Langmuir waves statistics in Type III burts : waveform and spectral data distributions

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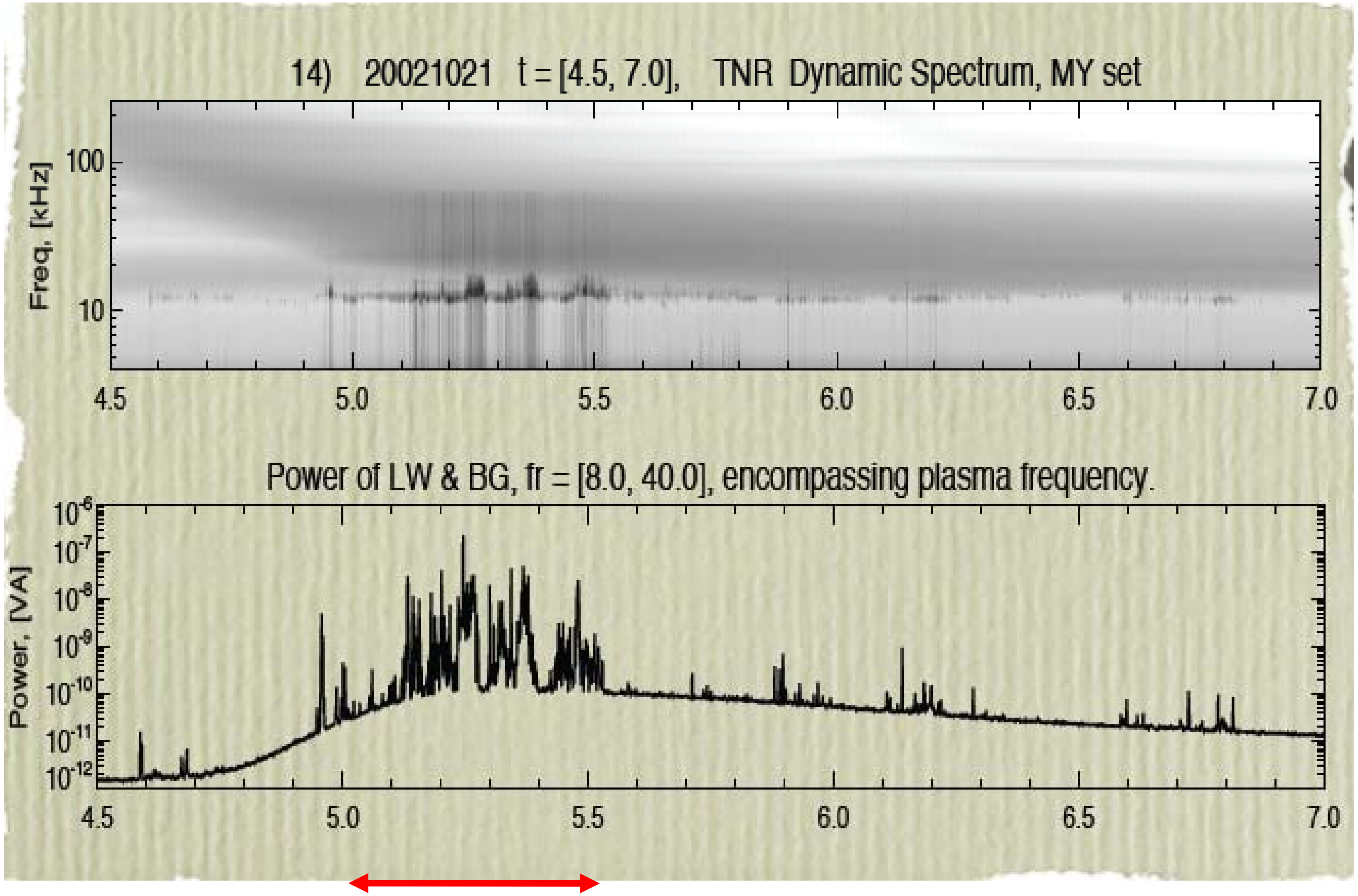
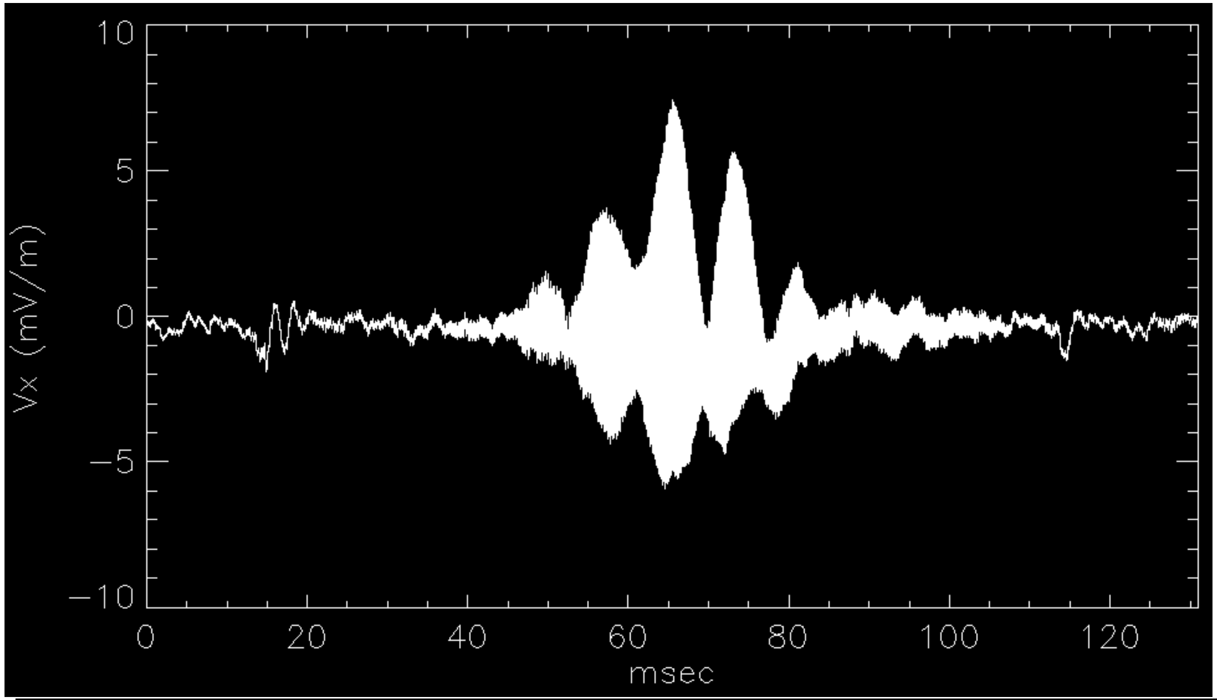
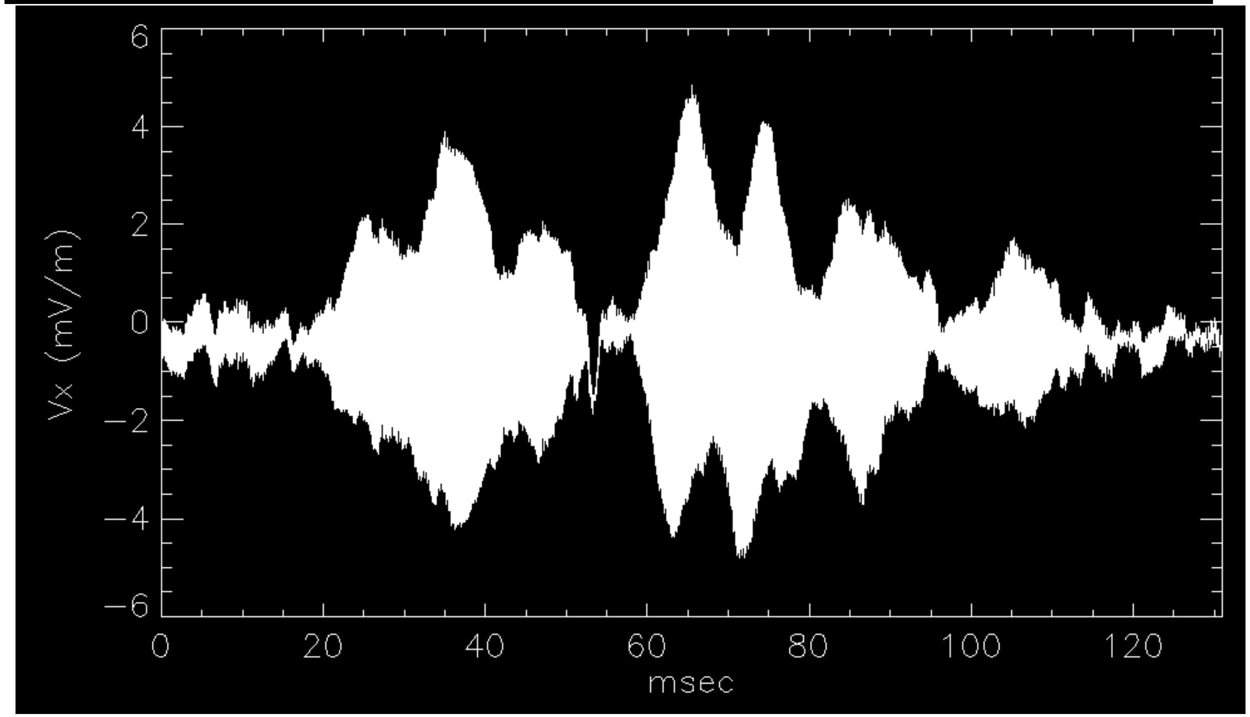
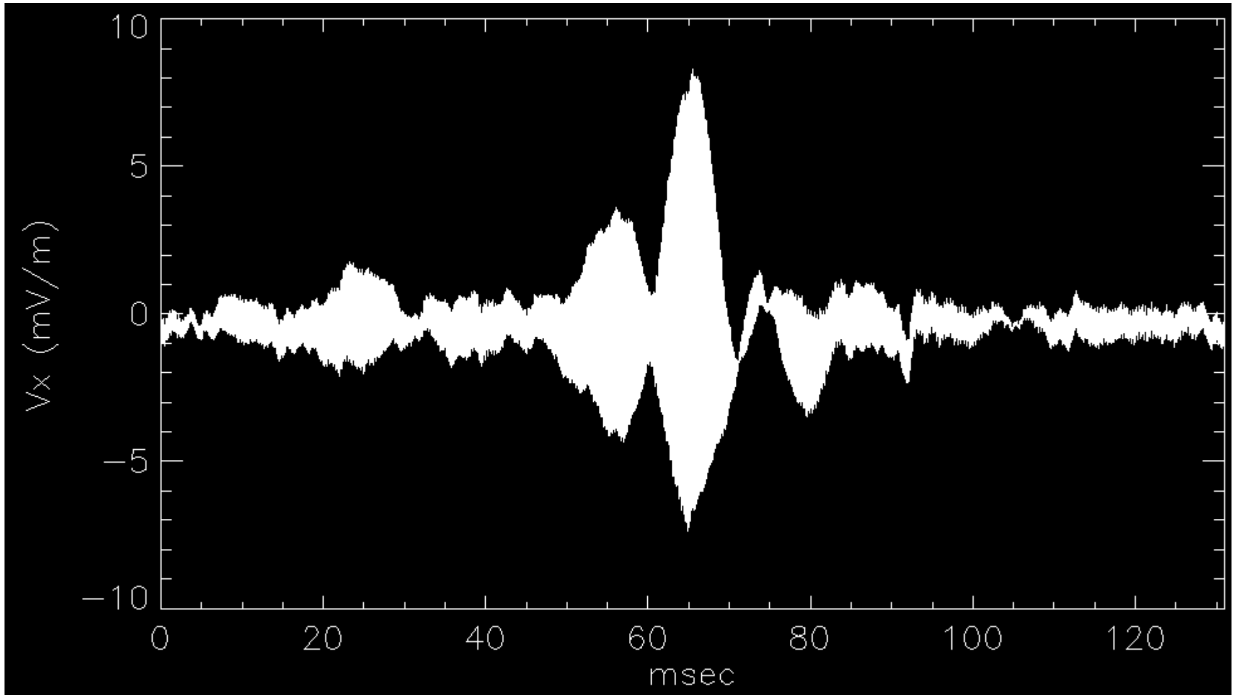


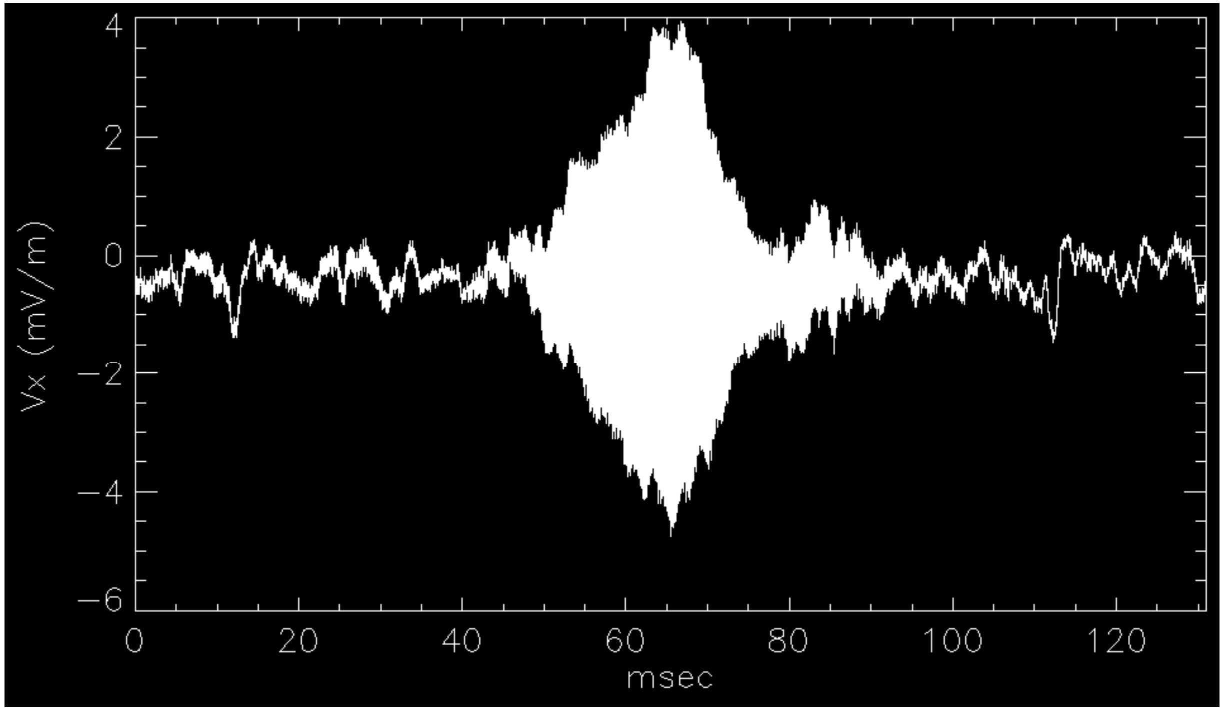
Typically 30 mins
3-4 orders of magnitude variations





TDS snapshots
On Stereo A
14 / 01 / 2007

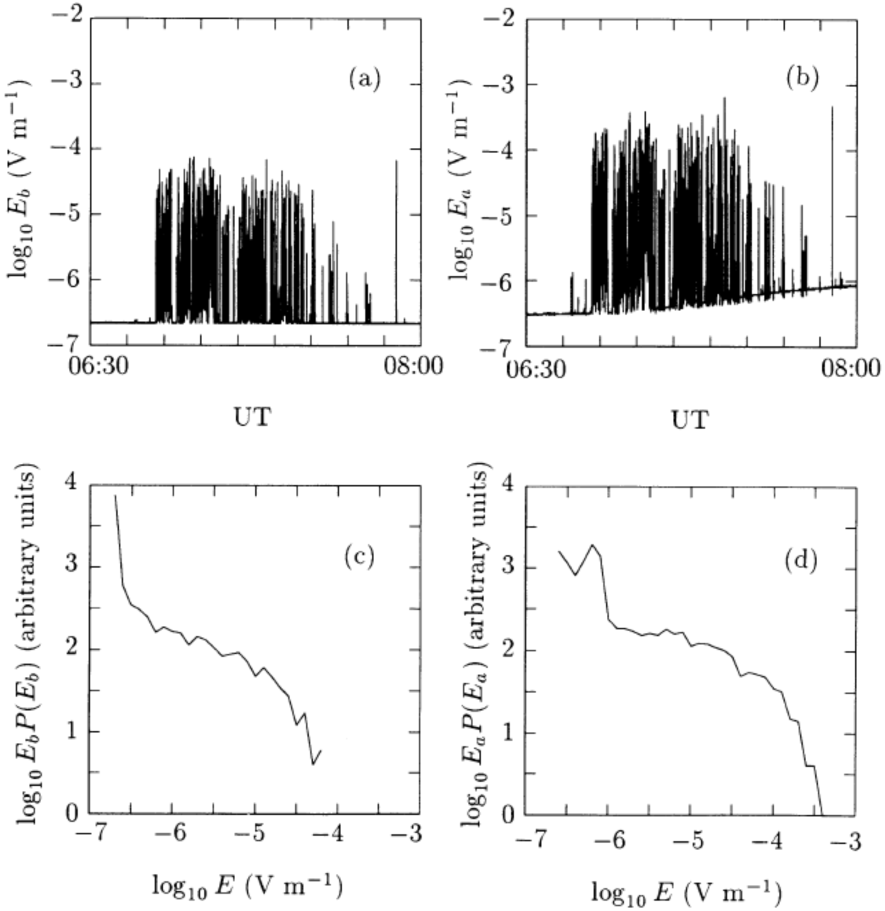


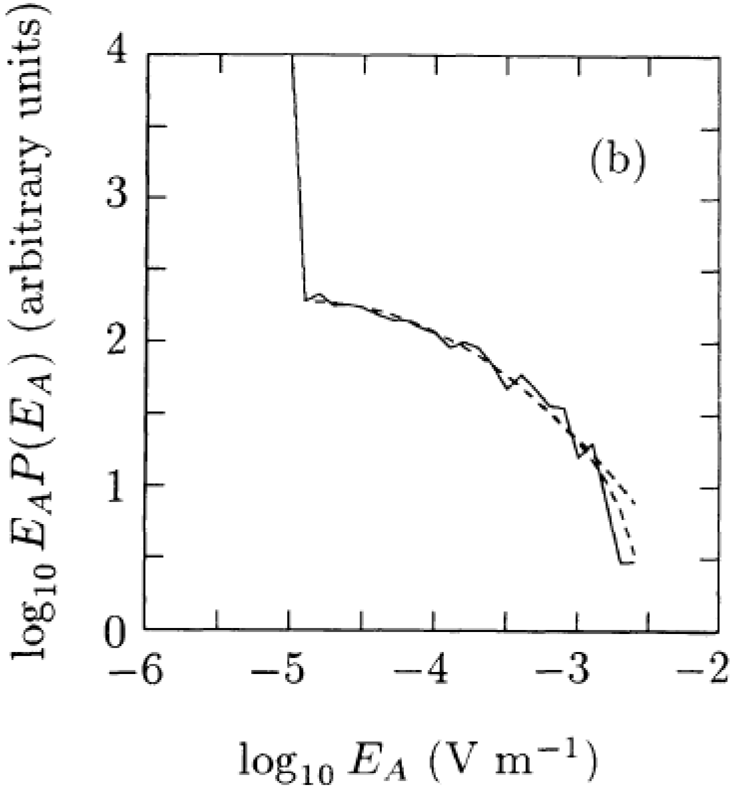


16384.*3*12./0.13
=4.53711e+006 bits /sec

Telemetry 5 to 10 kbits/sec

Robinson et al., ApJ 407, 790, 1993



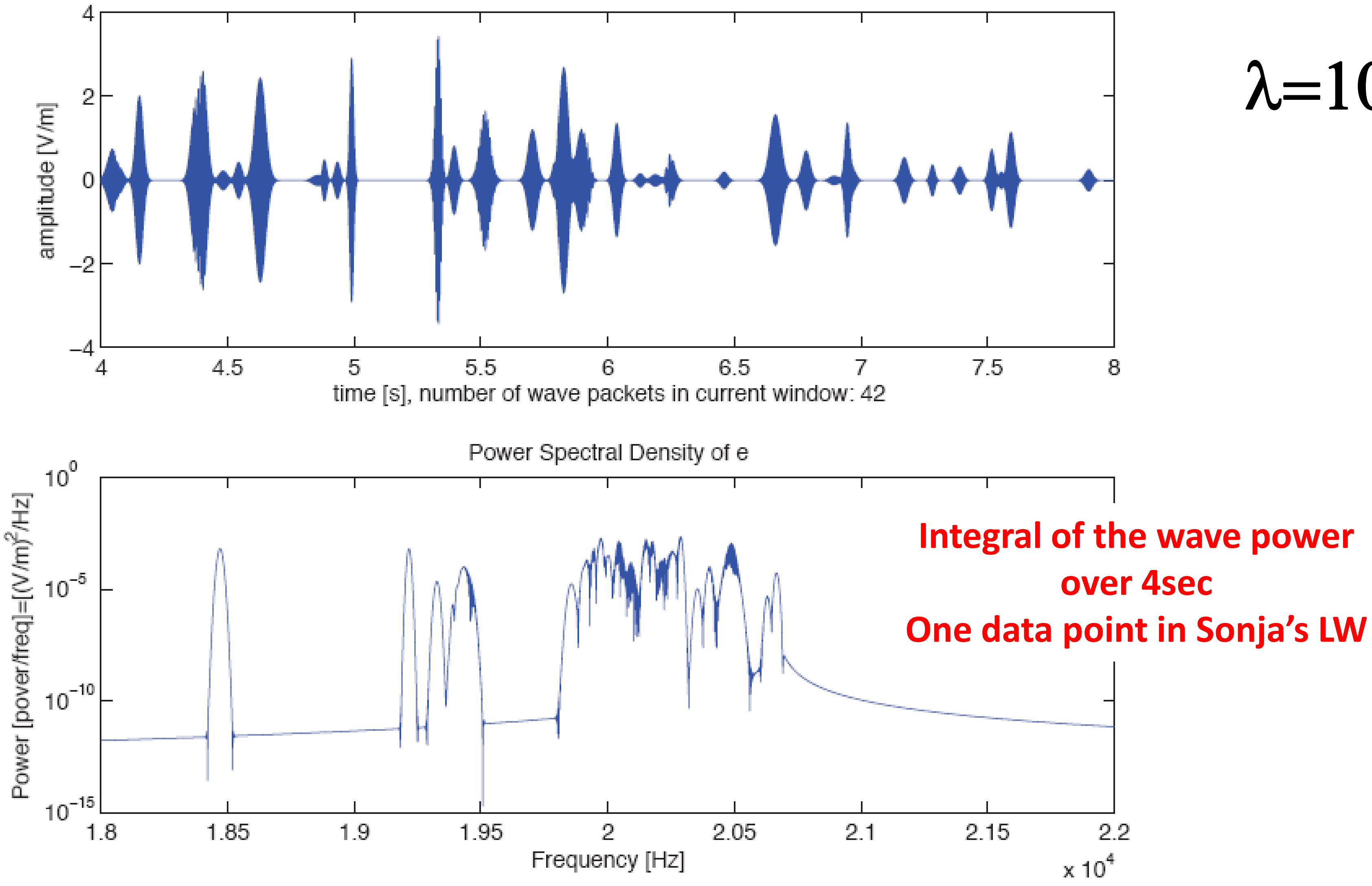


$$E(t) = \sum_{i=1}^{n} A_i \, e^{-\left(\frac{t-t_{0i}}{\tau_i}\right)^2} \, e^{i\omega_i t}$$

A_i	- wave amplitude	**Log Normal or Uniform**
t_{0i}	- starting time of wave packet	**Poisson**
τ_i	- duration of wave packet	**Normal**
ω_i	- circular plasma frequency	**normal**

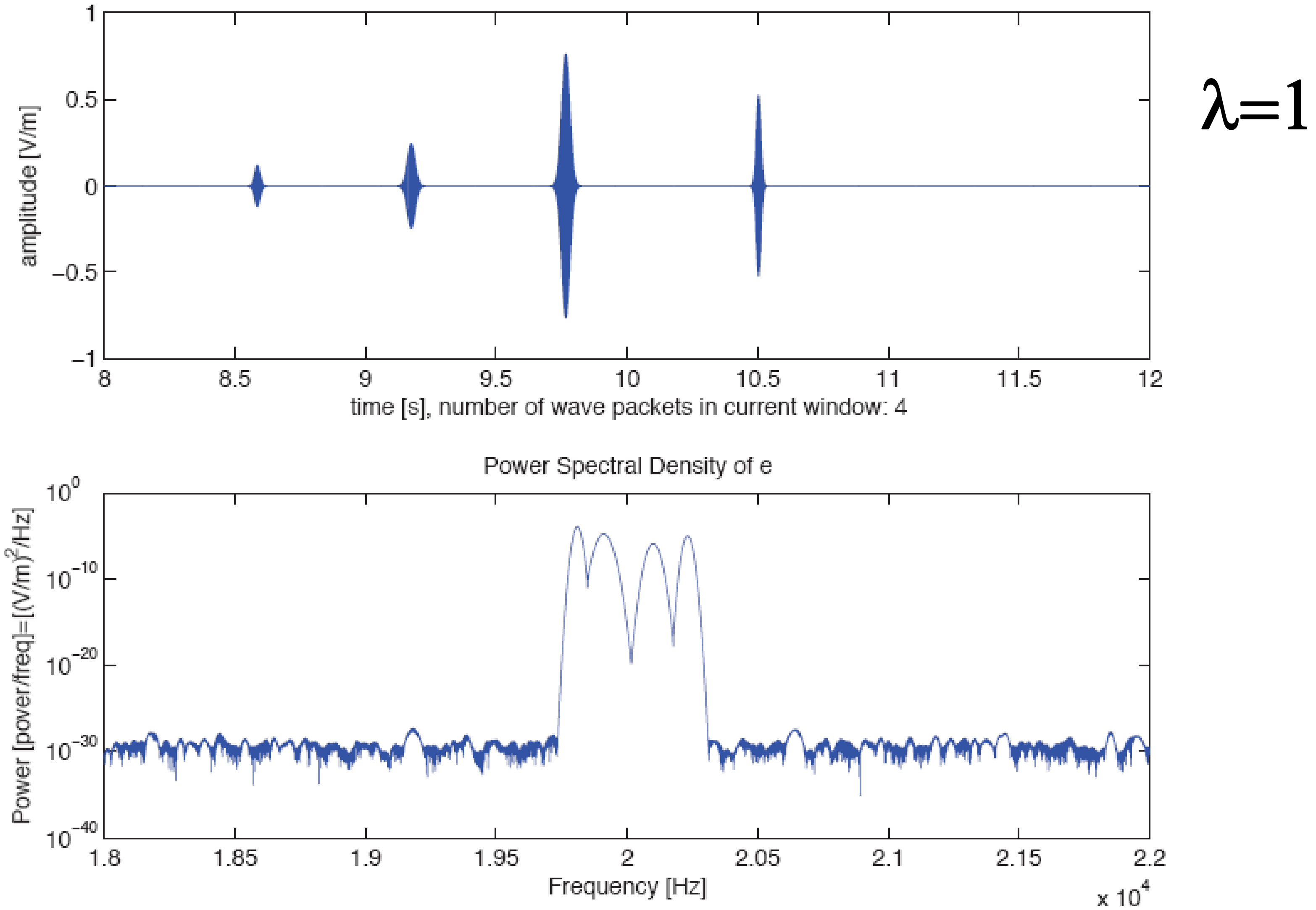
Key parameter : λ, average number of wave packets in one sec.

λ=10



(e) Wave form and Fourier transform, 4 seconds.

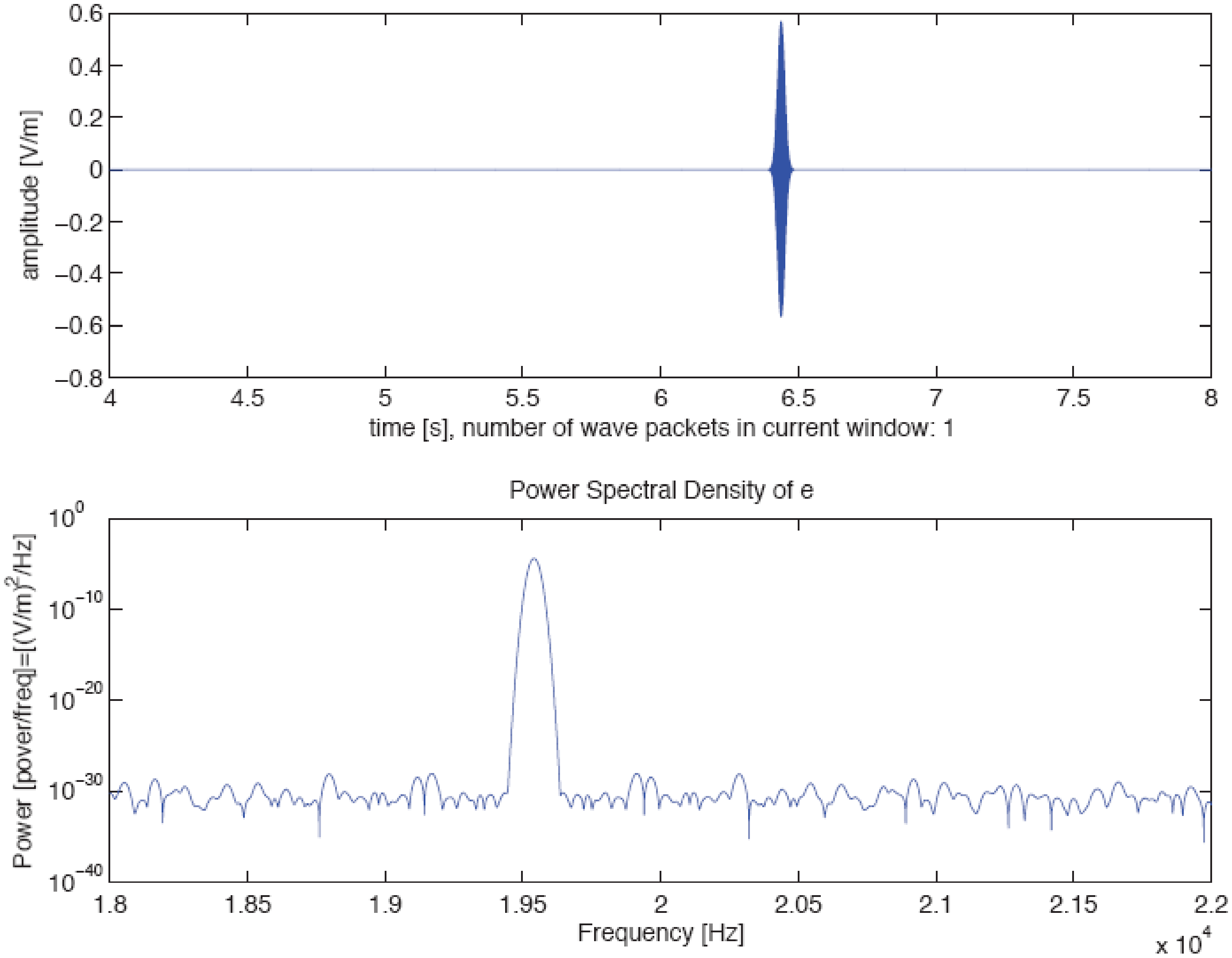
Figure 2: Experiment 2, example 1, $\mathcal{P}(\lambda = 10)$, $\log(A_i^2)$: $\mathcal{U}(a = -2, b = 1)$



(e) Wave form and Fourier transform, 4 seconds.

Figure 4: Experiment 4, example 1, $\mathcal{P}(\lambda = 1)$, $\log(A_i^2) : \mathcal{U}(a = -2, b = 1)$

λ=0.1



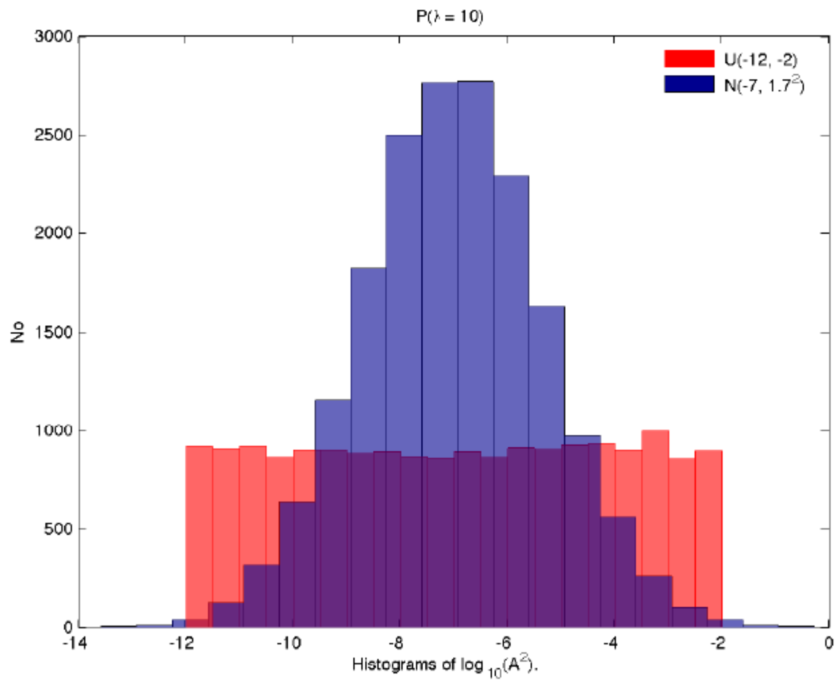
(e) Wave form and Fourier transform, 4 seconds.

Figure 6: Experiment 6, example 1, $\mathcal{P}(\lambda = 0.1)$, $\log(A_i^2)$: $\mathcal{U}(a = -2, b = 1)$

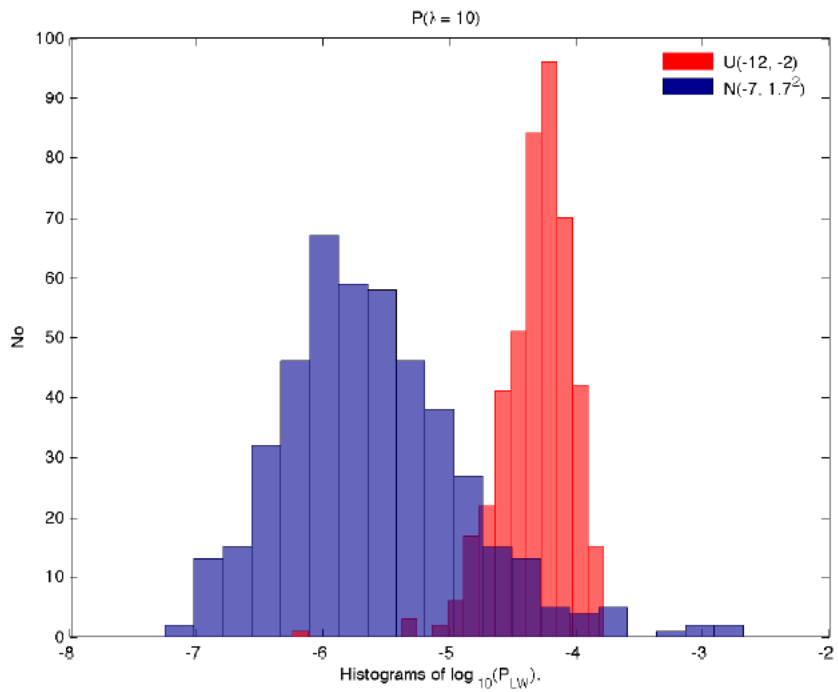
λ=10

4 Comparisons

4.1 $\log(A_i^2)$: $\mathcal{U}(a=-12, b=-2)$ and $\mathcal{N}(\mu=-7, \sigma^2=1.7^2)$, $\mathcal{P}(\lambda=10)$



(a) Histograms of amplitudes.

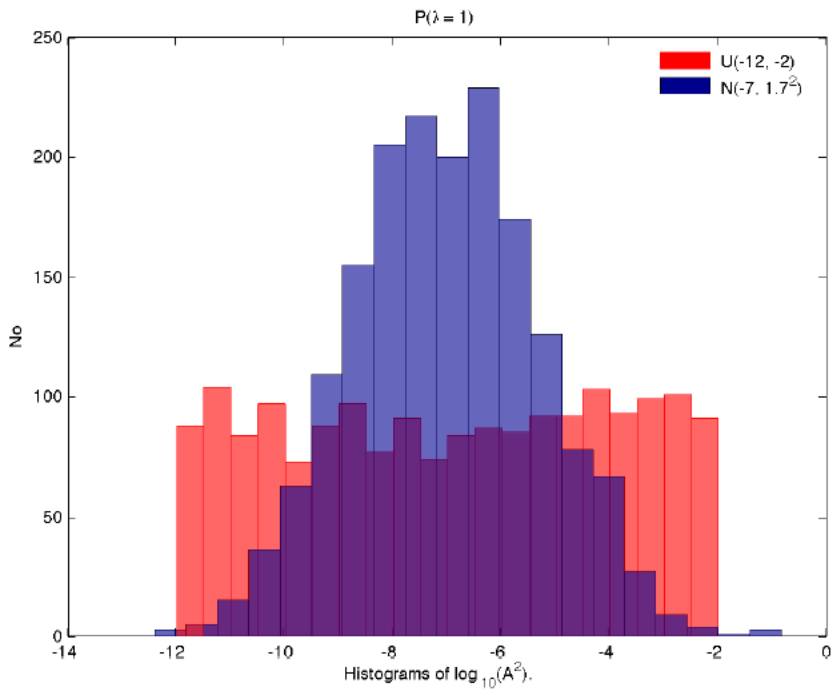


(b) Histograms of LW power in log scale.

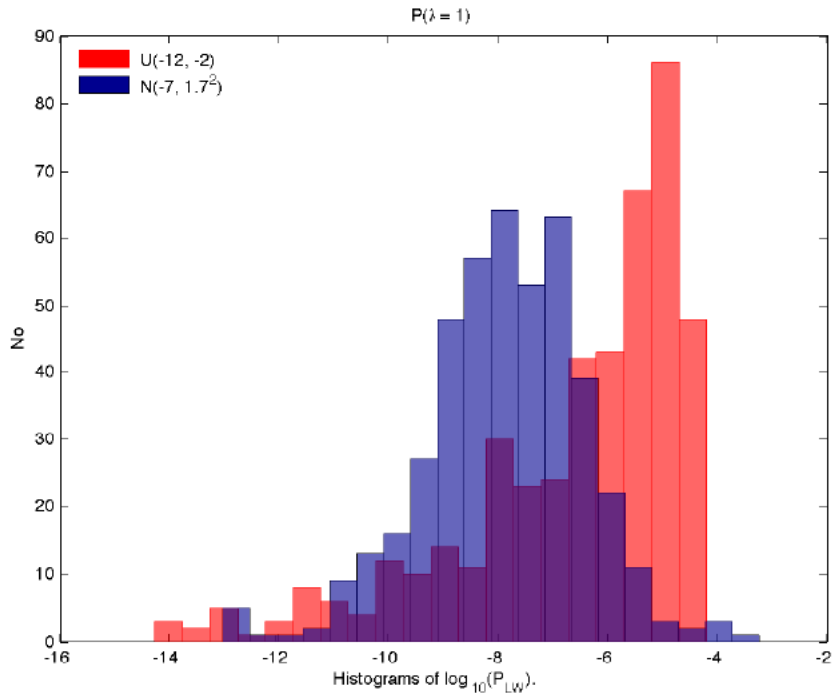
Figure 13: Experiment 1, example 1.

λ=1

4.3 $\log(A_i^2)$: $\mathcal{U}(a=-12, b=-2)$ and $\mathcal{N}(\mu=-7, \sigma^2=1.7^2)$, $\mathcal{P}(\lambda=1)$



(a) Histograms of amplitudes.

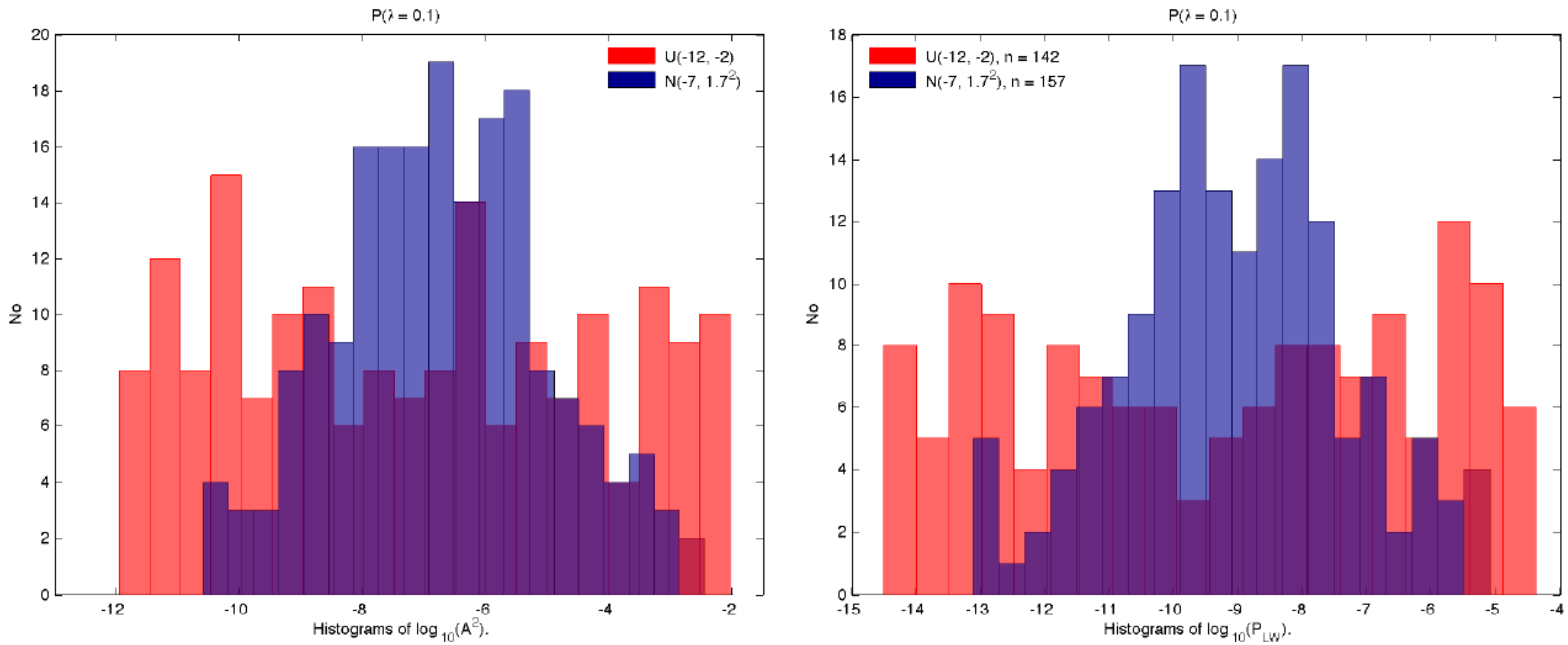


(b) Histograms of LW power in log scale.

Figure 15: Experiment 3, example 1.

λ=0.1

4.5 $\log(A_i^2)$: $\mathcal{U}(a=-12, b=-2)$ and $\mathcal{N}(\mu=-7, \sigma^2=1.7^2)$, $\mathcal{P}(\lambda=0.1)$



(a) Histograms of amplitudes.

(b) Histograms of LW power in log scale.

Figure 17: Experiment 5, example 1.

$$E(t) = \sum_{i=1}^{N} E_i e^{-(t-t_{0i})^2/2\Delta t_i^2} \cos\left(2\pi f_i t + \varphi_i\right)$$

$$V_f^2 = 2\int_{-\infty}^{+\infty} < V(t)V(t+\tau) > e^{i2\pi f\tau} d\tau,$$

$$V(t) = \Gamma Ł_{eff} E(t) \cos(\theta).$$

$$V_f^2 \simeq \left(\Gamma Ł_{eff}\right)^2 \sum_{i=1}^{N} \frac{\Delta t_i (E_i \cos\theta_i)^2}{T_S} \sqrt{\pi}\Delta t_i e^{-\pi^2 (f-f_i)^2 \Delta t_i^2}$$

$$V^2(t) = \int_{f_p-\delta f}^{f_p+\delta f} V_f^2 df$$

$$V^2(t) \simeq \left(\Gamma Ł_{eff}\right)^2 \sum_{i=1}^{N} \frac{\Delta t_i}{T_S} \left(E_i \cos\theta_i\right)^2$$

$$V^2(t) \simeq (\Gamma \text{Ł}_{eff})^2 \sum_{i=1}^{N} \frac{\Delta t_i}{T_S} (E_i \cos\theta_i)^2$$

If we consider the number N to be determined by a Poisson law with a flux parameter λ (s^{-1}), the probability to have N wavepackets within the time T_S (s) is given by

$$P[N] = e^{\lambda T_S} \frac{(\lambda T_S)^N}{N!} \qquad (7)$$

Then there are two possibilities : $\lambda T_S \gg 1$ and $\lambda T_S \ll 1$

Case $\lambda T_S \gg 1$

$$P\left[V^2\right] \sim \frac{1}{\sqrt{2\pi}\lambda T_S \sigma} e^{-(V^2 - \langle V^2 \rangle)^2 / 2\lambda T_S \sigma^2}$$

Roughly normal whatever initial E distribution

If one can define a mean $< E >$ and a variance σ_E

Case $\lambda T_S \ll 1$

$$V^2(t) \simeq (\Gamma \text{Ł}_{eff})^2 \frac{\Delta t_i}{T_S} (E_i \cos\theta_i)^2$$

Same distribution

Conclusion:

- Need to do the statictics directly on waveform data (Solar Orbiter, Solar Probe)
- Sonja's fittings can provide informations on λ