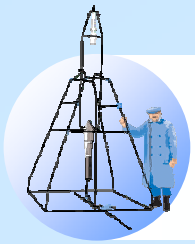

Upconversion Study with the Hilbert-Huang Transform

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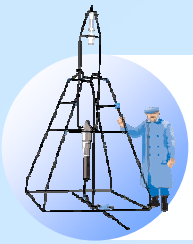
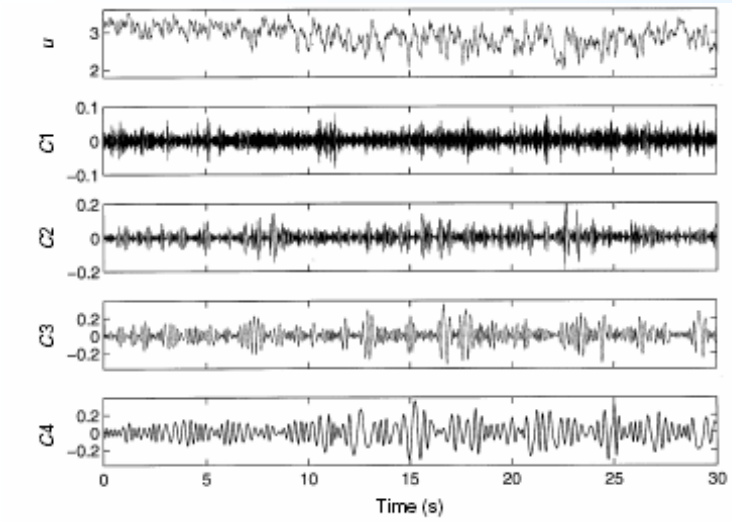


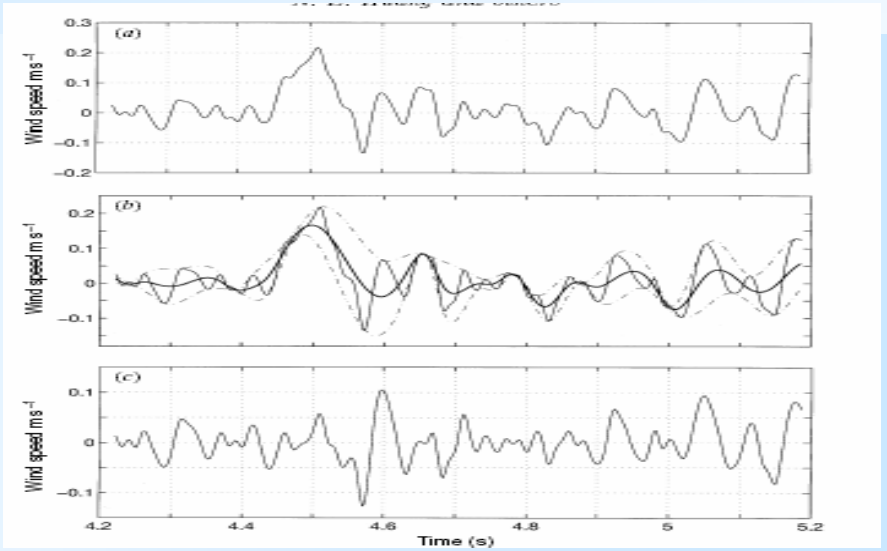
HHT – A new approach to time-series analysis

- Time-Frequency decomposition is key to identifying signals
  - Gravitational waves
  - Instrumental glitches
- Fourier and Wavelet analysis are "basis set" approaches
  - Express time-series as sum of fixed frequency waves
  - Works best when waves are actually present and stationary
  - If not, get time-frequency spreading: $\Delta t \, \Delta f \sim 1$
- HHT is adaptive approach
  - Does not impose any fixed form on decomposition
  - Allows very high t-f resolution
  - Not as good for persistent signal with very low SN

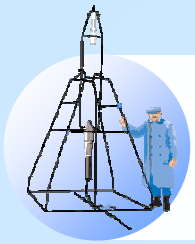
HHT: Empirical Mode Decomposition

- Data $X(t)$ is *sifted* into symmetric components with zero mean: $X_i(t)$
  - Sifting process is adaptive and does not assume a basis set
  - Sifted components occupy different frequency ranges of the data
  - Their sum forms the data





