SILENTSYS

ultralow noise systems

Refimeve+

Réseau fibré métrologique à vocation européenne

FIRST TF

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PRINCIPE ET PERFORMANCES DE L'OSCILLATEUR OPTIQUE À AUTO-AFFINEMENT SPECTRAL

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Prof. MEHDI ALOUINI

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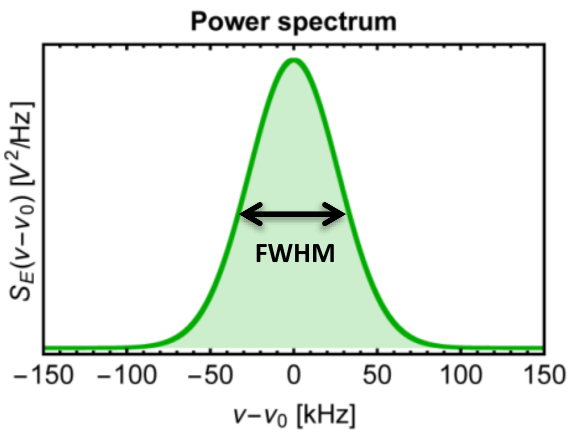
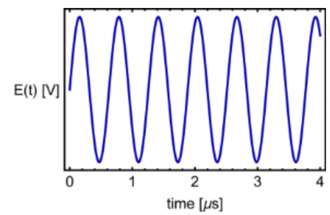
Power spectrum

$$S_E(\nu - \nu_0) = \mathcal{F}[R_E(\tau)]$$



CW LASER



$$E(t) = E_0 \sin[2\pi\nu_0 t + \phi(t)]$$

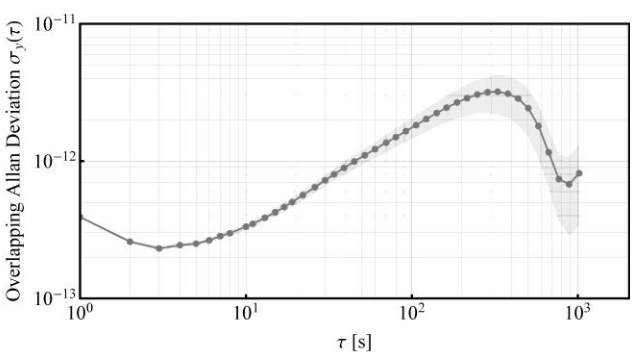
Intrinsic & Technical noise sources

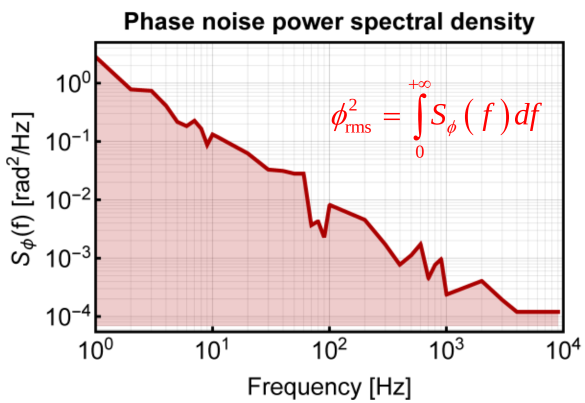
Phase noise spectrum

$$S_\phi(\mathrm{f}) = \mathcal{F}[R_\phi(\tau)]$$

Phase fluctuations autocorrelation function

Frequency Stability





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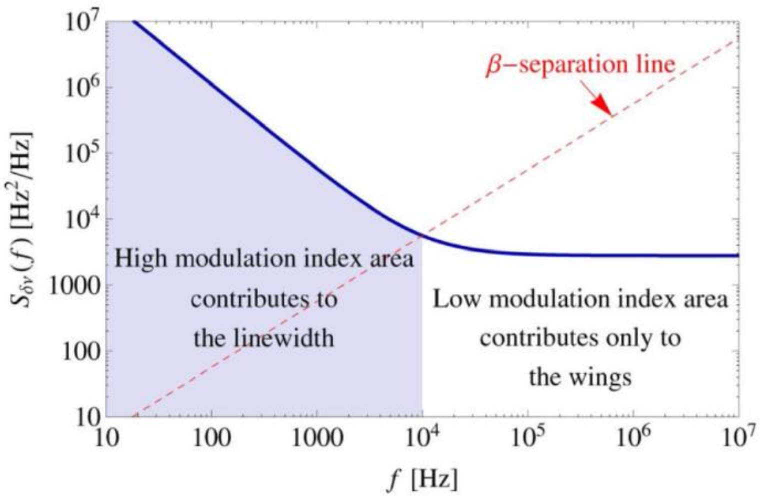
LASER : BRUIT, STABILITE, LARGEUR DE RAIE

name	*formula*	*derived from*	*unit*
FWHM, HWHM	------------------------------	Power spectrum	Hz, nm
Lorentzian linewidth Largeur de raie «Commerciale»	$\pi \cdot S_\nu^0$, where S_ν^0 is the white frequency noise PSD[17]	Power spectrum/frequency noise PSD	Hz
FWHM_β	$\sqrt{8 \cdot \ln(2) \cdot A}$	Frequency / Phase noise PSD	Hz



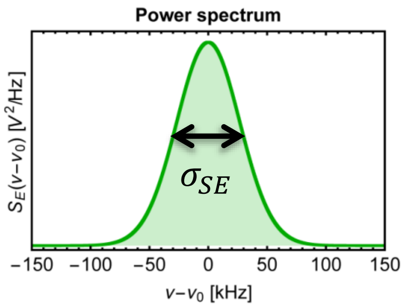
La FWHM peut être < à la Lorentzian linewidth pour les lasers stabilisé !

La FWHM dépend du temps d'observation, d'intégration !

G. Di Domenico, S. Schilt, and P. Thomann, "Simple approach to the relation between laser frequency noise and laser line shape," Appl. Opt., vol. 49, no. 25, pp. 4801–4807, 2010.

Relationship between the width of the power spectrum and phase noise spectrum:

Power Spectrum



Standard deviation of the Phase noise spectrum (double sideband)

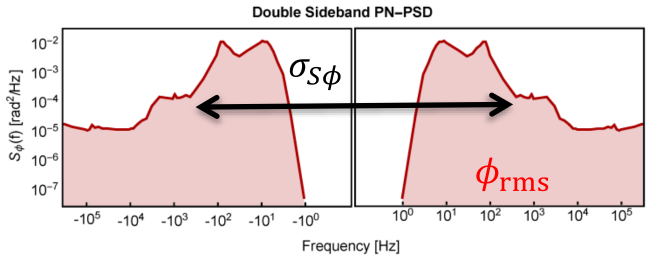
$$\sigma_{SE} = \sigma_{S\phi} \cdot \phi_{\rm rms} = \upsilon_{\rm rms}$$

Standard deviation of the Power spectrum

Integrated phase noise

Integrated frequency noise

Phase noise Spectrum



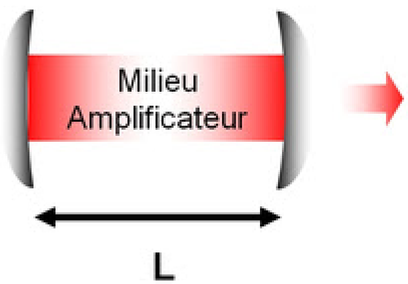
Minimiser le bruit de phase ne minimisera pas toujours la FWHM !

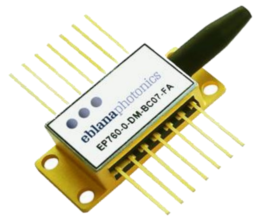
Il faut minimiser le bruit de fréquence (lock en phase vs lock en fréquence)

TYPES DE LASERS CONTINUS MONOMODE

(non exhaustif…)

LASER
(VULGARISÉ)





SEMICONDUCTEUR

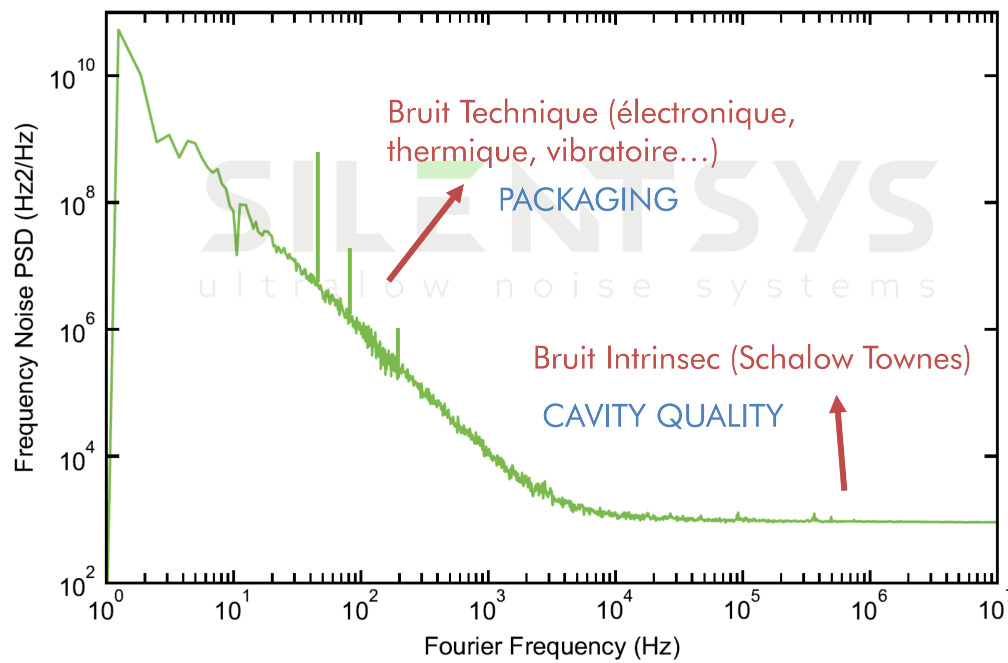
FIBER LASER

CORPS SOLIDE

Optimisation Gain et ISL pour fonctionnement monomode

$$E(t) = E_0 \sin[2\pi\nu_0 t + \phi(t)]$$

Intrinsic & *Technical*
noise sources



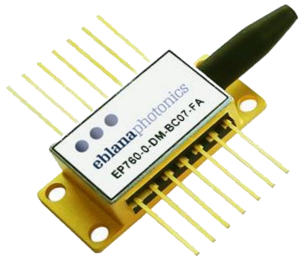
COMMENT REDUIRE LE BRUIT DE FREQUENCE DU LASER ??

(REDUCTION DE LA LARGEUR DE RAIE)

UTILISATION D'UNE CAVITE EXTERNE
(STABILISATION OPTIQUE / SELF-INJECTION LOCKING)

STABILISATION ELECTRONIQUE
(FEED-BACK / FEED-FORWARD)

LASER

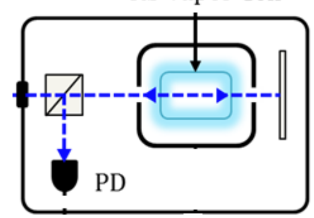


- PZT
- Température
- Courant
- AOM, EOM

…

DISCRIMINATOR

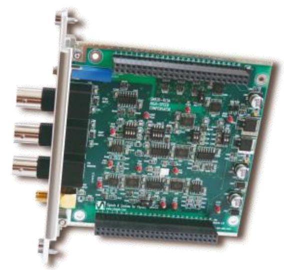
(real time !)



- Cavité optique (bulk, fibre…)
- Absorption atomique
- Laser de référence
- Réseau de diffraction
- Prisme de diffusion
- Filtre Optique (Bragg, …)

…

LASER frequency to usable electrical signal



SERVO CONTROLLER

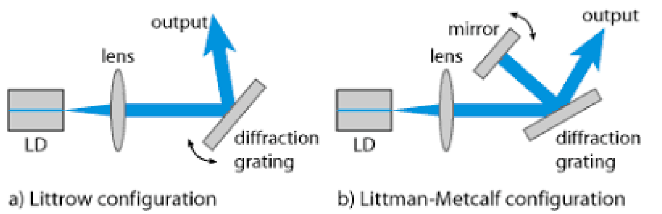
Analogique, FPGA, microcontrôleur : PID, PI, PI^2, PI^{2}D, PI^{3}D^2, …

ON NE CORRIGE QUE DANS UNE BANDE PASSANTE LIMITEE

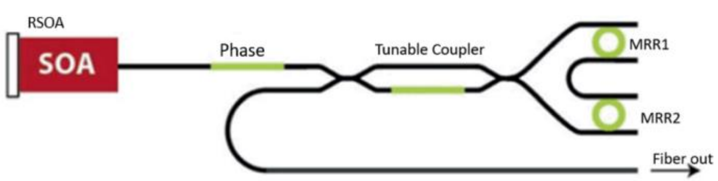
STABILISATION OPTIQUE

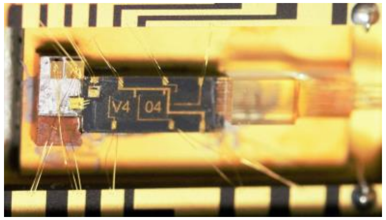
SELF-INJECTION LOCKING SUR CAVITÉ DE TRÈS HAUTE QUALITE

CAVITES EN ESPACE LIBRE



CAVITES EN OPTIQUE INTEGREE



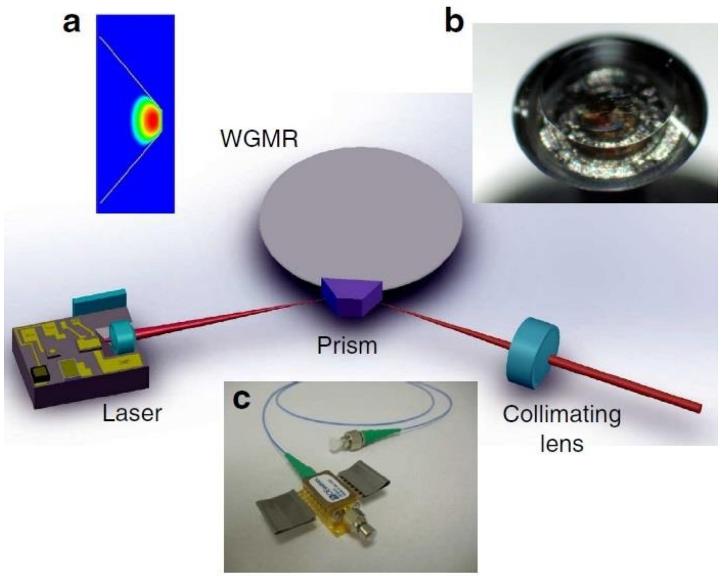


LARGEUR DE LA RÉSONNANCE :

- PERTES DANS LA CAVITÉ
- LONGUEUR DE LA CAVITÉ

(risque de sauts de modes)

CAVITES AVEC MICRO-RESONATEUR



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INVENTEURS : MEHDI ALOUINI, GWENNAËL DANION, MARC VALLET

DEPOT DU BRVET : 06/2016
LICENSE EXCLUSIVE SILENTSYS : 07/2023

Ultra-narrow linewidth self-adaptive photonic oscillator: principle and realization

