.2 | 0.03 |
| HD161239 | 5.1 | 1.3 | 0.02 |
| HD10476 | 10.4 | 1.3 | 0.16 |
| HD4628 | 8.5 | 1.4 | 0.02 |
| SUN | 11 | 1.5 | 0.03 |
| HD81809 | 8.1 | 1.5 | 0.08 |
| HD26965 (y) | 10 | 1.5 | 0.18 |
| HD103095 | 7.2 | 1.5 | 0.18 |
| HD187691 | 8 | 1.7 | 0.08 |
| HD219834B | 16 | 1.7 | 0.15 |
| HD20630 (y) | 5.5 | 2.9 | 0.11 |
| HD18256 (y) | 7 | 3.8 | 0.27 |

Chromospheric activity time series and wavelet and DWA spectra (green line-DWA, red line-wavelet spectra for 2 stars: