

Smartphone Instrument de Mesure



Réunion IRES
13 décembre 2017
Renaud Mathevet



Plan

1)Présentation de Phyphox

2)Un classique: le pendule

3)Moins classique: 2 SM dans un pendule

4)Analyse du bruit

Plan

1)Présentation de Phyphox

2)Un classique: le pendule

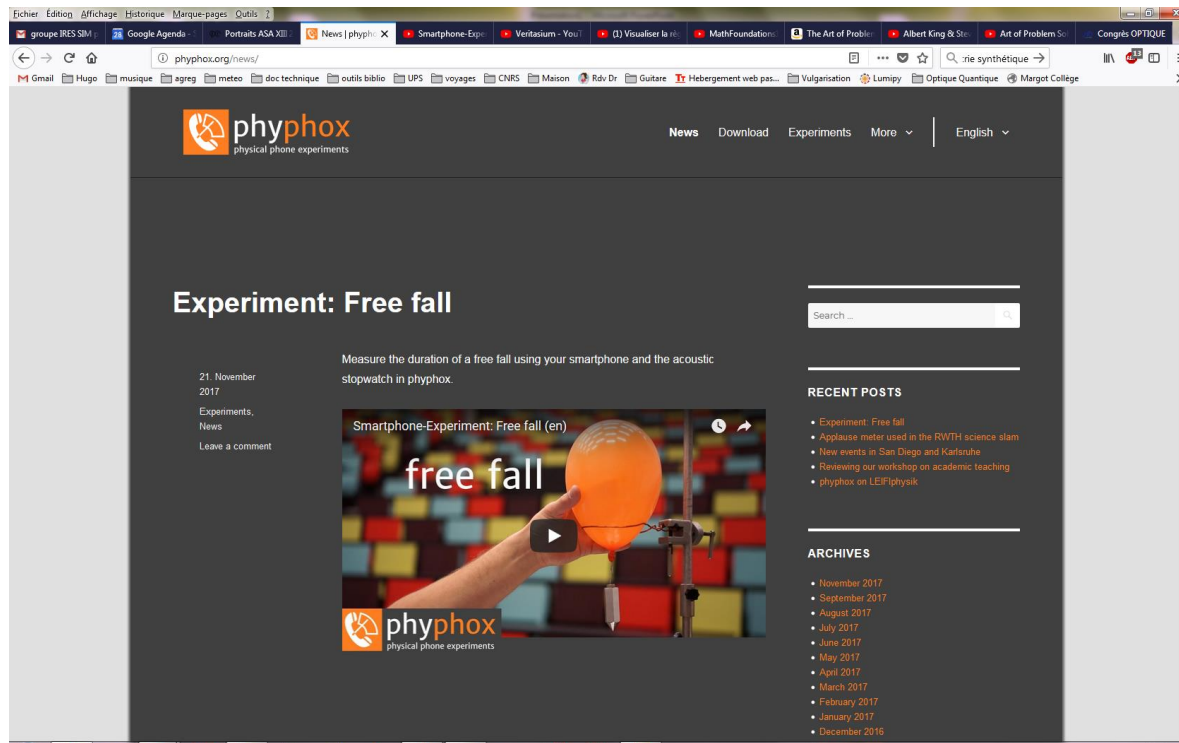
3)Moins classique: 2 SM dans un pendule

4)Analyse du bruit

Plateforme

Phyphox: www.phyphox.org

Université de Aachen, Allemagne (Aix la Chapelle)



The screenshot shows a web browser displaying the phyphox website. The page features a dark theme with a white header containing the phyphox logo and navigation links for News, Download, Experiments, and More. The main content area is titled "Experiment: Free fall" and includes a video player showing a hand holding an orange balloon. The video title is "Smartphone-Experiment: Free fall (en)". Below the video, there is a search bar and sections for "RECENT POSTS" and "ARCHIVES".

phyphox
physical phone experiments

News Download Experiments More English

Experiment: Free fall

21. November 2017
Experiments, News
Leave a comment

Measure the duration of a free fall using your smartphone and the acoustic stopwatch in phyphox.

Smartphone-Experiment: Free fall (en)

free fall

phyphox
physical phone experiments

Search...

RECENT POSTS

- Experiment: Free fall
- Applause meter used in the RWTH science slam
- New events in San Diego and Karlsruhe
- Reviewing our workshop on academic teaching
- phyphox on LEIPhysik

ARCHIVES

- November 2017
- September 2017
- August 2017
- July 2017
- June 2017
- May 2017
- April 2017
- March 2017
- February 2017
- January 2017
- December 2016

Phyphox

The screenshot shows the Phyphox website interface. At the top left is the logo 'phyphox physical phone experiments'. Navigation links include 'News', 'Download', 'Experiments', 'More', and 'English'. A 'Filter experiments' section is highlighted with a red circle, containing three filter categories: 'By Feature: Wiki entry, video instructions, material for students (German)', 'By topic: acoustics, eye spy, fire, fun, mechanics, tools', and 'By hardware: accelerometer, gyroscope, light sensor, pressure sensor, magnetometer, microphone, speaker'. Below this, a search bar is visible. The main content area lists several experiments, each with a red circle around its title: 'Acceleration (without g) (Raw data)', 'Acceleration Spectrum (Tools)', 'Acceleration with g (Raw data)', 'Acoustic Stopwatch (Tools)', and 'Audio Amplitude (Acoustics)'. Red arrows point from these circles to the right-hand text blocks. On the right side of the page, there are sections for 'RECENT POSTS' (listing 100,000 installs, applause meter, pendulum frequencies, Doppler effect, and experiment database) and 'ARCHIVES' (listing months from November 2017 to August 2016). A 'META' section at the bottom right includes links for 'Log in', 'Entries RSS', 'Comments RSS', and 'WordPress.org'.

Options de tri:

- Par support: vidéo, wiki...
- Par thème: acoustique...
- Par capteur

Raw data: données brutes du capteur avec fonction export (Excel ou équivalent)

Tools: outil de traitement des données brutes (pour copier-coller dans ses propres programmes)

Acoustics: thème d'une expérience clé en main

Manip pendule Phyphox

- 7 ou 8 manip filmées: projeter celle du pendule
- Pendule: données brutes du capteur

https://www.youtube.com/watch?time_continue=198&v=xY3NfCdG3ZU

YouTube FR

Phyphox

À suivre LECTURE AUTOMATIQUE

Fidget spinner speed using magnetism (referring to Matt)
phyphox
954 vues
4:36

Smartphone-Experiment: Sonar (en)
phyphox
4,7 k vues
4:10

Smartphone-Experiment: Centrifugal Acceleration (en)
phyphox
2,3 k vues
4:20

Smartphone-Experiment: Free fall (en)
phyphox
132 vues
Nouveau
5:26

Smartphone-Experiment: Spring oscillator (en)
phyphox
817 vues
5:32

Physics Experiment (Pendulum)
Firdaus Zulkifli
91 k vues
3:42

Smartphone-Experiment: Freier Fall (de)
phyphox
101 vues
Nouveau
5:13

Charge Your Phone using COIN - Amazing Life Hack - Science
RoyTecTips
6,7 M vues
3:57

Smartphone-Experiment: Fadenpendel (de)
phyphox
2,5 k vues
4:31

Smartphone-Experiment: Pendulum (en)
1 145 vues
15 2 PARTAGER

phyphox
Ajoutée le 13 mars 2017

Part 2 on oscillations with phyphox and simple pendulums. You can watch part 1 here:
<https://youtu.be/VbL4InVAO4>

SABONNER 438

Mon montage

185 +/-1mm



1283 +/-3mm

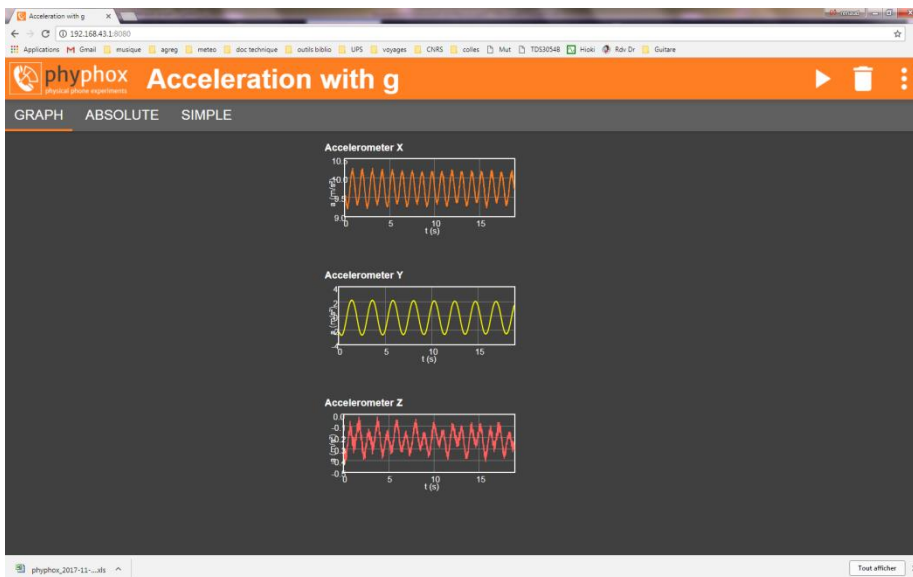


160 +/-1mm

Enveloppe à bulles
2 fils électriques fins

Accès à distance

1. Télécharger l'application Phyphox sur le portable
2. Configurer le smartphone en « point d'accès wifi »
3. Dans les paramètres de connexion, récupérer le mot de passe: 59d78ece
4. Connecter le réseau wifi de l'ordinateur (portable) sur le smartphone avec le mot de passe ci-dessus
5. Lancer l'application Phyphox, choisir le programme « Acceleration with g » et ouvrir le menu en haut à droite (... verticaux)
6. Cocher « allow remote access »: une adresse s'affiche: <http://192.168.43.1:8080>
7. Copier l'adresse dans le navigateur de l'ordinateur



On pilote le smartphone à distance

- Acquisition 3 axes
- À la fin, export des données (.xls, .csv...)