Sifting identifies, fits to, and subtracts using the data extrema



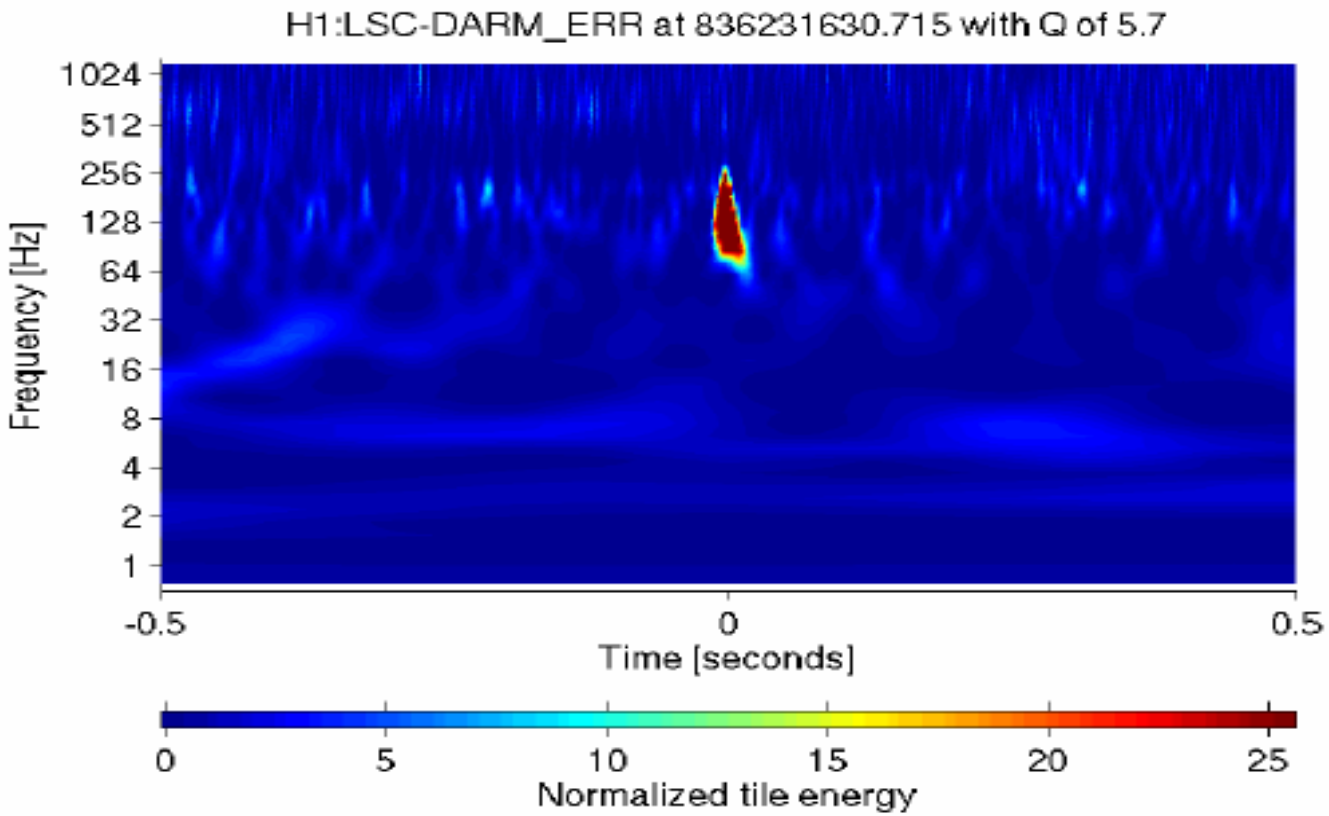
HHT: Hilbert Transform

- **Application of Hilbert Transform to sifted data yields *instantaneous* frequency and power**
  - **Very different from Fourier frequency**
  - **X(t) must have monochromatic form (obtained from sifting)**

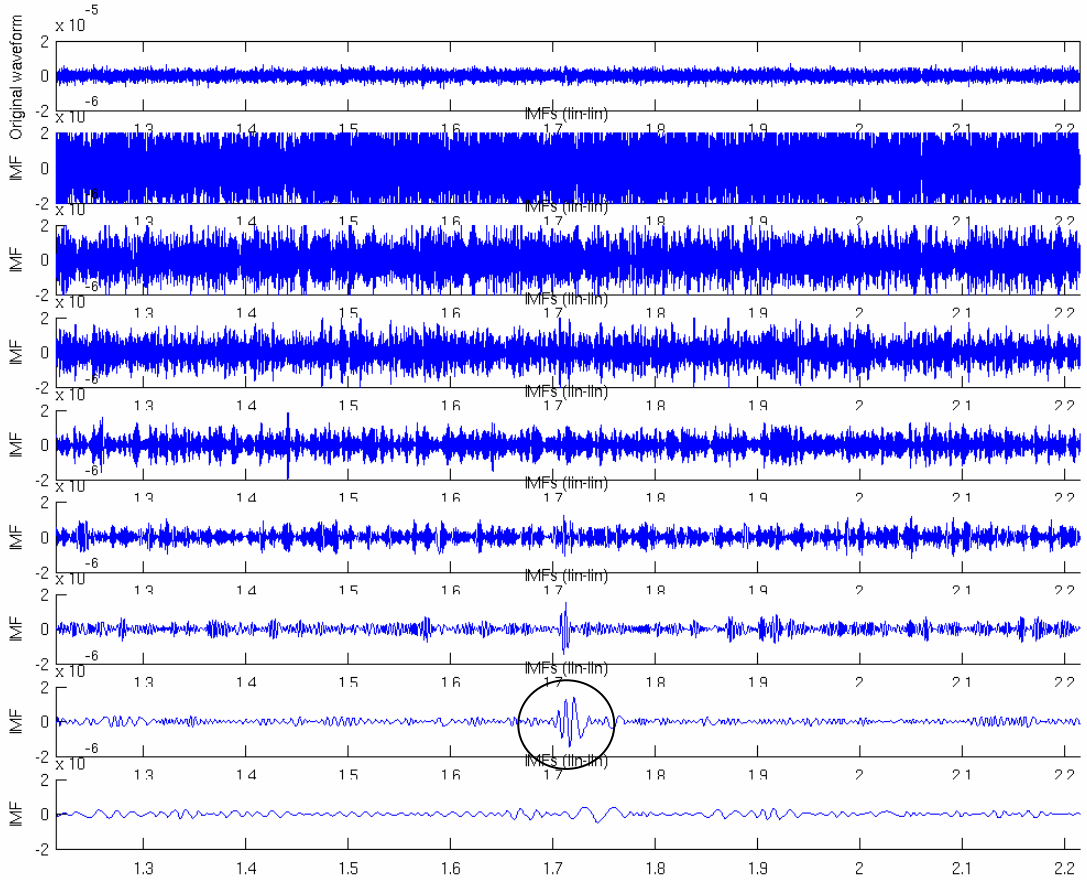
$$Y_i(t) = \frac{1}{\pi}\int \frac{X_i(t')}{t-t'}dt'$$

$$\omega_i(t) = \frac{d}{dt}\left(\arctan\left[\frac{Y_i(t)}{X_i(t)}\right]\right) \qquad a(t) = \left[X(t)^2 + Y(t)^2\right]^{1/2}$$

