Synchronisation chez les micro-organismes à deux flagelles

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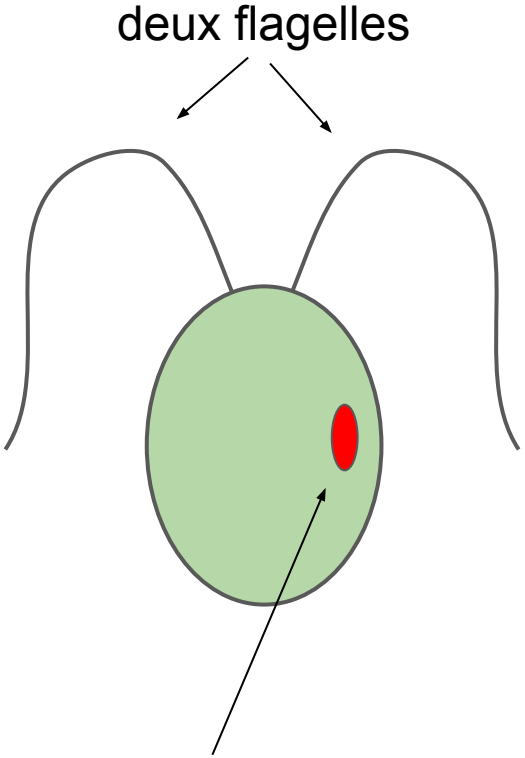
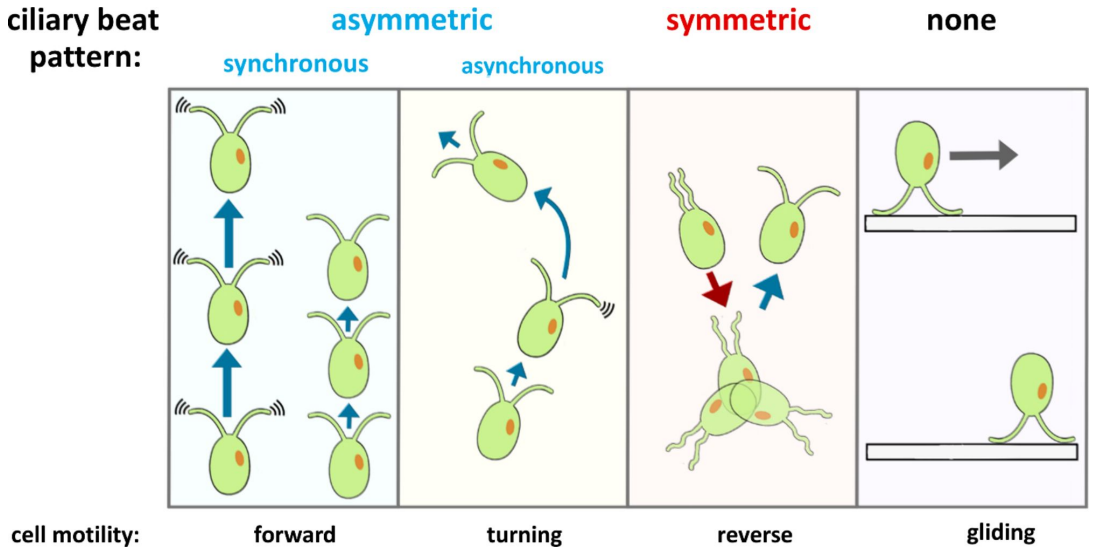
Sous la direction de Françoise ARGOUL et Antoine ALLARD

Chlamydomonas reinhardtii



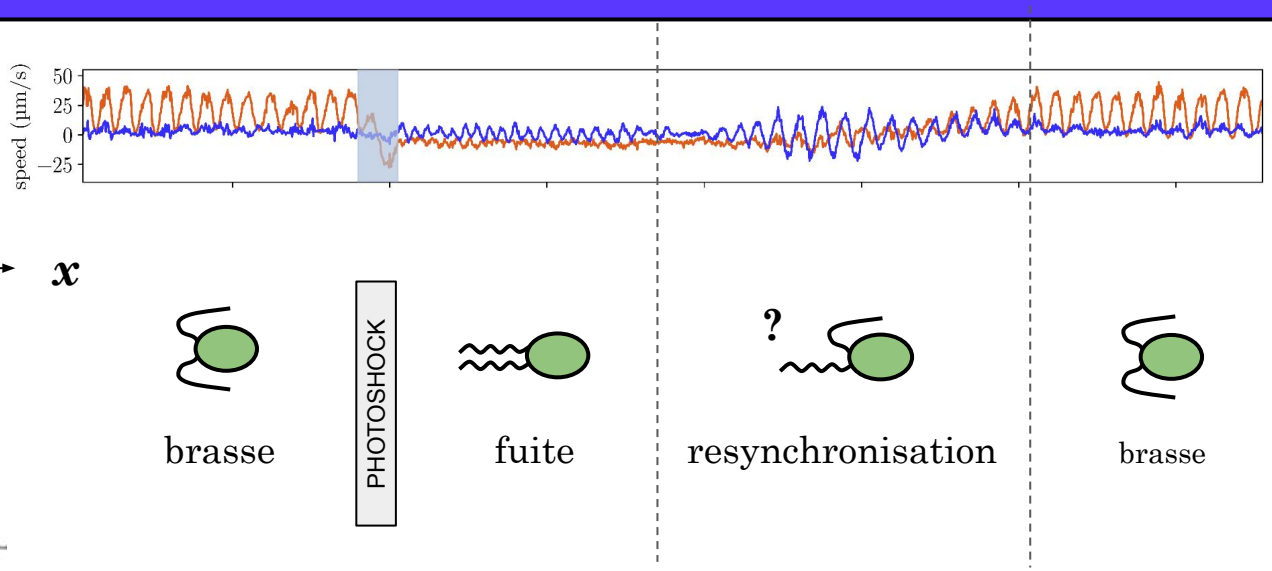


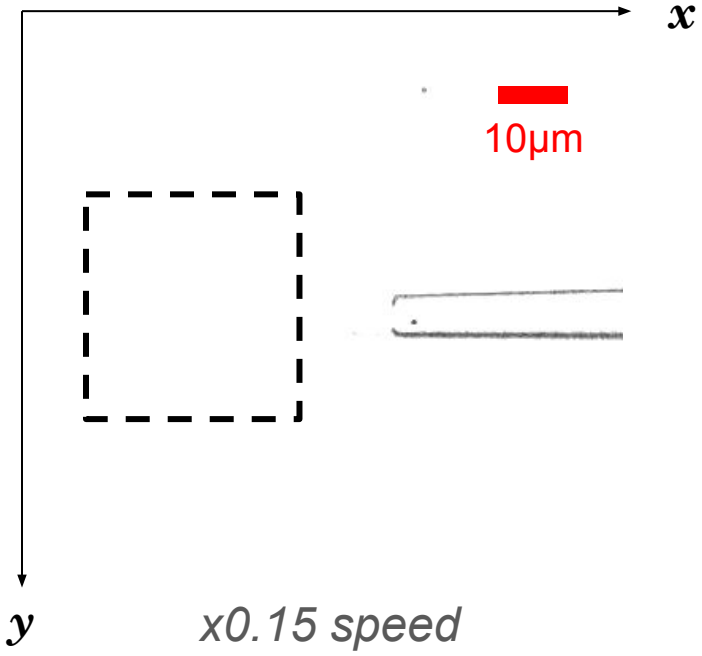
Strain et al. , COP5/HKR1 changes ciliary beat pattern and biases cell steering during chemotaxis in Chlamydomonas reinhardtii

<u>Couplage entre les flagelles:</u>
-Hydrodynamique
-Basal

Données expérimentales

GPV puis moyenne des vitesses sur une zone



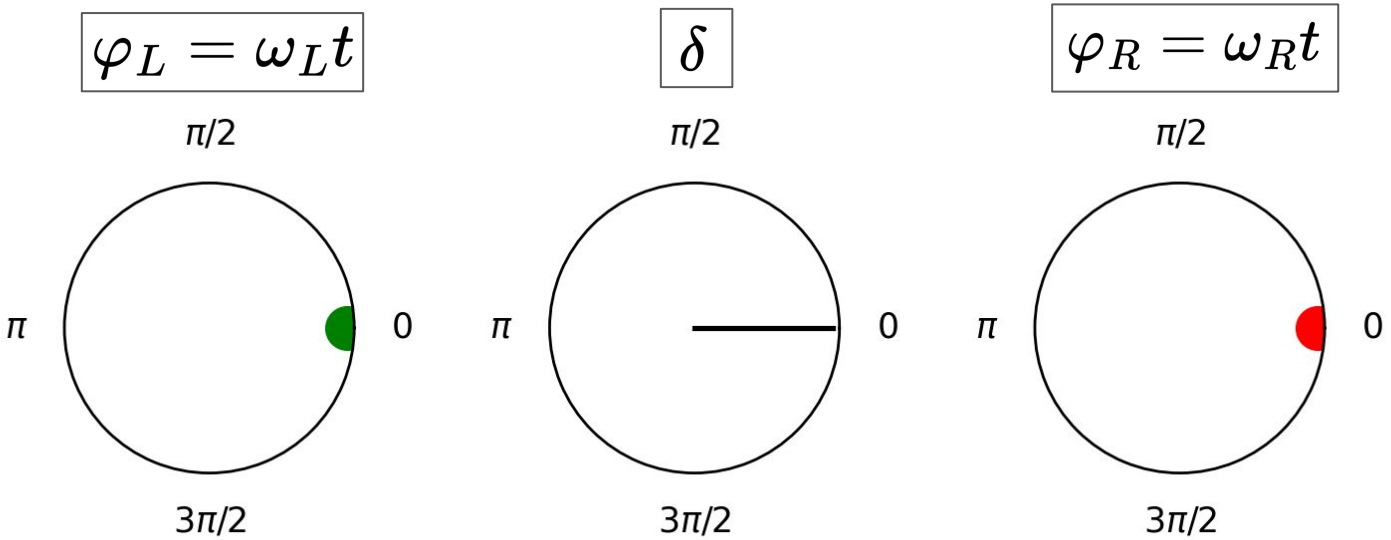


Vitesses moyennées **Ux** et **Uy**.
Le photochoc induit des changements dans la nage.

2 oscillateurs : $Z_L(t) = A_L e^{i\varphi_L(t)}$ $Z_R(t) = A_R e^{i\varphi_R(t)}$

Différence de phase: $\delta = \varphi_L - \varphi_R$

Synchronisation: $\dot{\varphi}_L = \dot{\varphi}_R \implies \dot{\delta} = 0$



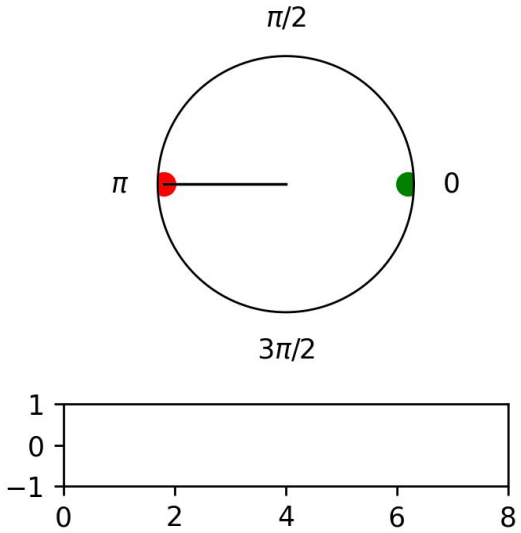
Couplage entre deux oscillateurs

Système à 2 oscillateurs:

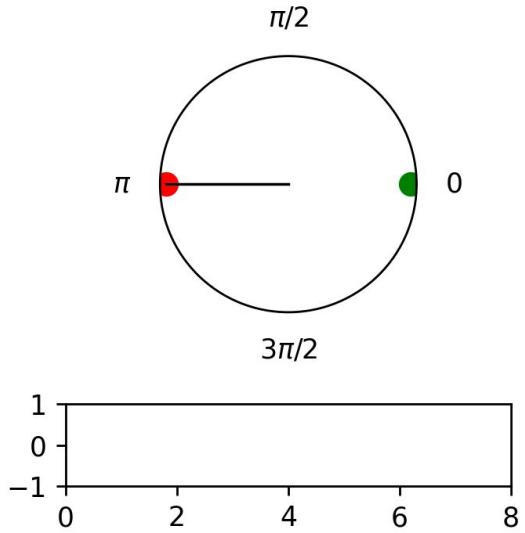
$$\begin{cases} \dot{\varphi}_L = \omega_L + B\sin(\delta) \\ \dot{\varphi}_R = \omega_R - B\sin(\delta) \end{cases}$$

$$\dot{\delta} = \Delta\omega + 2B\sin(\delta)$$

Equation d'Adler



Couplage fort

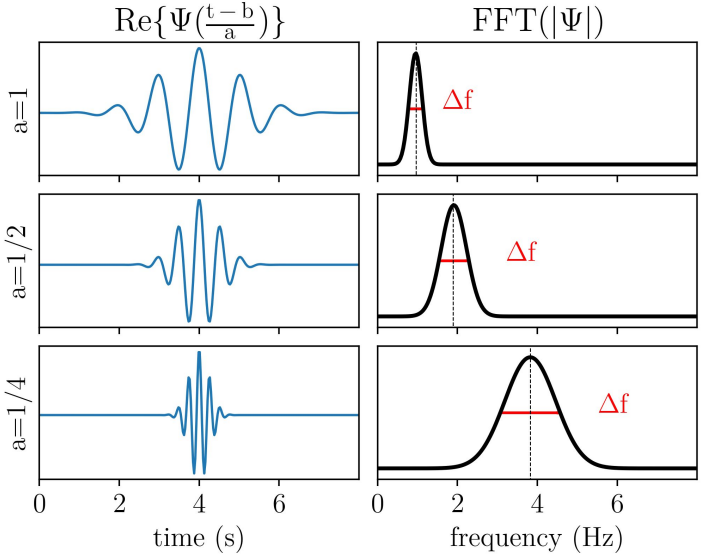


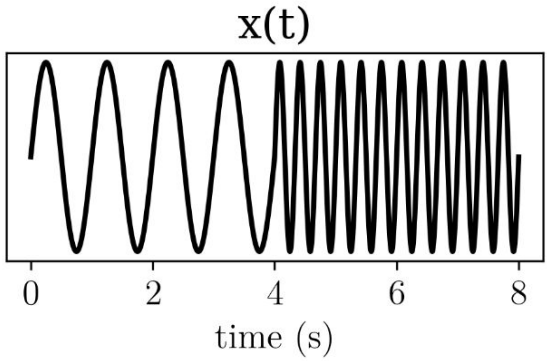
Couplage faible

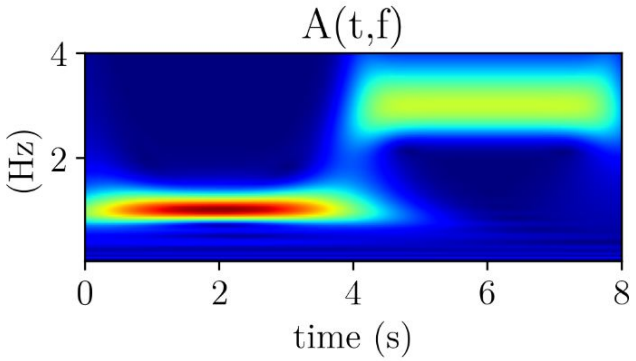
Ondelette de Morlet : $\Psi_{n_0}(t) = \pi^{-1/4} e^{in_0 t} e^{-t^2/2}$

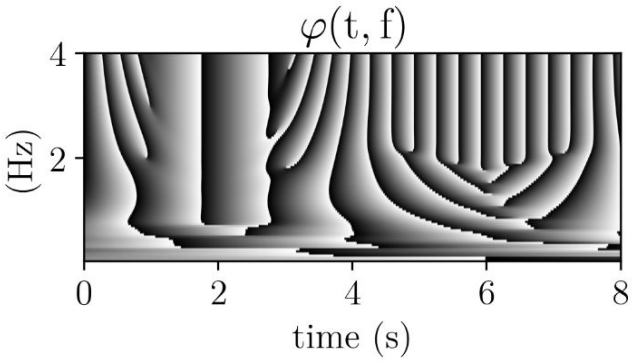
CWT: $W(a,b) = \frac{1}{|a|^{1/2}} \int_{-\infty}^{+\infty} x(t) \Psi^*(\frac{t-b}{a}) dt$

$$W(t,f) = A(t,f) e^{i\varphi(t,f)}$$







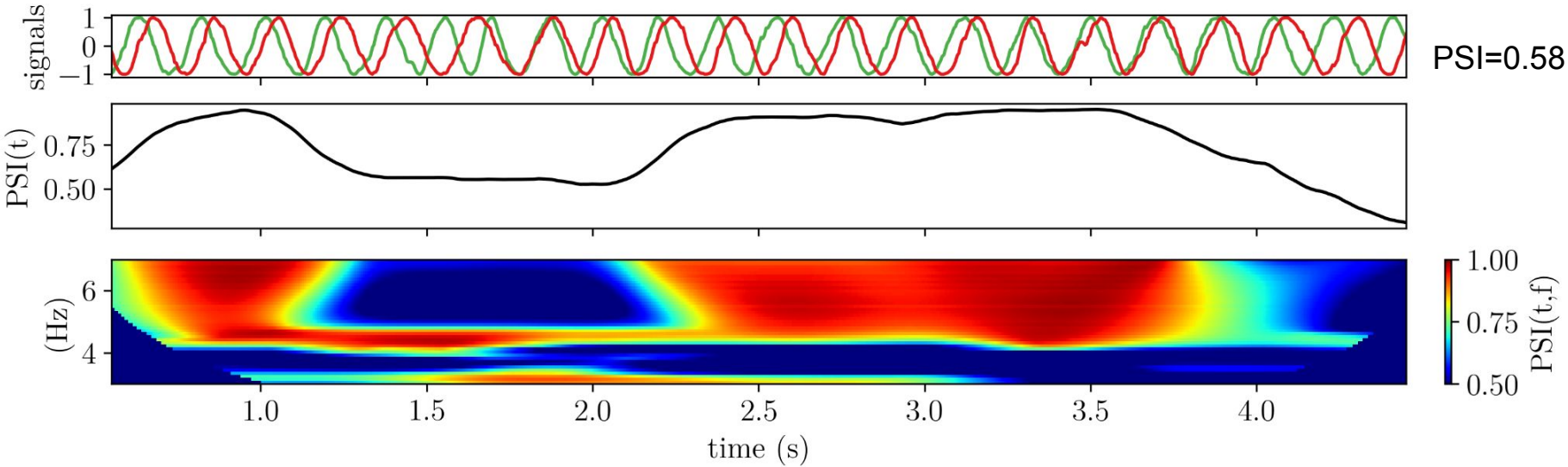


Phase Synchronization Index (PSI)

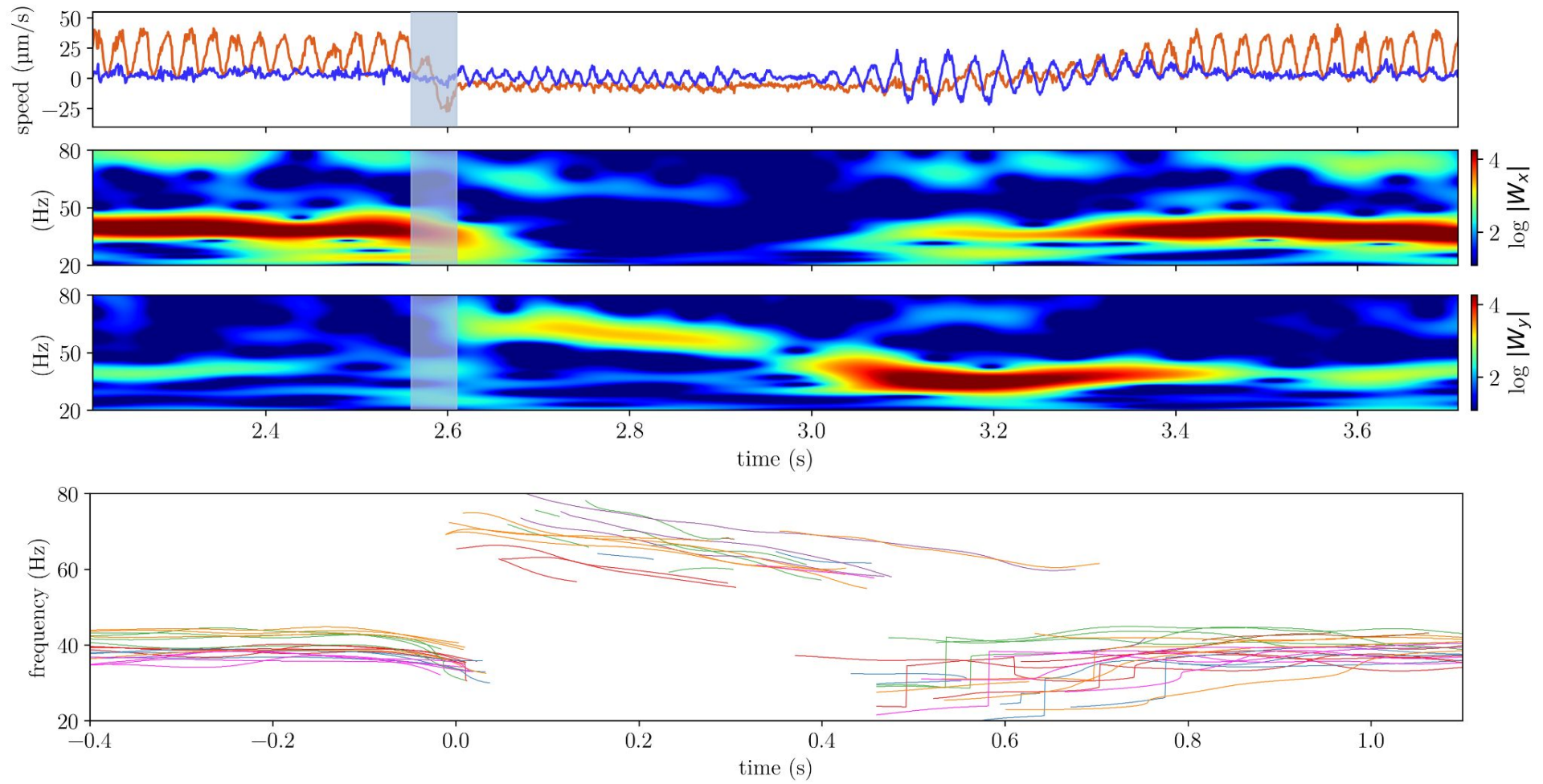
$$PSI = \frac{1}{N}\left|\sum_{k=t_0}^{t_f} e^{i(\varphi_L(k)-\varphi_R(k))}\right| \quad \textit{classique}$$

$$PSI(t) = \frac{1}{N}\left|\sum_{k=t-T/2}^{t+T/2} e^{i(\varphi_L(k)-\varphi_R(k))}\right| \quad \textit{glissant}$$

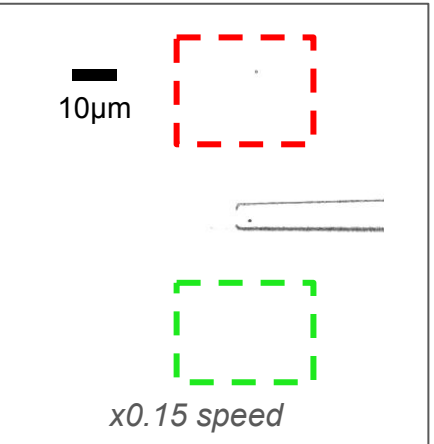
$$PSI_\Psi(t,f) = \left|\left\langle \frac{W_1(t,f)W_2^*(t,f)}{|W_1(t,f)||W_2(t,f)|}\right\rangle_{\Delta T_\Psi}\right| \quad \textit{temps-fréquence}$$

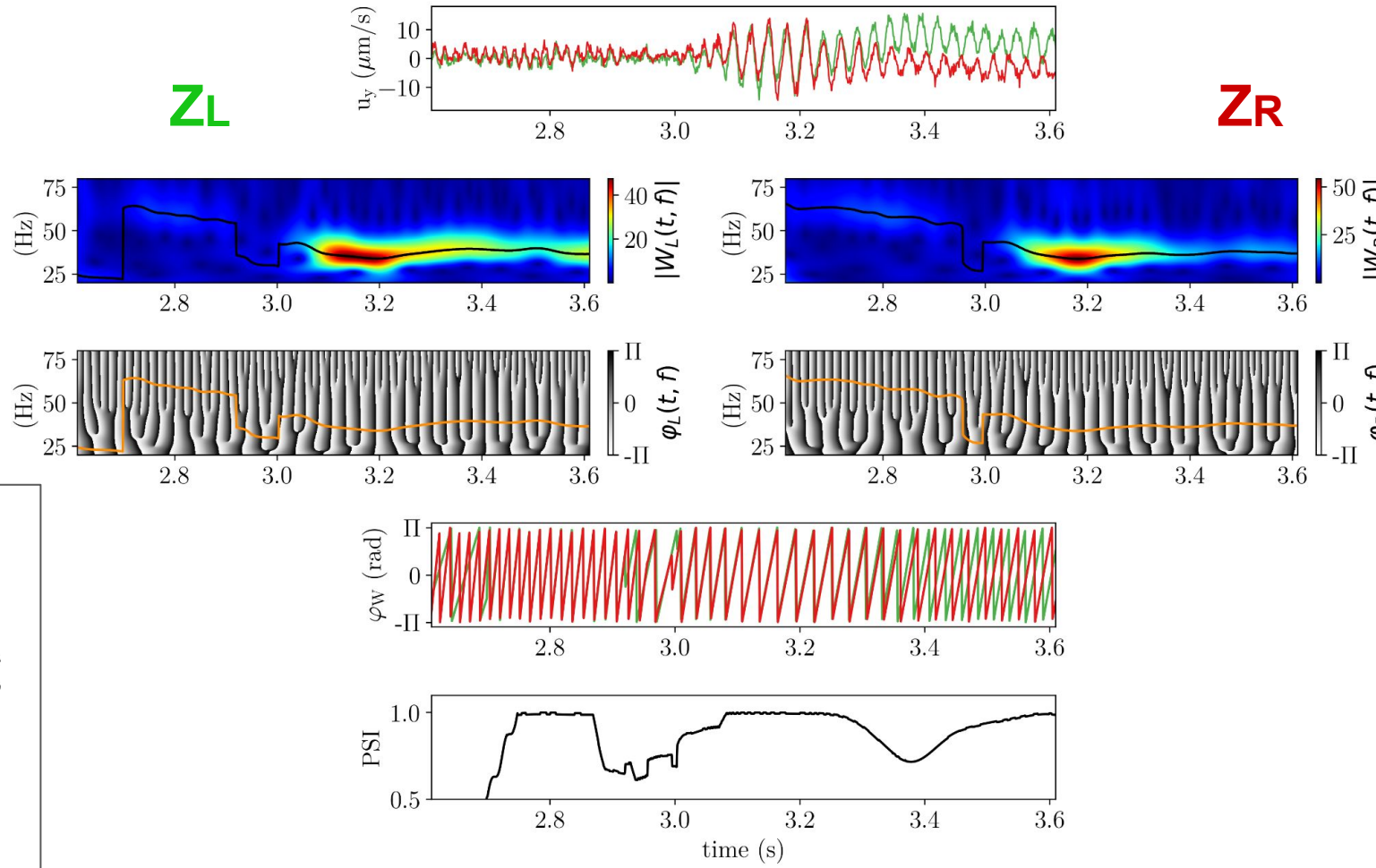


Résultats - Fréquences de nage

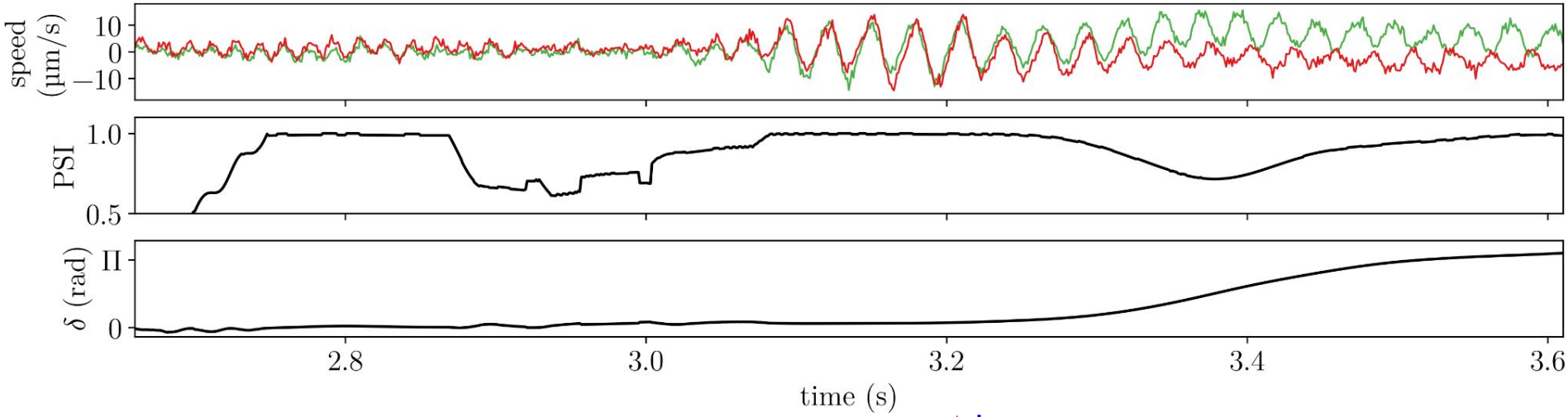


Résultats - Estimation du PSI



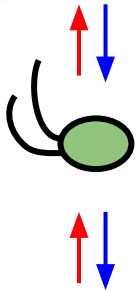


Résultat - Resynchronisation



EN PHASE
(haute fréquence)

PERTE DE SYNCHRONISATION



EN PHASE
(basse fréquence)

ANTI PHASE
(basse fréquence)