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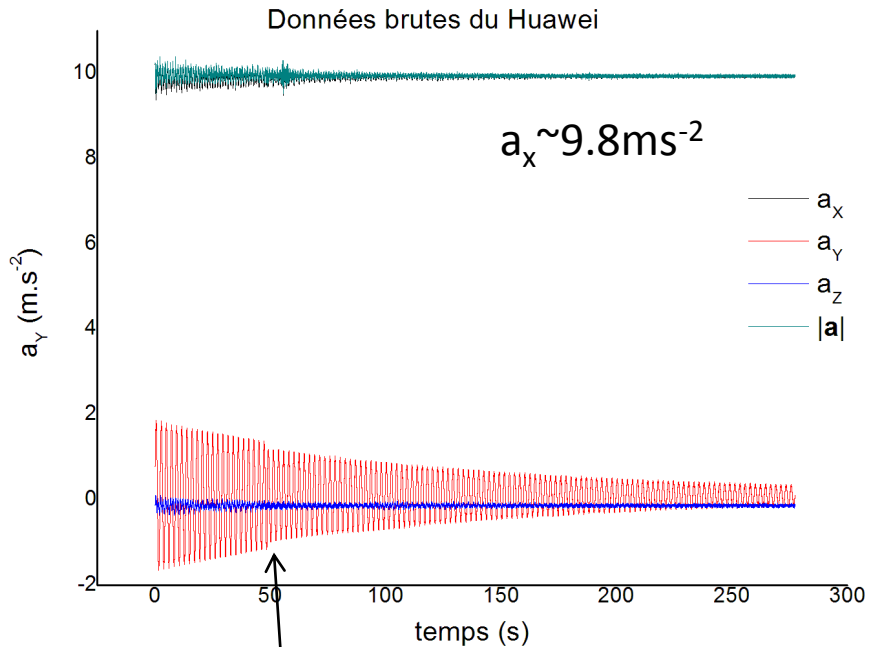
4)Analyse du bruit

Première manip

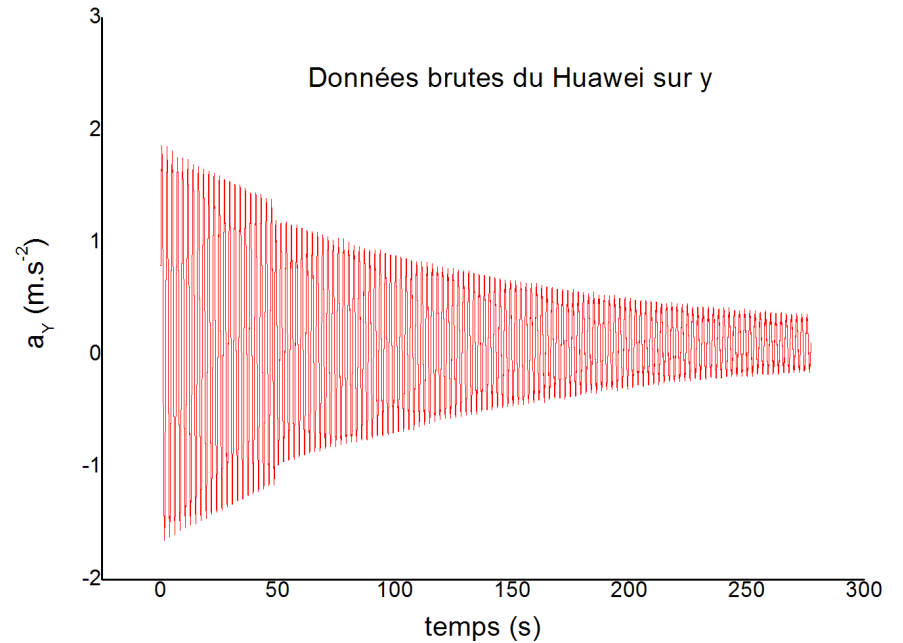
- Smartphone « Huawei »
- Enregistrement sur 5 minutes
- 40k échantillons



Résultats bruts

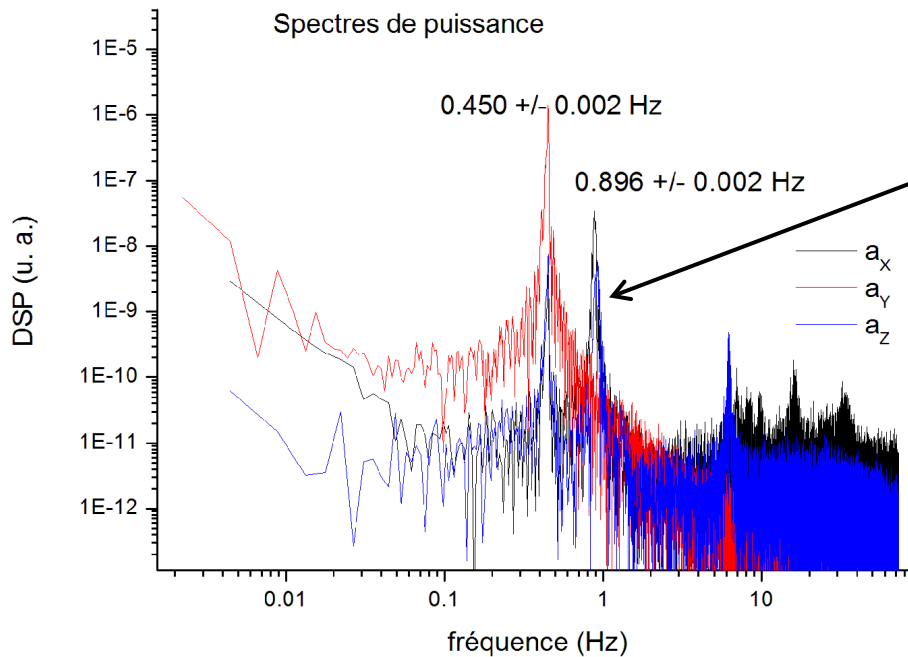


↑
Interruption/reprise
enregistrement



$f \sim 0.44 \text{ Hz}$
 $\tau \sim 150 \text{ s}$
 $Q \sim 2\pi \cdot 340$

Spectre



harmonique:
oscillations transverses

$$f_{att.} = \frac{1}{2\pi} \sqrt{\frac{g}{L}}$$

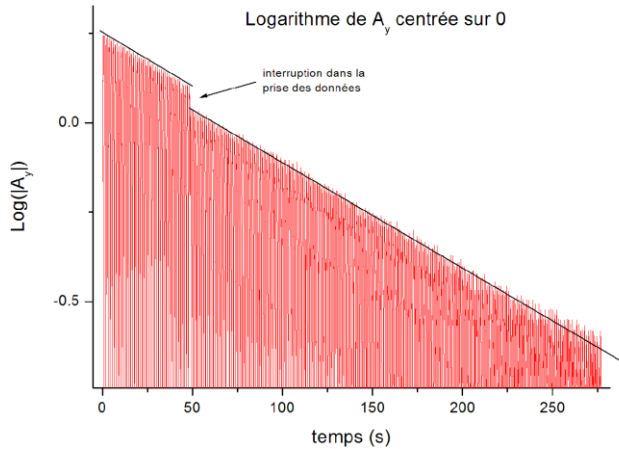
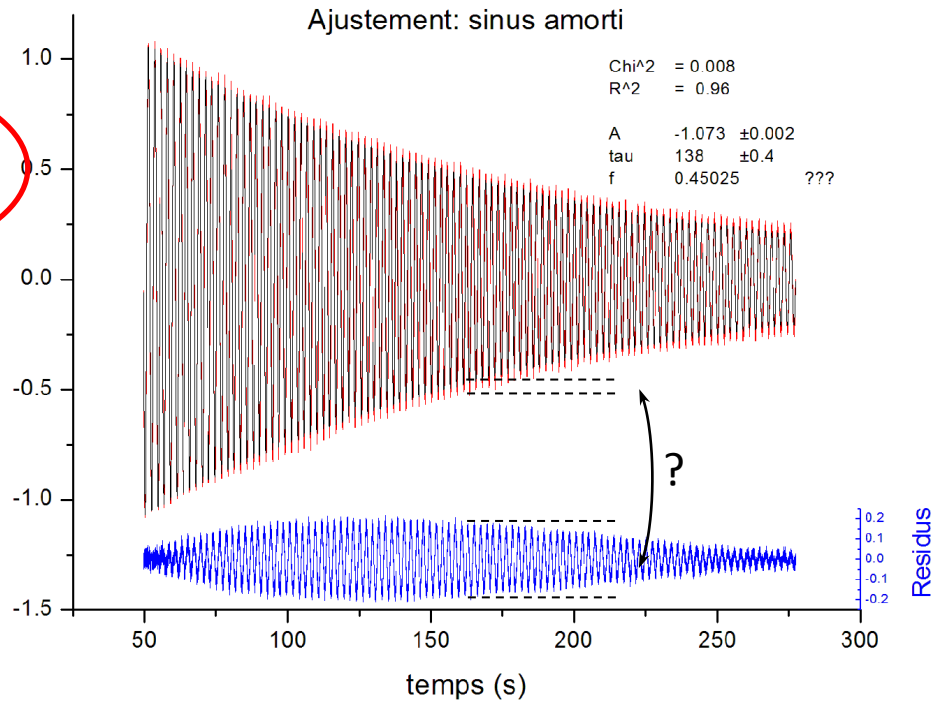
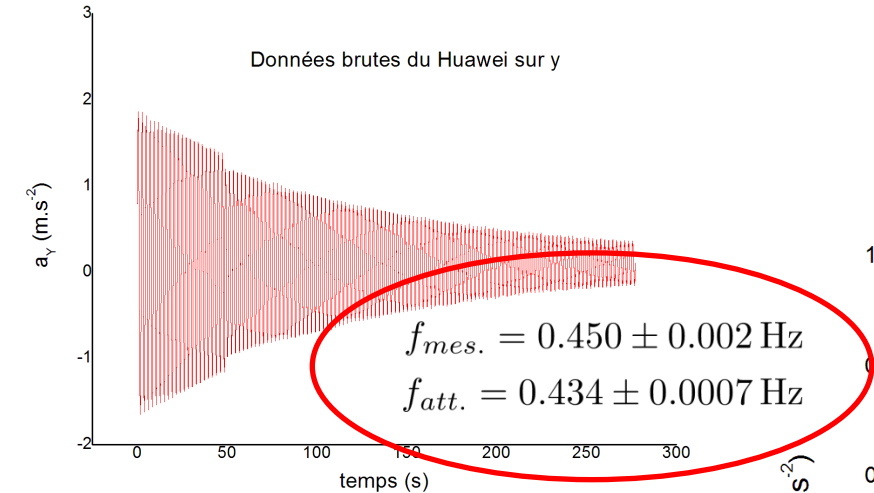
$$L = 1319 \pm 3 \text{ mm}$$

$$g = 9.80 \pm 0.02 \text{ ms}^{-2}$$

$$f_{att.} = 0.434 \pm 0.0007 \text{ Hz}$$

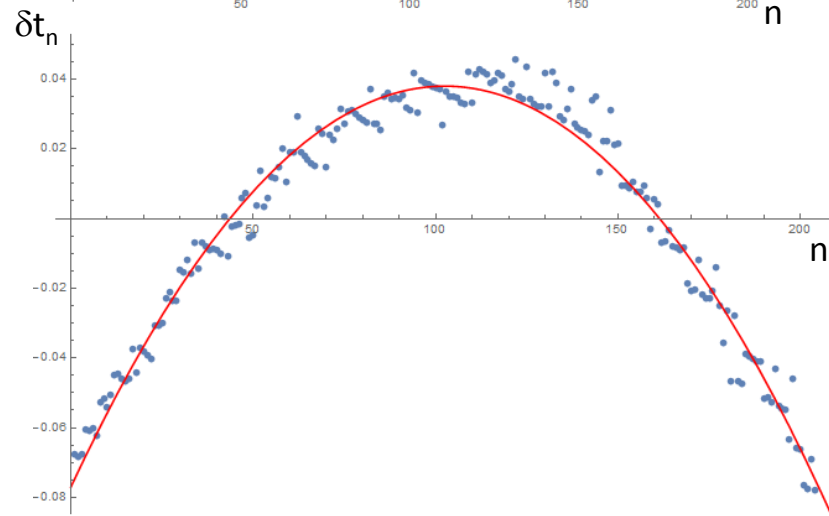
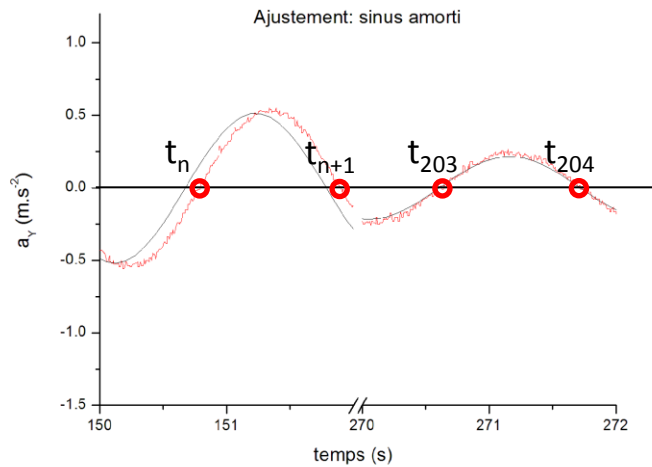
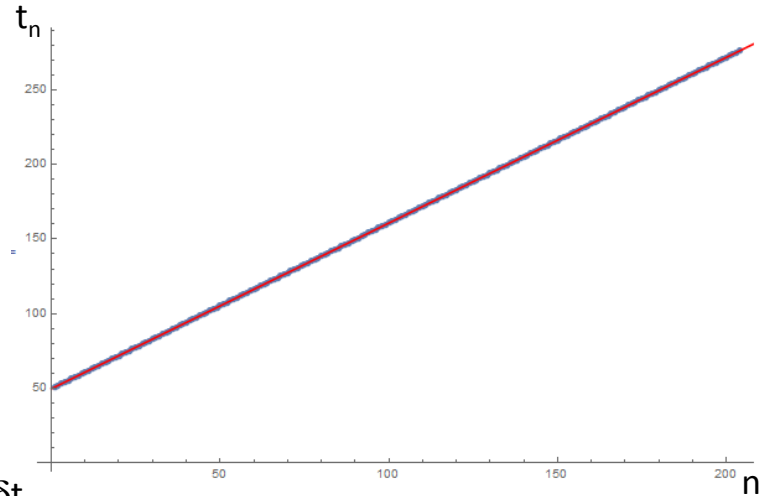
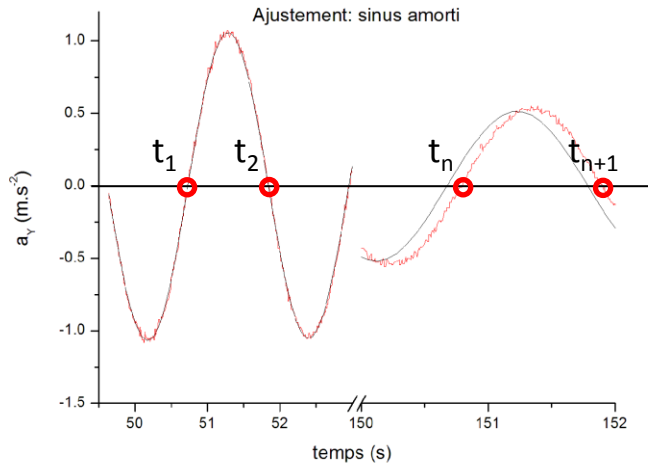
non compatible: modèle? mesures?

Ajustement

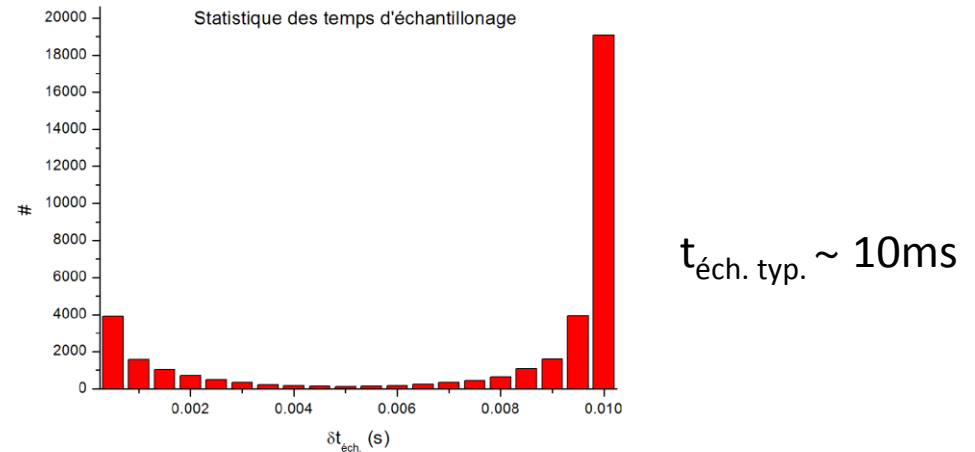
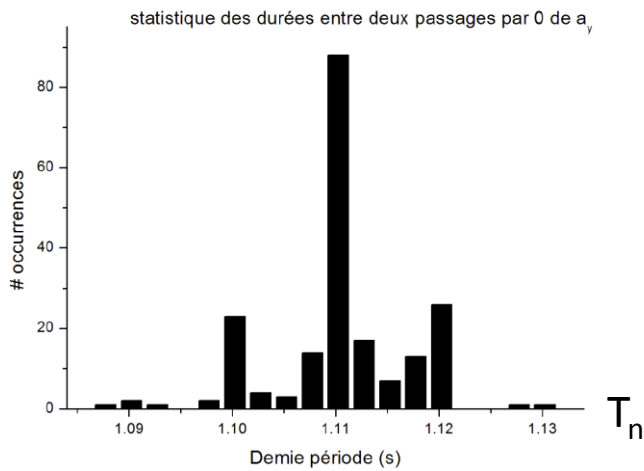
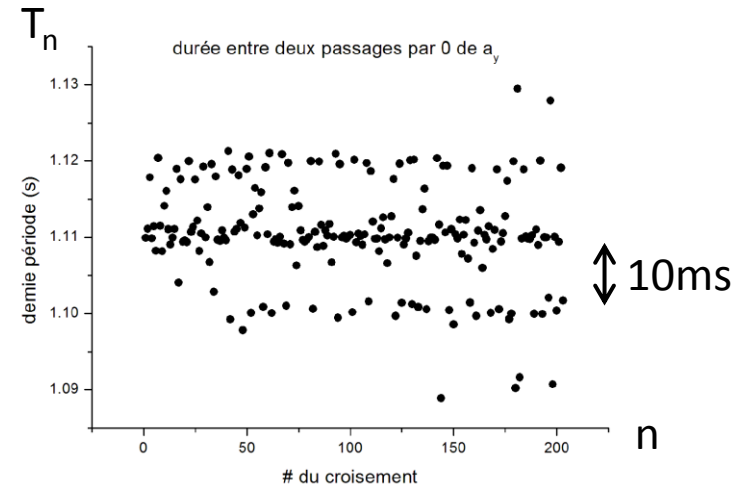
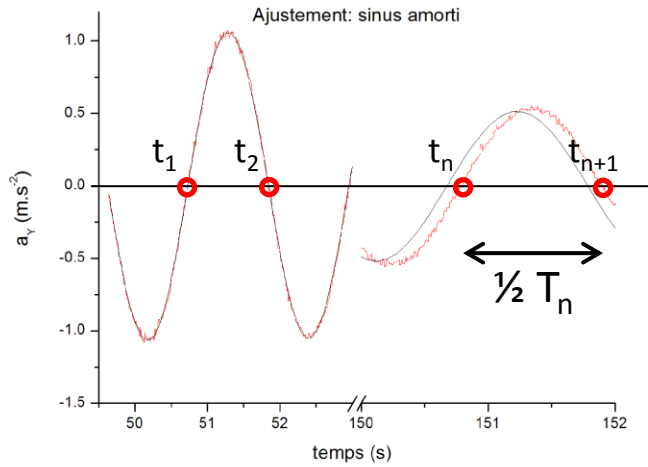


$f_{fit.} = 0.450 \pm 0.001 \text{ Hz}$

Fréquence ?



Passages par 0



Formule de Borda

$$\ddot{\theta} + \frac{g}{L} \sin \theta = 0 \longrightarrow \ddot{\theta} + \frac{g}{L} \theta = 0$$

harmonique

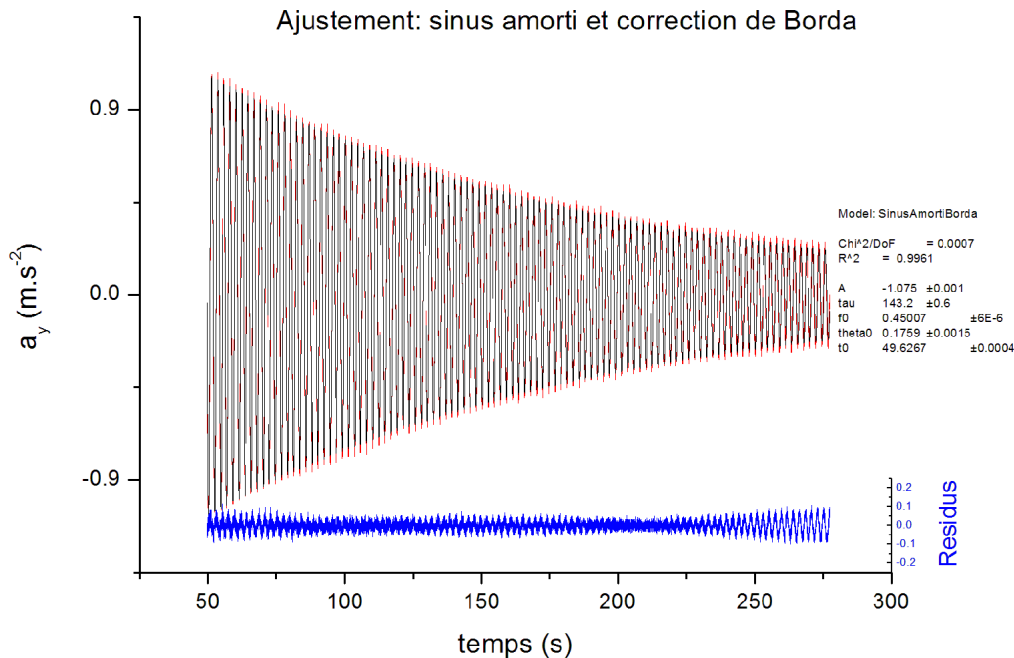
$$f_0 = \frac{1}{2\pi} \sqrt{\frac{g}{L}}$$

$$\longrightarrow \ddot{\theta} + \frac{g}{L} \left(\theta - \frac{\theta^3}{6} \right) = 0$$

Duffing

$$f = f_0 \left(1 - \frac{\theta_0^2}{16} \right)$$

Amortissement: $\theta_0 \longrightarrow \theta_0 \exp(-t/\tau) \longrightarrow f = f_0 \left(1 - \frac{\theta_0^2 \exp(-2t/\tau)}{16} \right)$