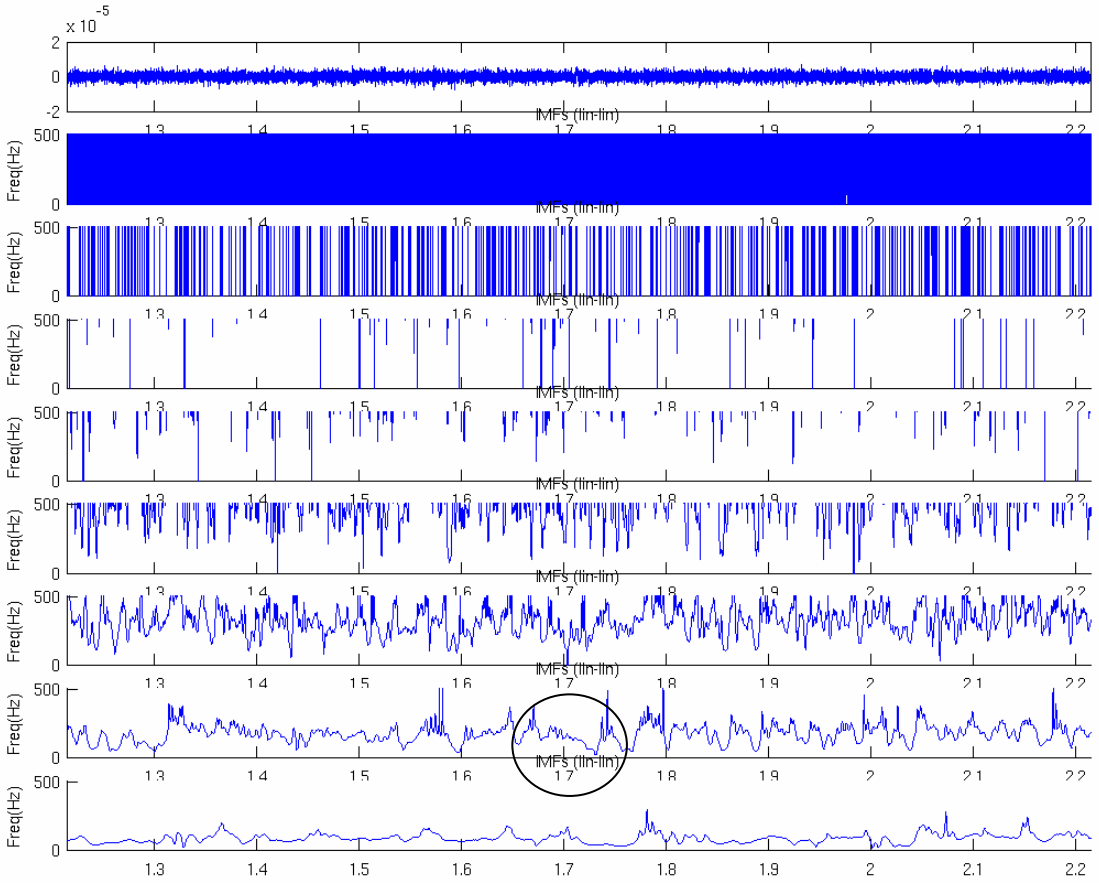
A look at Glitch at t = 836231630.715



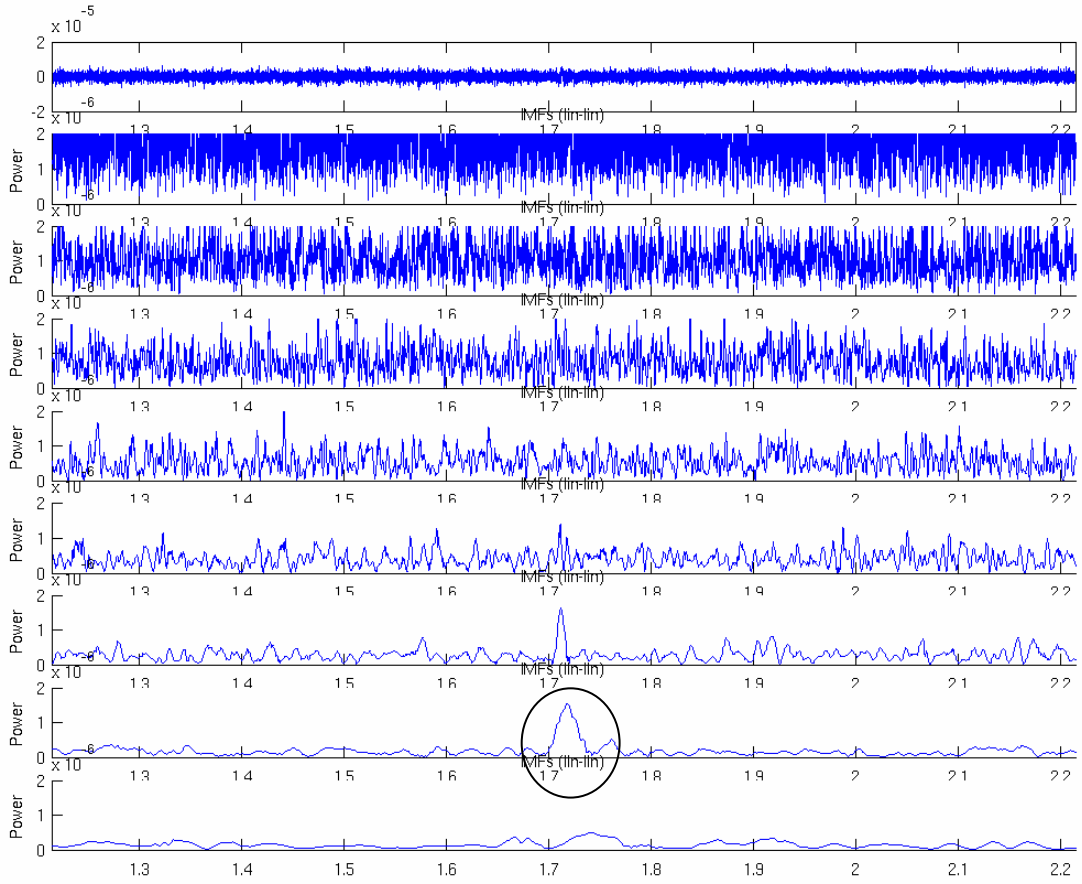
HHT of Glitch: IMF's

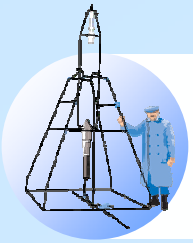


HHT of Glitch : Instantaneous Freq.



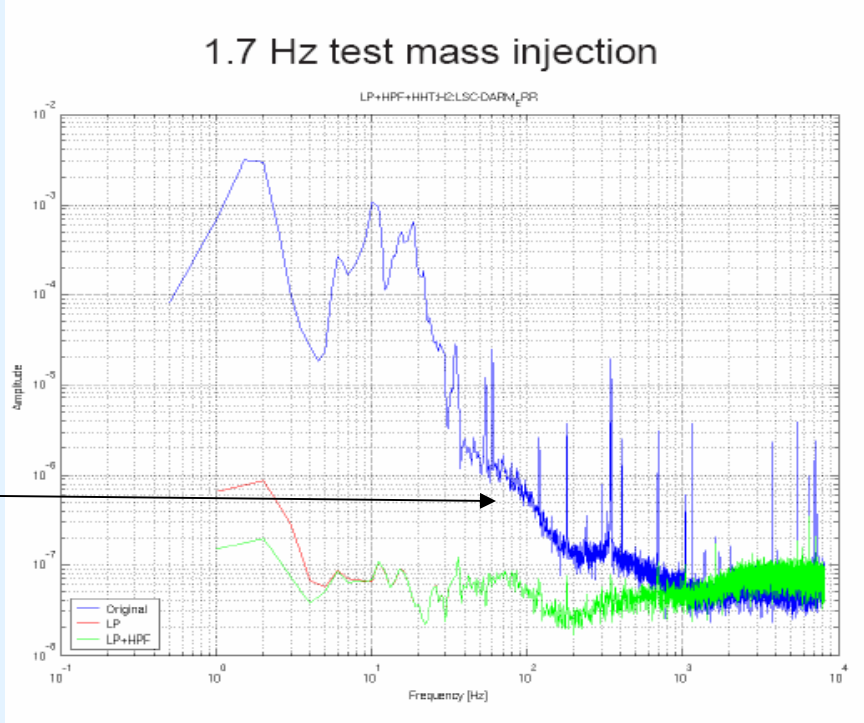
HHT of Glitch : Instantaneous Power





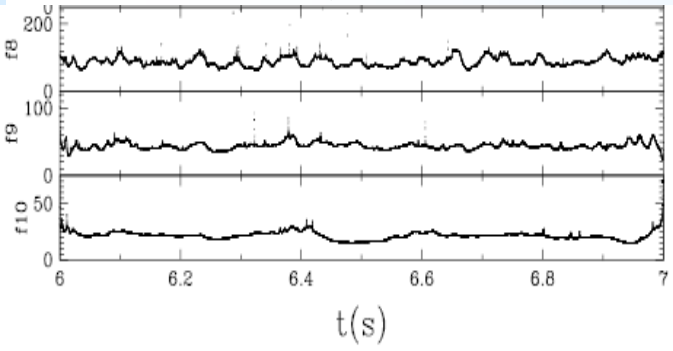
Upconversion Study

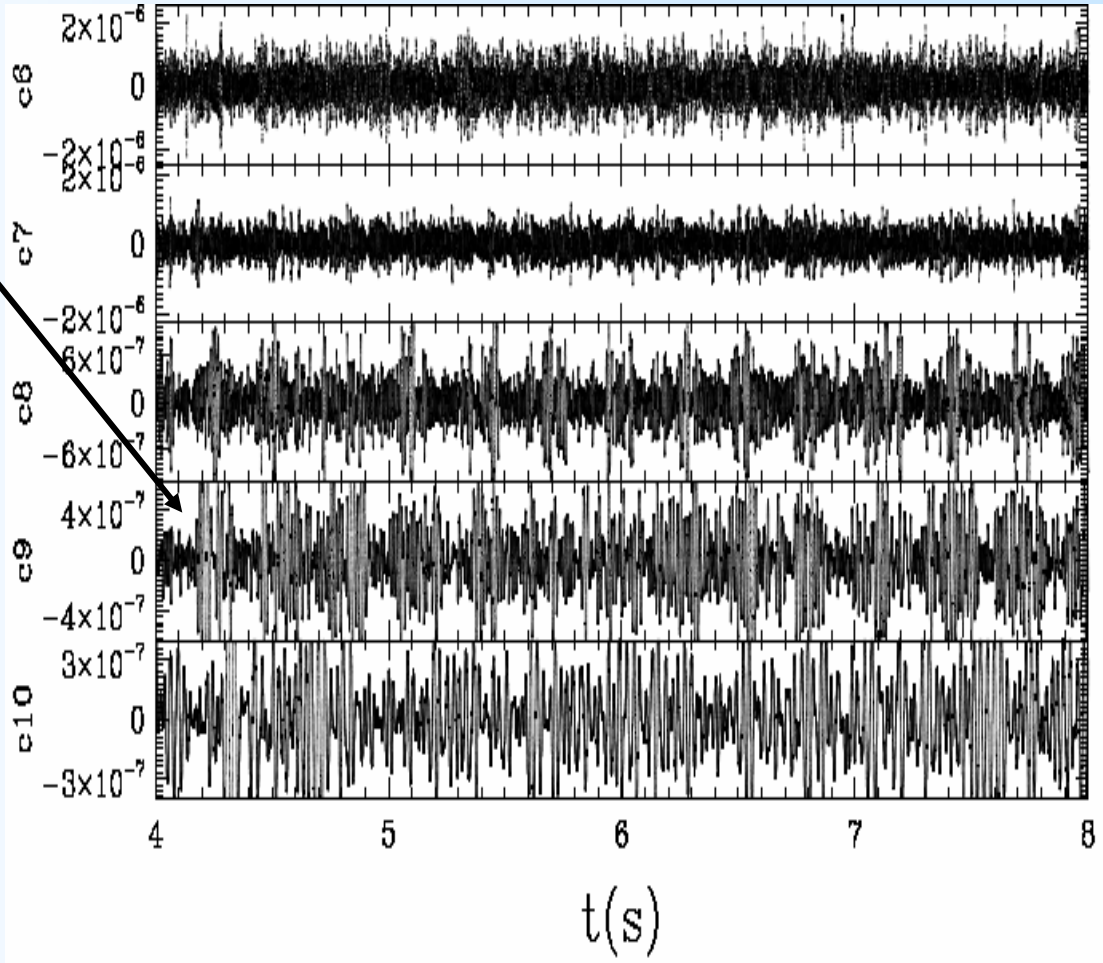
- Excess of detector noise observed between 40 and 200 Hz due to upconversion of seismic noise
- Robert Schofield has simulated this problem with a direct test mass injection at 1.7 Hz
- The Fourier spectrum shows noise excess from 40 to 100 Hz
- We have analyzed the DARM-ERR timeseries with the HHT to see if we could learn anything about the nature of the upconversion

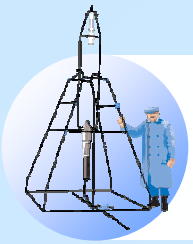


HHT analysis of upconversion

- HHT shows bursts of noise at 2nd harmonic of 1.7 Hz stimulus
- Associated frequencies for c8, c9, c10 are 30 – 100 Hz







Next: What can be said of mechanism of upconversion?

- Robert Schofield has suggested that determine where the bursts are taking place relative to the stimulus
  - Maxima: saturation of electronics?
  - Zero-crossings: magnetization noise?

- Expect a definitive answer by next week