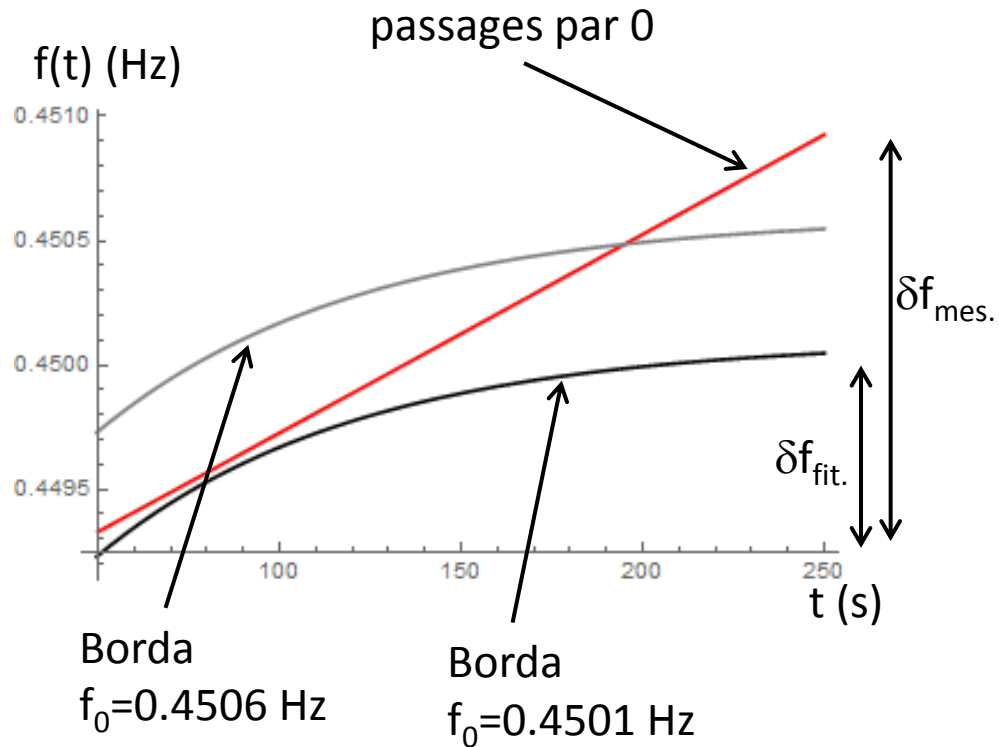
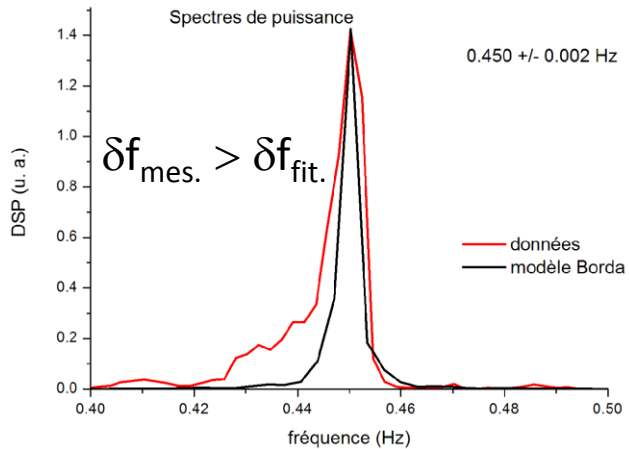
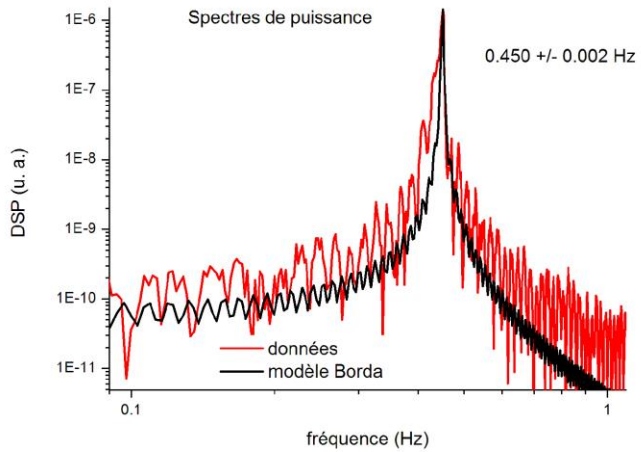
$$\chi^2 : 0.0077 \rightarrow 0.0007$$

$$R^2 : 0.96 \rightarrow 0.996$$

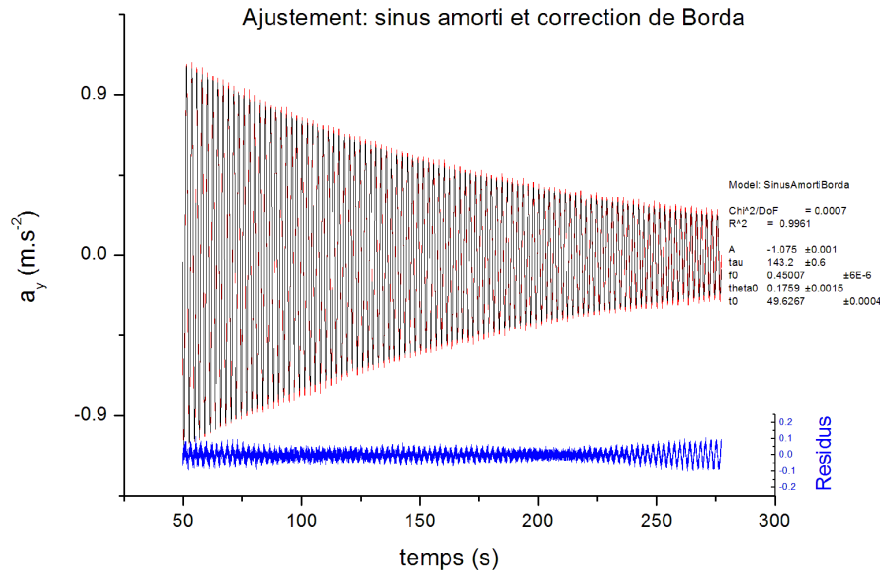
$$\tau = 143 \text{ s}$$

$$Q = \omega_0 \tau \approx 400$$

Analyse spectrale



Gros problème...



$$\ddot{\theta} + \frac{g}{L}\theta = 0$$

$$(a_y)_{max} = L\ddot{\theta}_{max} = g\theta_0$$

$$(a_y)_{max}^{mes.} = 1.075 \pm 0.001 \text{ m.s}^{-2}$$

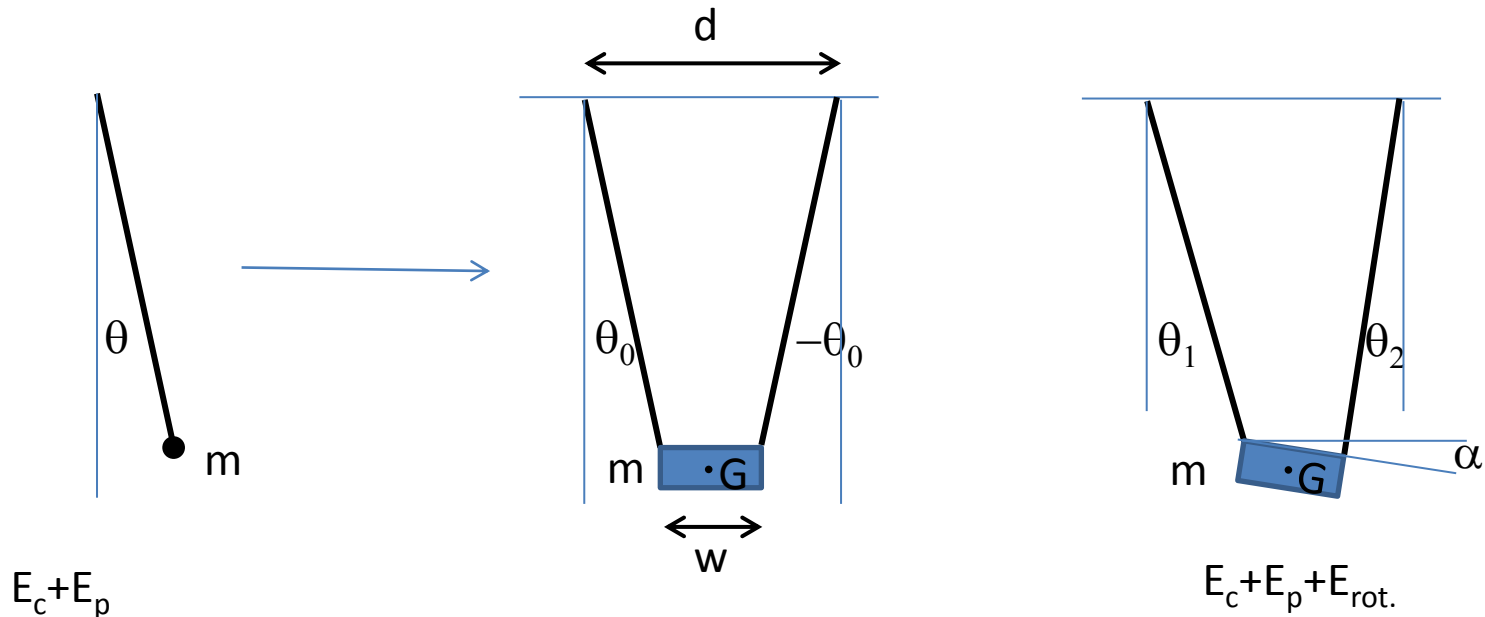
$$(a_y)_{max}^{att.} = 9.8 \times 0.1759 = 1.732 \text{ m.s}^{-2}$$

$$f_{mes.} = 0.450 \pm 0.002 \text{ Hz}$$

$$f_{att.} = 0.434 \pm 0.0007 \text{ Hz}$$



Amélioration du modèle



$$f_{mod.} = 0.436 \pm 0.001 \text{ Hz}$$

$$f_{att.} = 0.434 \pm 0.001 \text{ Hz}$$

$$(a_y)_{max}^{mes.} = 1.075 \pm 0.001 \text{ m.s}^{-2}$$

$$(a_y)_{max}^{mod.} = 1.705 \pm 0.001 \text{ m.s}^{-2}$$

Montrer programme Mathematica: corrections marginales

la rotation donne une contribution négligeable car ici d est proche de w

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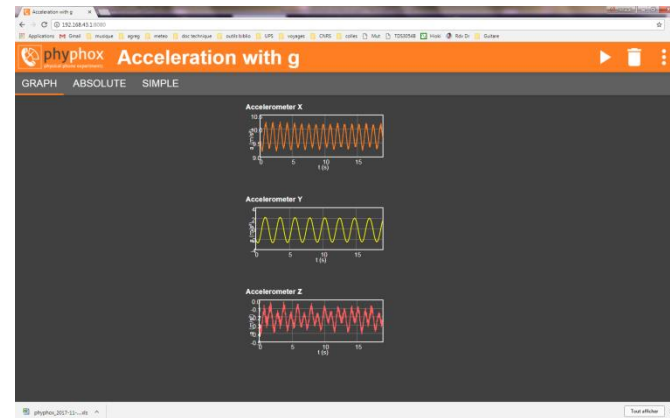
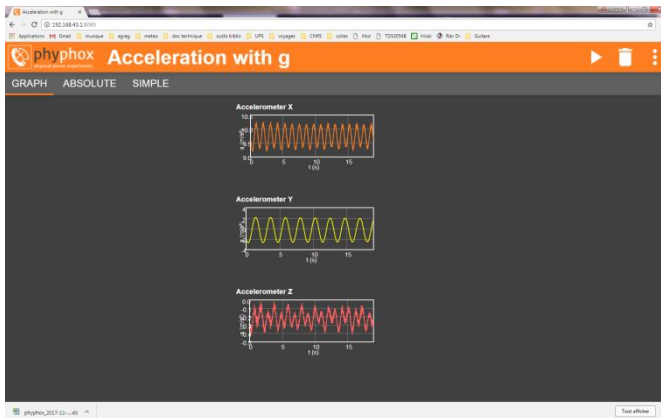
Deuxième manip

- Smartphone « Huawei » + « Wiko »
- Enregistrements simultanés
- Pas de synchronisation

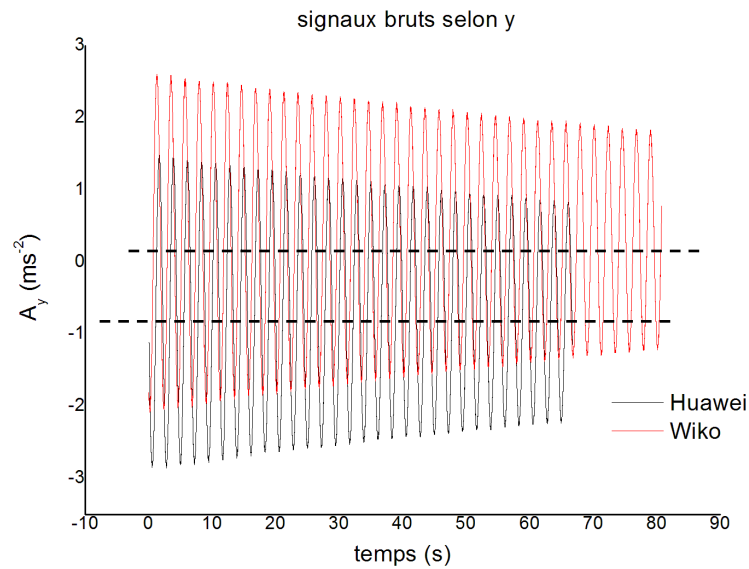
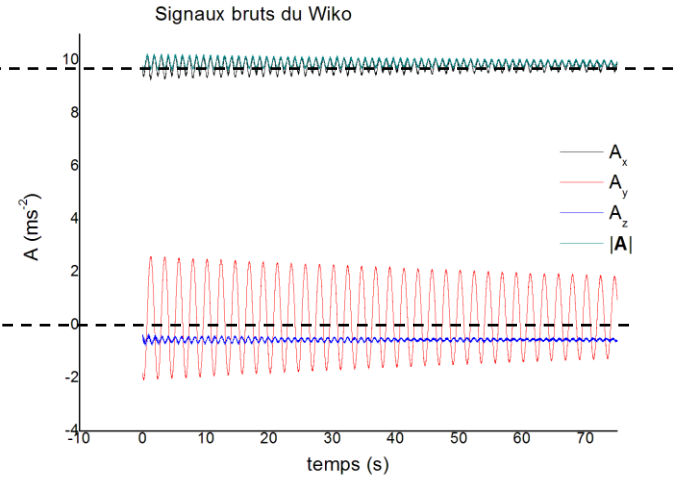
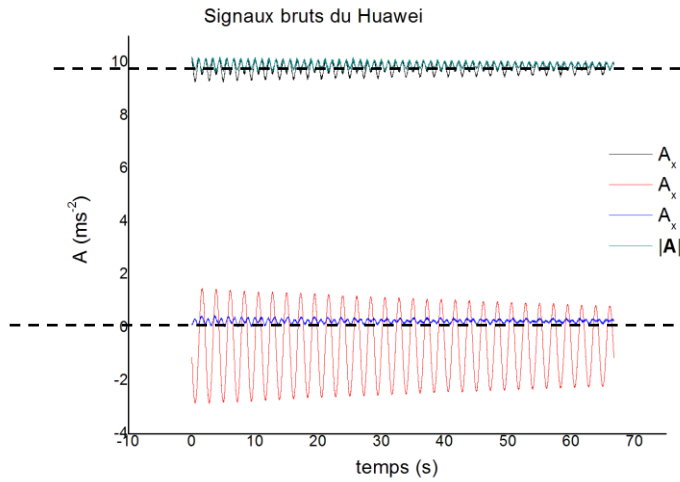


Protocole de connexion

1. Connecter le second smartphone sur le point d'accès du premier avec le mot de passe: 59d78ece
2. Lancer l'application Phyphox, choisir le programme « Acceleration with g » et ouvrir le menu en haut à droite (... verticaux)
3. Cocher « allow remote access »: une adresse s'affiche:
<http://192.168.43.20:8080>
4. Copier l'adresse dans un second onglet du navigateur de l'ordinateur (2 fenêtres serait mieux...)

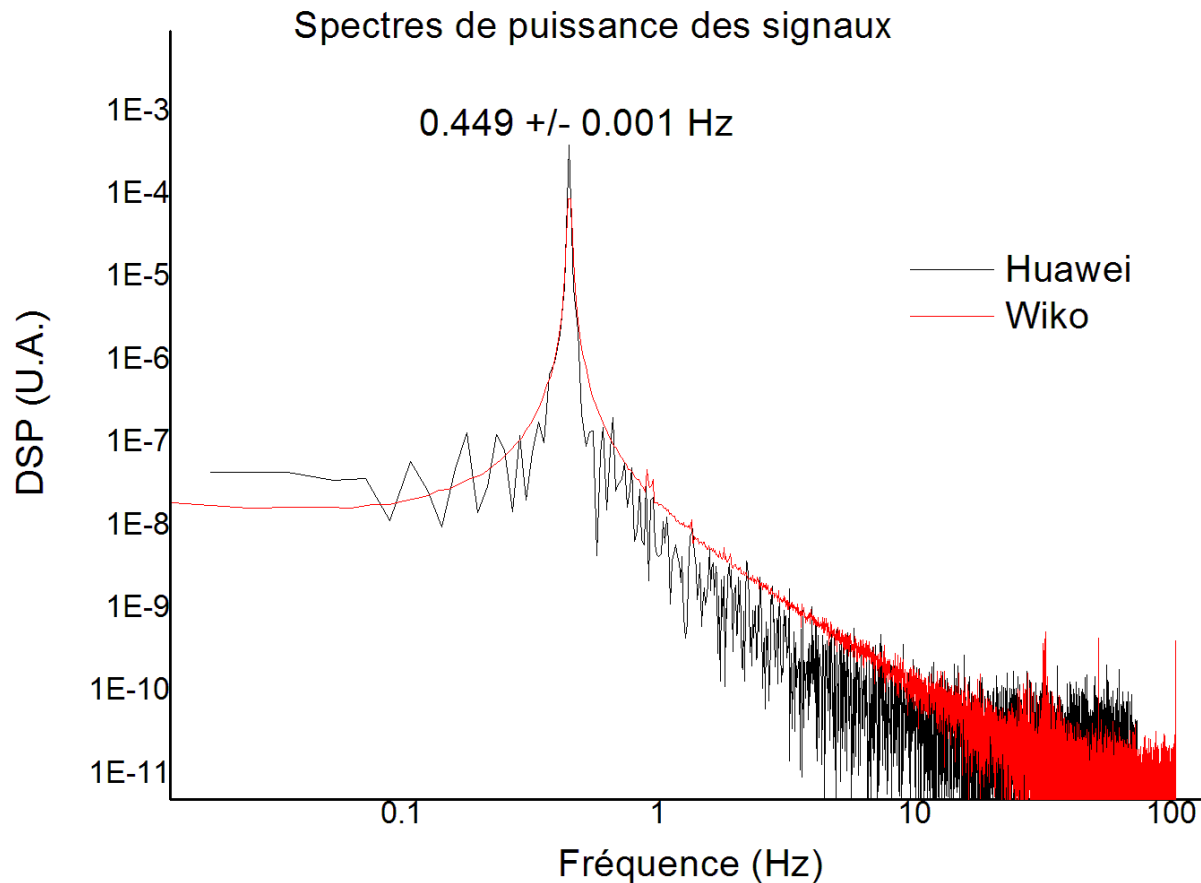


Données brutes



Huawei!!!

Spectres



0.449 +/- 0.001 Hz

vs

0.450 +/- 0.001 Hz

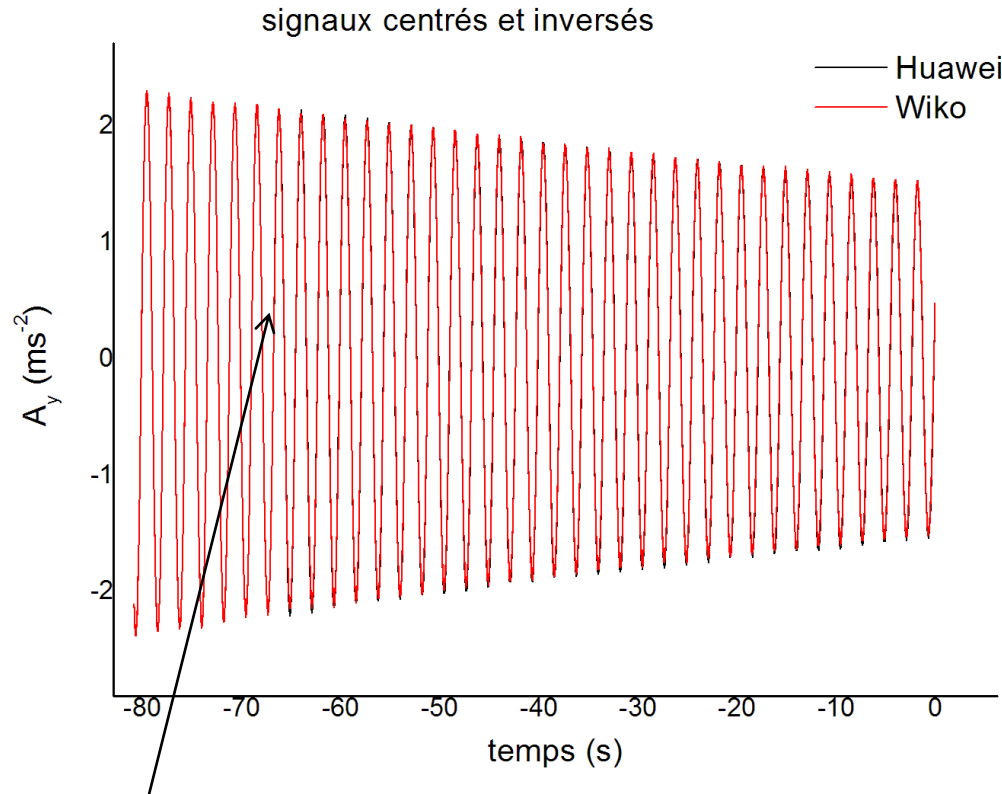
Pas de différence significative

$$f_{att.} = \frac{1}{2\pi} \sqrt{\frac{g}{L}}$$

Indep. de $M=m_1+m_2$

=> pas de déplacement de G

Centrage et synchronisation



départ Huawei

Choix:

- des t_0
- des y_0

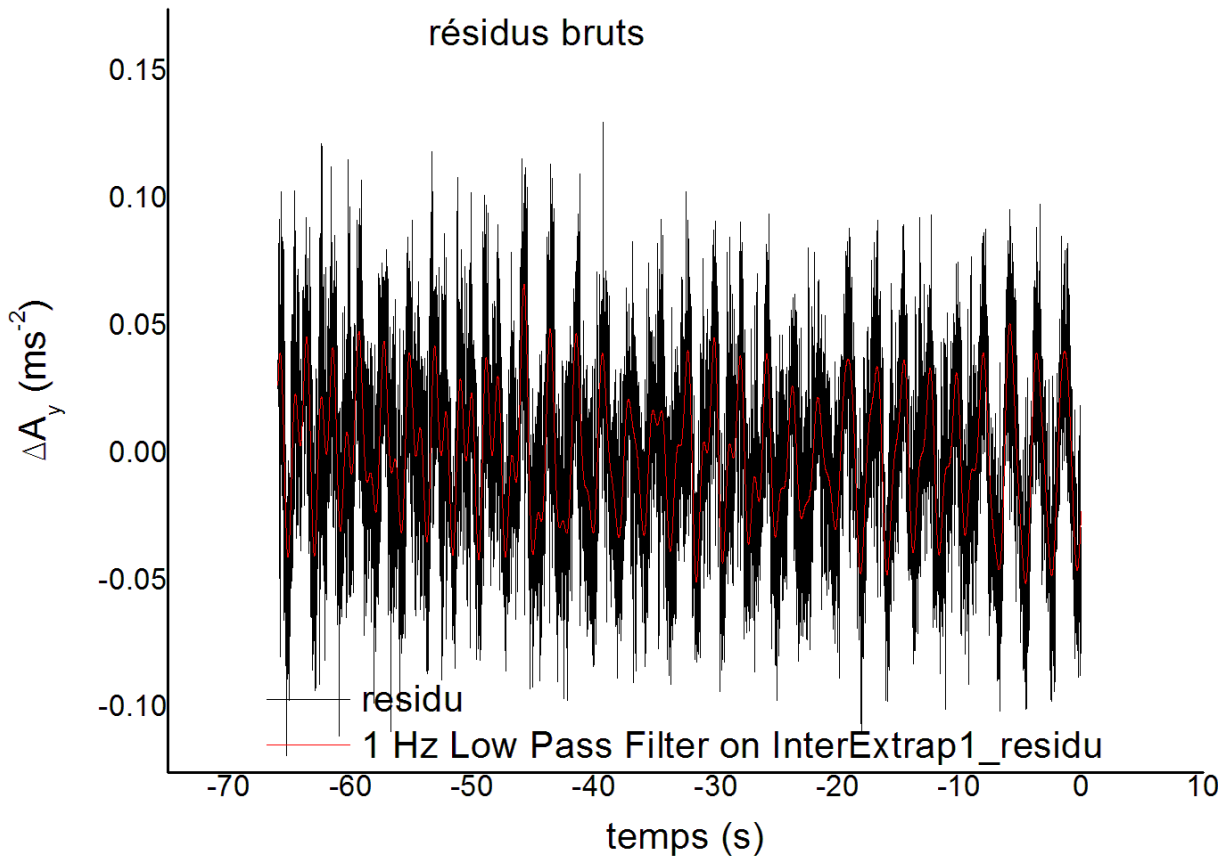
+ inversion

Identiques?

Comparaison?

difficile car chaque smartphone a ses propres paramètres: t_0 , $f_{\text{éch.}}$...

→ Interpolation de $t=-66$ à 0 s pas de 0.01 s



- qq%
- Forte composante à f_0 ...

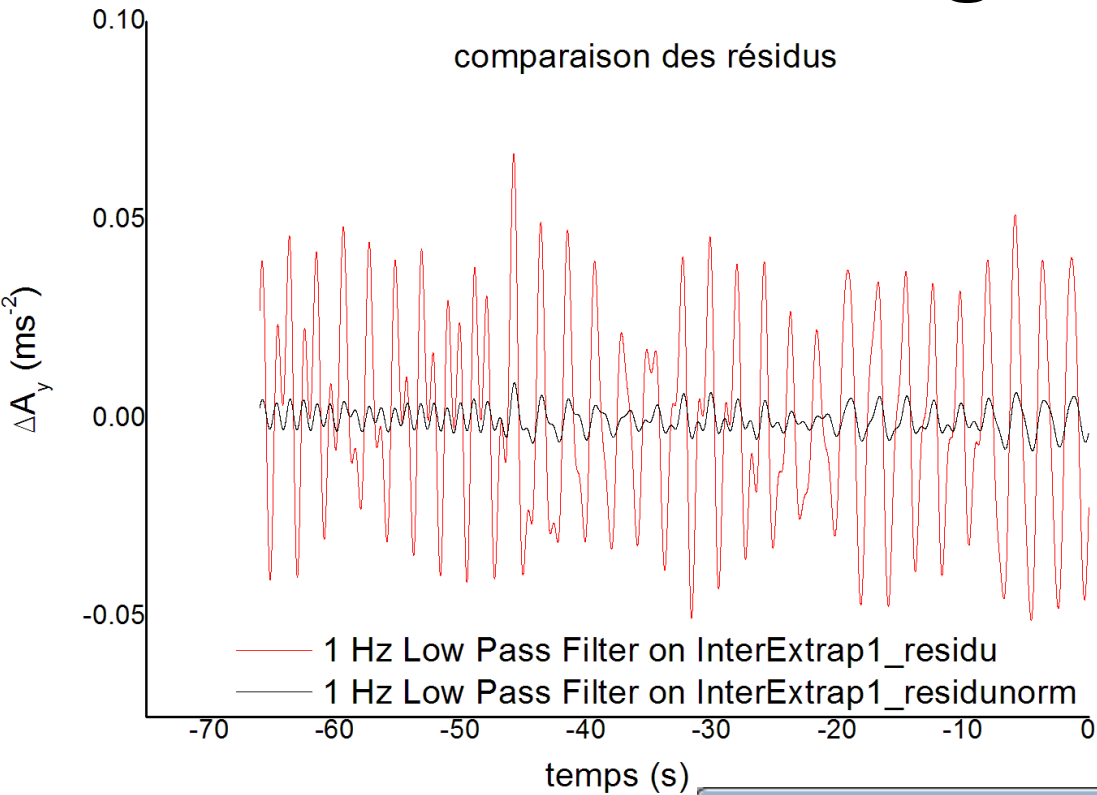
Origine?

	Col(X)	Mean(Y)	sd(yEr±)	Min(Y)	Max(Y)
1	Data2G	-0.01386	1.29485	-2.19989	2.15315
2	Data3G	-0.00164	1.28048	-2.13549	2.12026
3	Data2Centre	-3.594E-12	1.29485	-2.18603	2.16701
4	Data3Centre	2.4085E-12	1.28048	-2.13385	2.1219

étalonnage différent > à 1%

normalisation:
$$res_{norm.} = \left(\frac{(a_y)_2}{1.29485} - \frac{(a_y)_3}{1.28048} \right) \times \left(\frac{1.29485 + 1.28048}{2} \right)$$

Progrès



résidu divisé par 7 !

Stats - Data from InterExtrap1

Data from InterExtrap1

Recalculate

Advanced Statistics

Entire Dataset Use Rows

Percentile 95.00

	Col(X)	Mean(Y)	Std(Y)Er±	Min(Y)	Max(Y)
5	residu	-6.00258E-12	0.03617	-0.11822	0.13061
6	residunorm	-9.04079E-13	0.00501	-0.0161	0.01953

Amélioration?

Synchronisation: $\cos(\omega t) - \cos(\omega t - \phi) = 2 \sin(\phi/2) \sin(\omega t + \phi/2)$

Plan

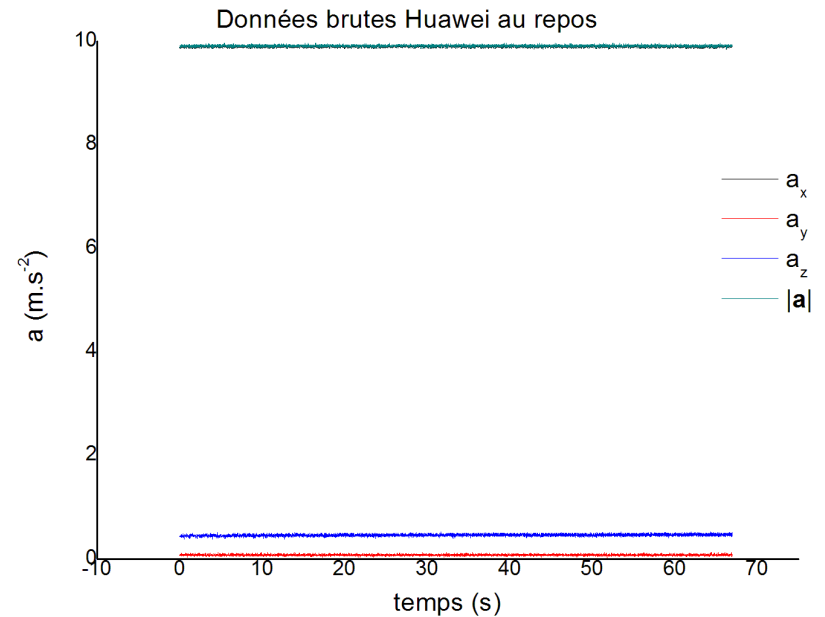
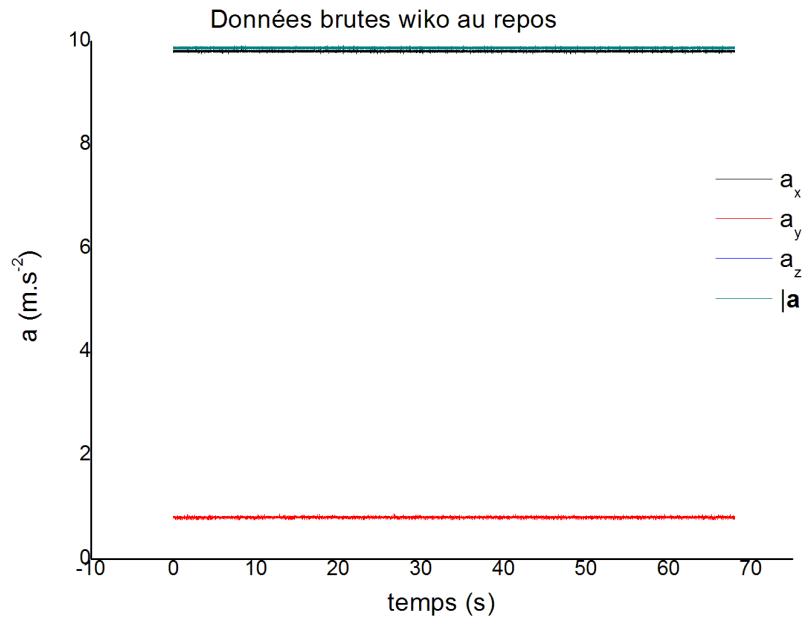
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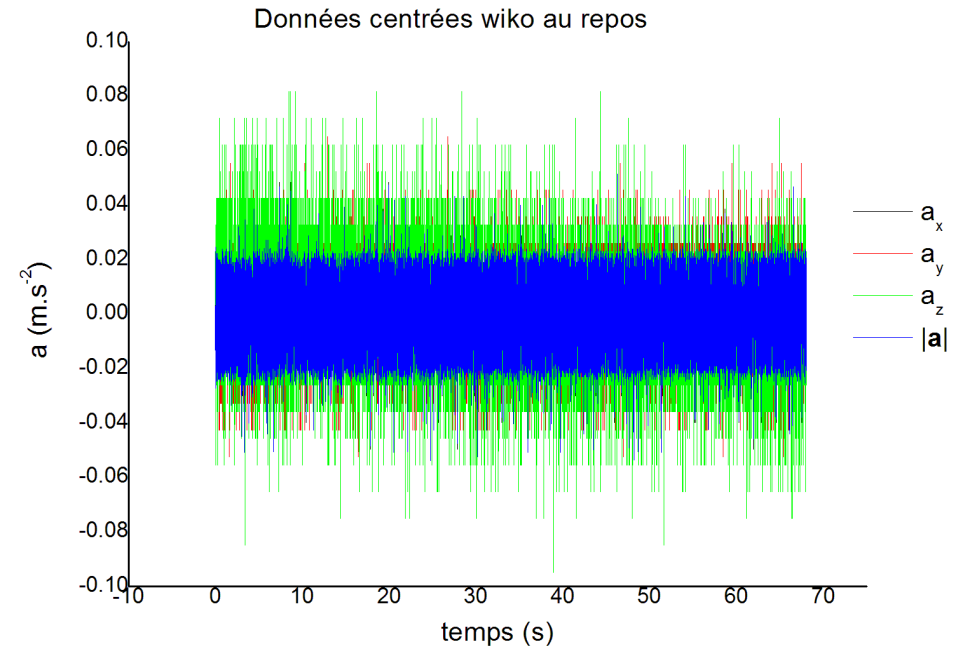
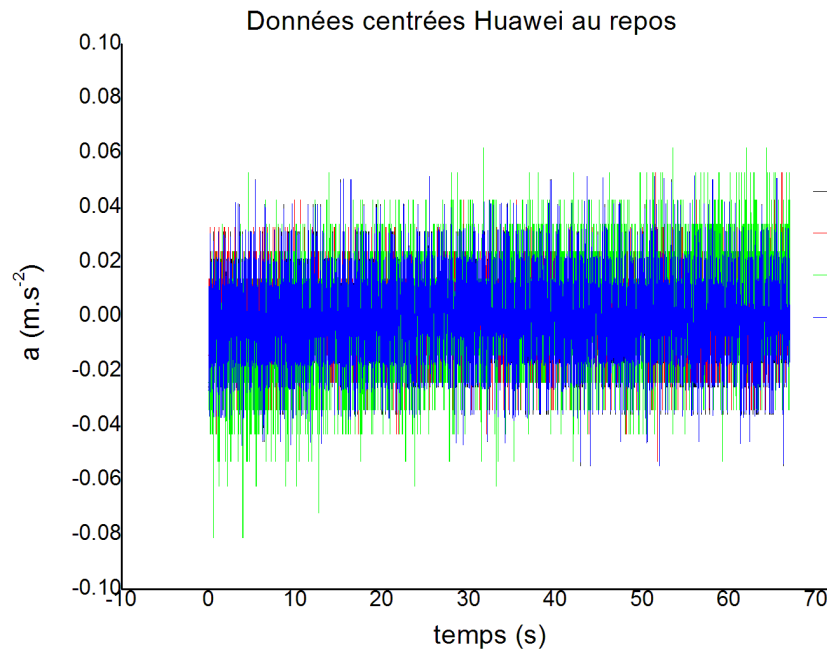
4)Analyse du bruit

Comparaison des 2 smartphones



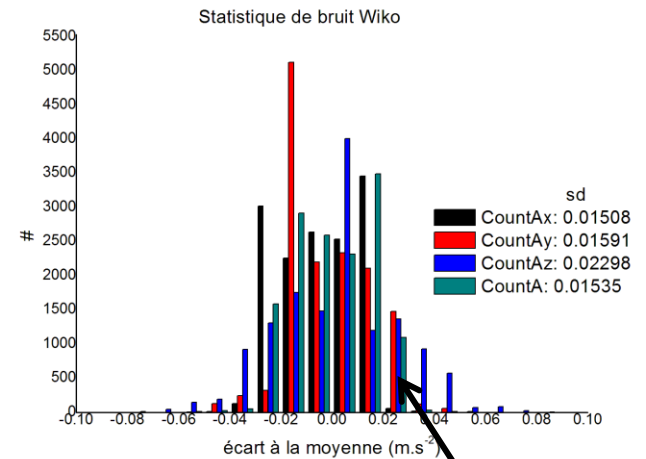
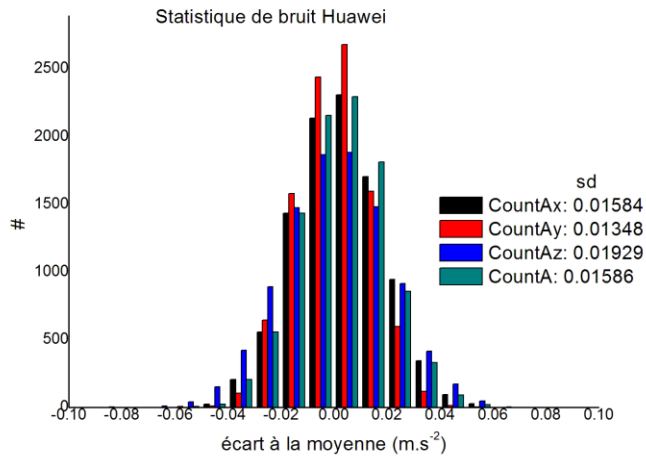
→ Analyse du bruit

Bruit



Wiko plus rapide, plus bruité...

Statistiques



Data1 - Data from HuaweiBrut

Data from HuaweiBrut

Recalculate

Advanced Statistics Percentile 95.00

	Col(X)	Rows(Y)	Mean(Y)	sd(yEr±)	Min(Y)	Max(Y)
1	ax	[1:9795]	9.89981	0.01584	9.845	9.95
2	ay	[1:9795]	0.08111	0.01348	0.028	0.134
3	az	[1:9795]	0.46409	0.01929	0.383	0.526
4	a	[1:9795]	9.91105	0.01586	9.85639	9.96274

Data3 - Data from WikoBrut

Data from WikoBrut

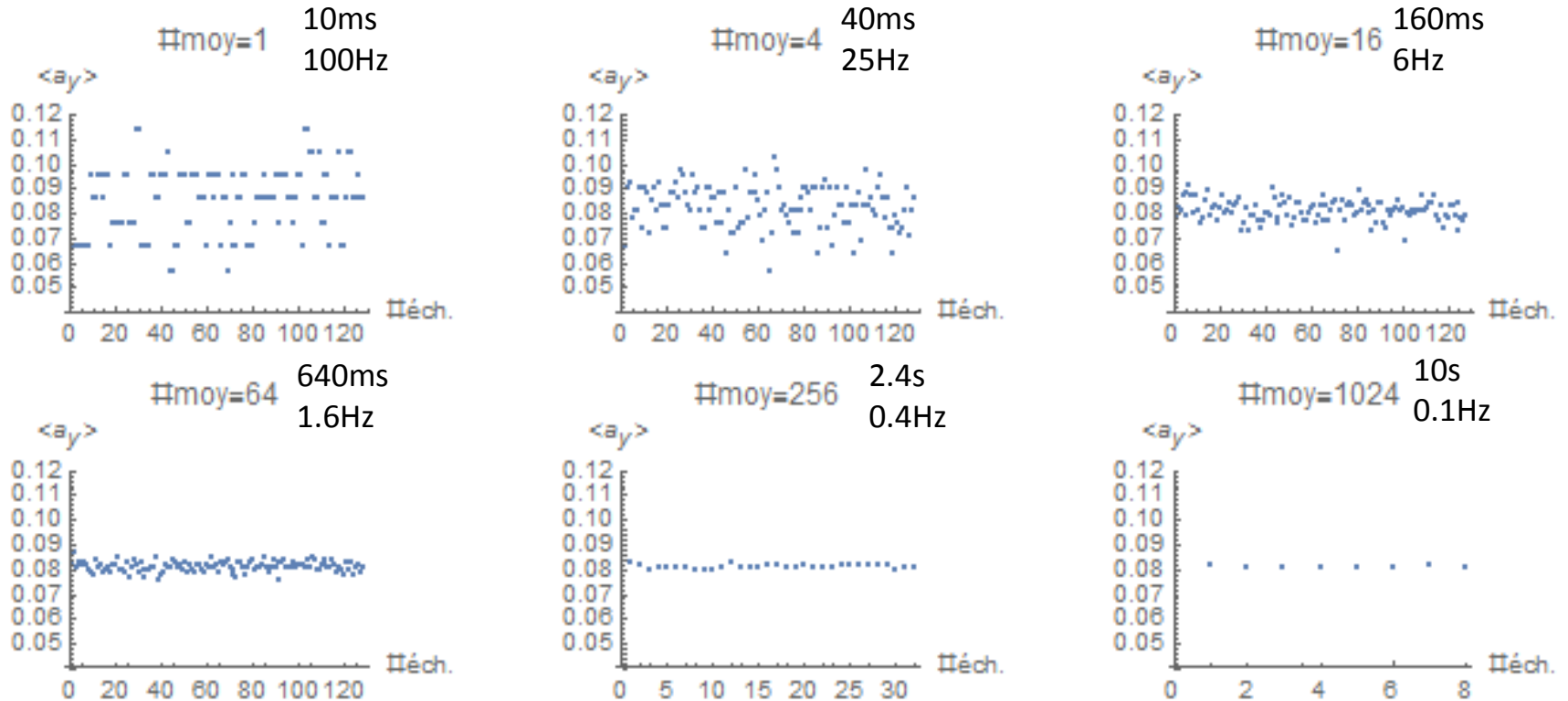
Recalculate

Advanced Statistics Percentile 95.00

	Col(X)	Rows(Y)	Mean(Y)	sd(yEr±)	Min(Y)	Max(Y)
1	ax	[1:14146]	9.8073	0.01508	9.75762	9.85568
2	ay	[1:14146]	0.80748	0.01591	0.75511	0.87279
3	az	[1:14146]	-0.78787	0.02298	-0.8826	-0.70608
4	a	[1:14146]	9.87201	0.01535	9.81822	9.92354

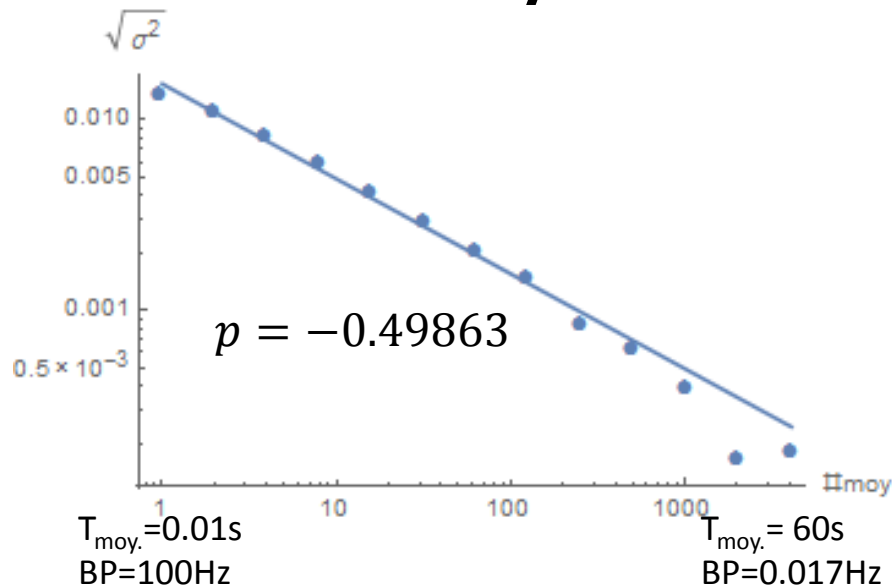
Pas très gaussien...

Variance/déviation d'Allan (I)



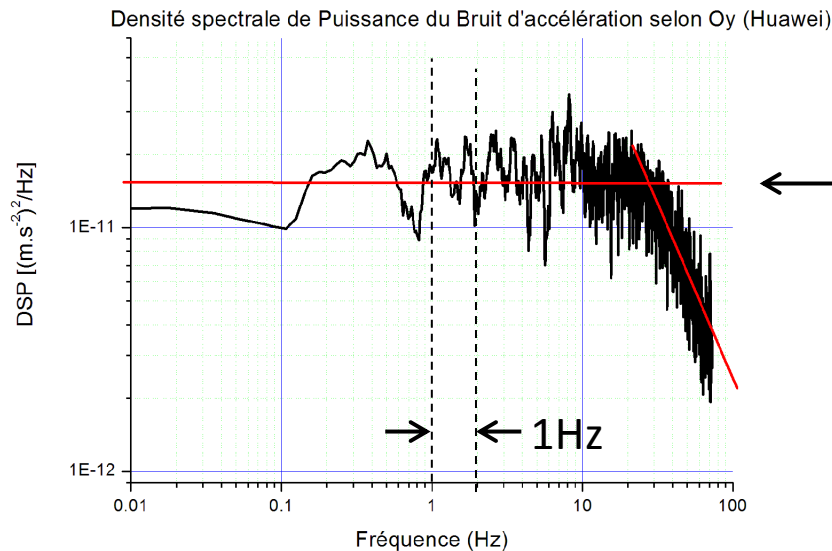
D'un graphe à l'autre on regroupe les points par 4 dont on fait la moyenne

Variance/déviatiion d'Allan (II)



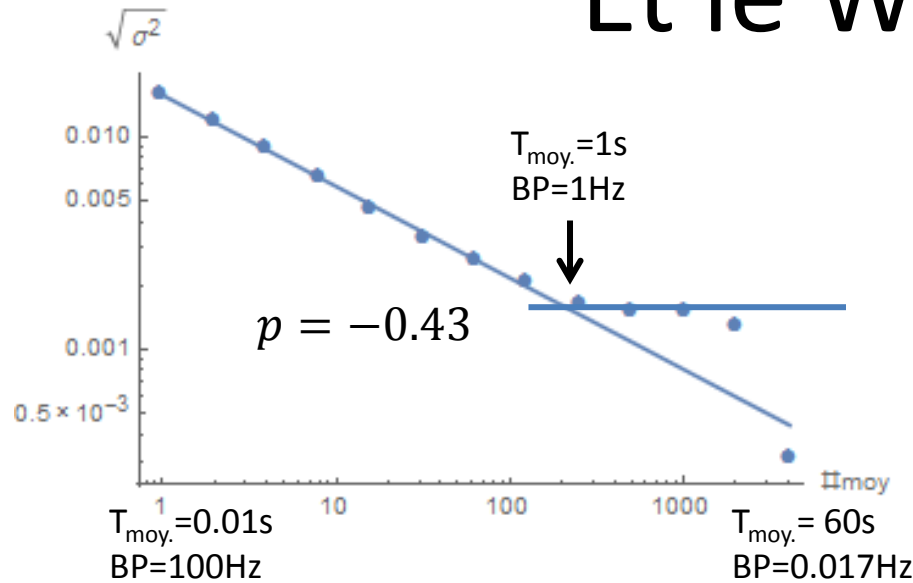
Bruit blanc stationnaire
 $0.01s < T_{moy} < 60s$

$$\sqrt{\sigma^2} = \frac{1.5 \times 10^{-3}}{\sqrt{T_{moy}}} \text{ m.s}^{-2} \cdot \sqrt{s}$$

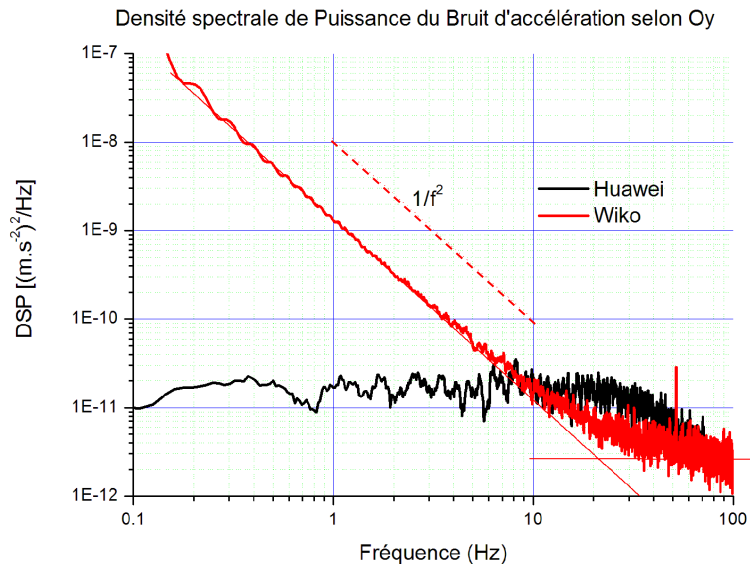


← $\sqrt{DSP} = 1.5 \times 10^{-3} \text{ m.s}^{-2} / \sqrt{\text{Hz}}$

Et le Wiko?



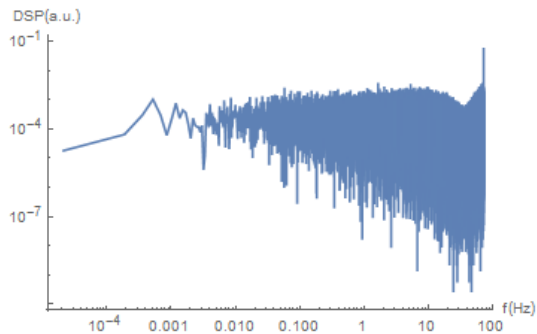
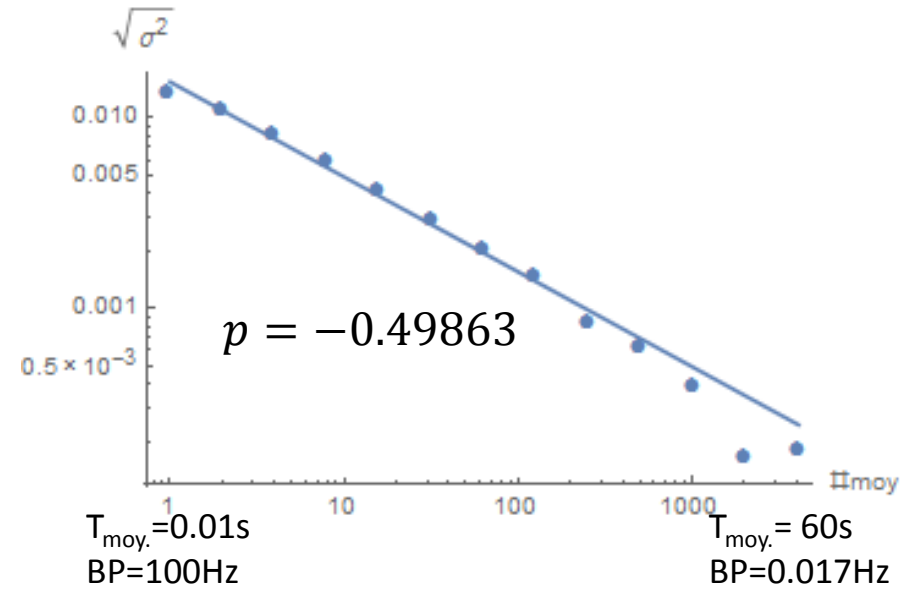
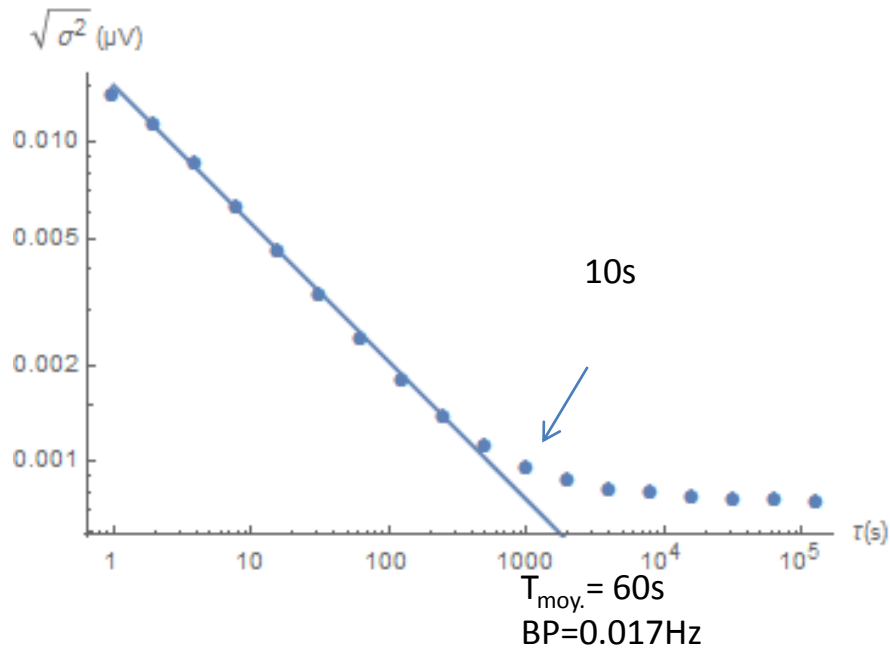
Palier vers 1s



$1/f$: bruit extrêmement non gaussien!
 → bruit rose, en excès, de scintillation
 → *flicker noise*


Amélioration

Programme simplifié MyAy => acquisition sur 50 minutes, 450kéchantillons



Pas totalement clair....

On n'est pas les seuls...



NORTHWESTERN UNIVERSITY
Department of
Earth & Atmospheric Sciences

Smartphones – the Geophysics Lab in Your Students' Pocket

Amir Salaree¹, Seth Stein², Nooshin Saloor³, and Reece Elling⁴

1.amir@earth.northwestern.edu 2.seth@earth.northwestern.edu 3.nooshin@earth.northwestern.edu 4.reece@earth.northwestern.edu

AGU FALL MEETING
New Orleans
11-15 Dec. 2017 What will you discover?

ED21B-0278

"Damn! I wish we could do that in class..."

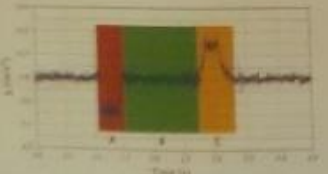
Smartphones, which students own and are (perhaps un-tilly) comfortable with, have many otherwise expensive instruments as built-in sensors. These instruments are wily tools that make labs easier, faster, and more fun. We use smartphones in several labs in an introductory geophysics class.

Here, we demonstrate three activities in an introductory geophysics class at Northwestern University. These applications illustrate the potential for using smartphones in a wide variety of geophysics teaching, much as their value is being increasingly recognized in other educational applications.

1. Measuring g

Goal: Learn how gravity measurements represent accelerations.

Students used their smartphones to measure the acceleration of gravity in a moving elevator. They used an app (G-Sensor Logger) to save values of g recorded by the accelerometers in their smartphones as a function of time.




Students:



1. Learned to calibrate their instruments.
2. Extracted and analyzed time series.
3. Interpreted the segments in their plots.

2. Measuring Seismic Wave Velocity

Goal: Learn about seismic data acquisition & interpret seismic records.



The class measured the speed of sound (P-waves) in a wooden table using a linear array of smartphones similar to the procedure used in reflection seismology. The students made an approximately 3 m long, equally spaced, array of smartphones and used their seismometer apps (Seismometer) to record vibration signals from pounding on the table at one end of the array. They then extracted and saved the recorded time-series from their phones. These text files were uploaded onto Google Drive to share with everyone in the class. Connecting the first arrivals on the record section gave the velocity of the table as ~ 3500 m/s.

Students:

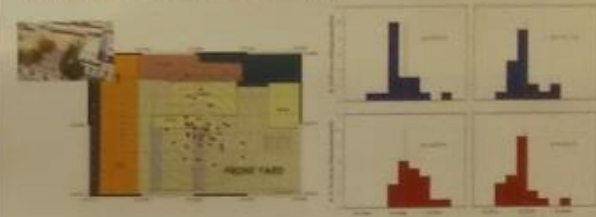
1. Learned that different instruments record the same signal differently.
2. Learned to interpret seismic arrival times.
3. Designed "better arrays" to record better seismic shots.

The compressed image picture from the experiment. The red lines connect the first arrivals throughout the three shots.

3. Positioning – Accuracy and Precision

Goal: Learn concepts of accuracy vs. precision using geographic data.

Students used their smartphones to make measurements, at least 6 hours apart, of the latitude and longitude of the southeast corner of a planter in front of a university building. Then they extracted the coordinates using the Google Maps app, entered their results in a spreadsheet, and shared them with their labmates on Google Drive.



Cumulative scatter of coordinates, with Android and iPhone. Histograms showing which of the measurement groups are more precise and/or accurate.

The yellow star shows the geospatial reference.

Students:

1. Learned how to make and extract coordinate measurements.
2. Analyzed the distribution of coordinates from their measurements.

The Road ahead

Smartphones let educators develop creative pedagogy in the active learning process. Such applications can, in some cases, replace computer simulations with real data. Instructors have two options: forget about these nifty tools and keep doing labs in the old ways, or benefit from smartphones as mini-computers and tiny, powerful instruments. Our advice to instructors is to see whether smartphones work in their applications.

MANUSCRIPT TO BE PRESENTED AT THE AGU FALL MEETING 11-15 DEC 2017, NEW ORLEANS, LA. REFERENCE CODE: A, S11, 0, 0000, 0, 001. FOR MORE INFORMATION SEE: www.agu.org, AGU & Earth & Space Science

À faire

- Écrire un article: BUP, AMJPhys?
- Se documenter sur le bruit: DSP, Allan...
- Améliorer la prise de données: bande passante, capteur 1D, compression des données, moyenne...