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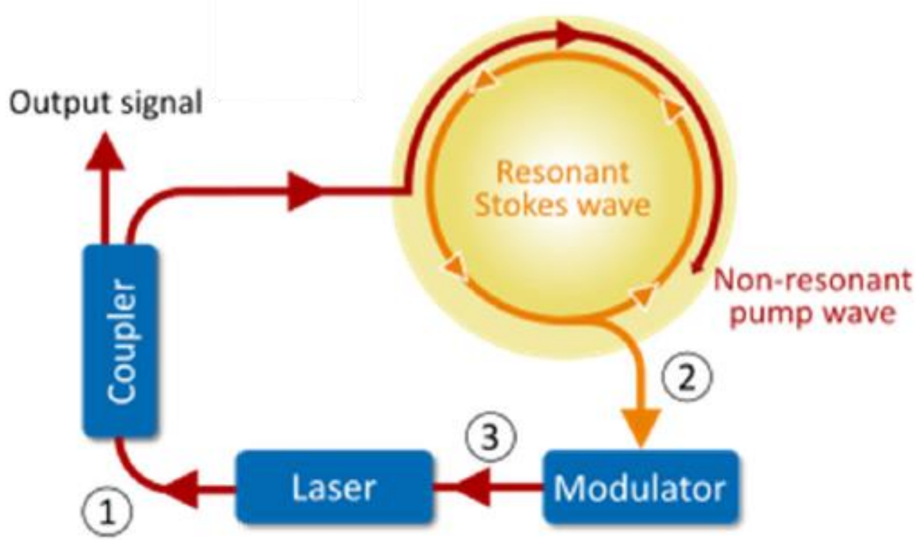
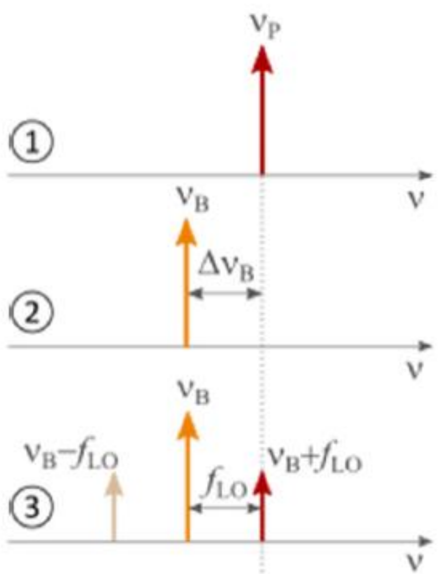
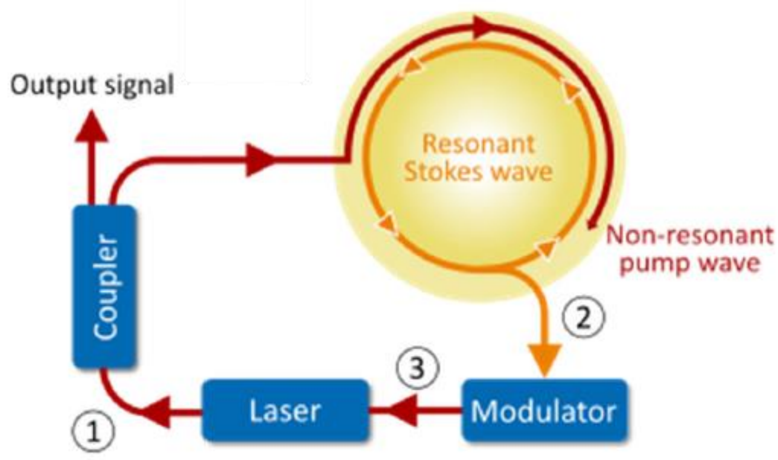
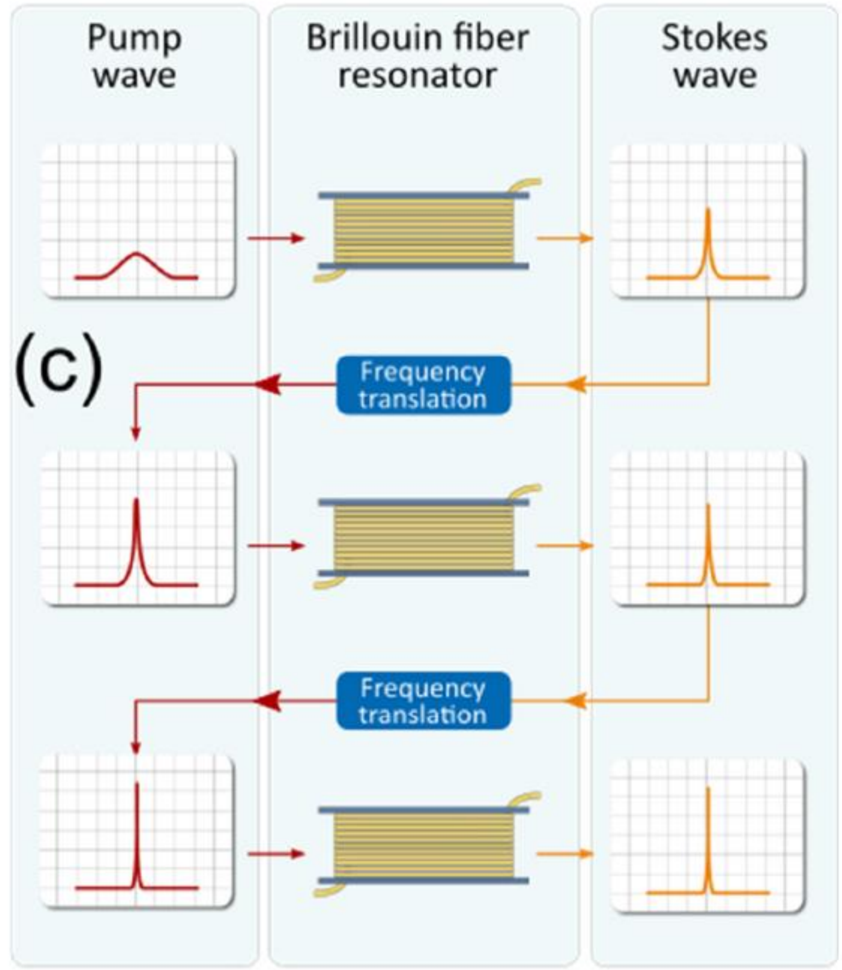




STABILISATION OPTIQUE – SLIM LINER

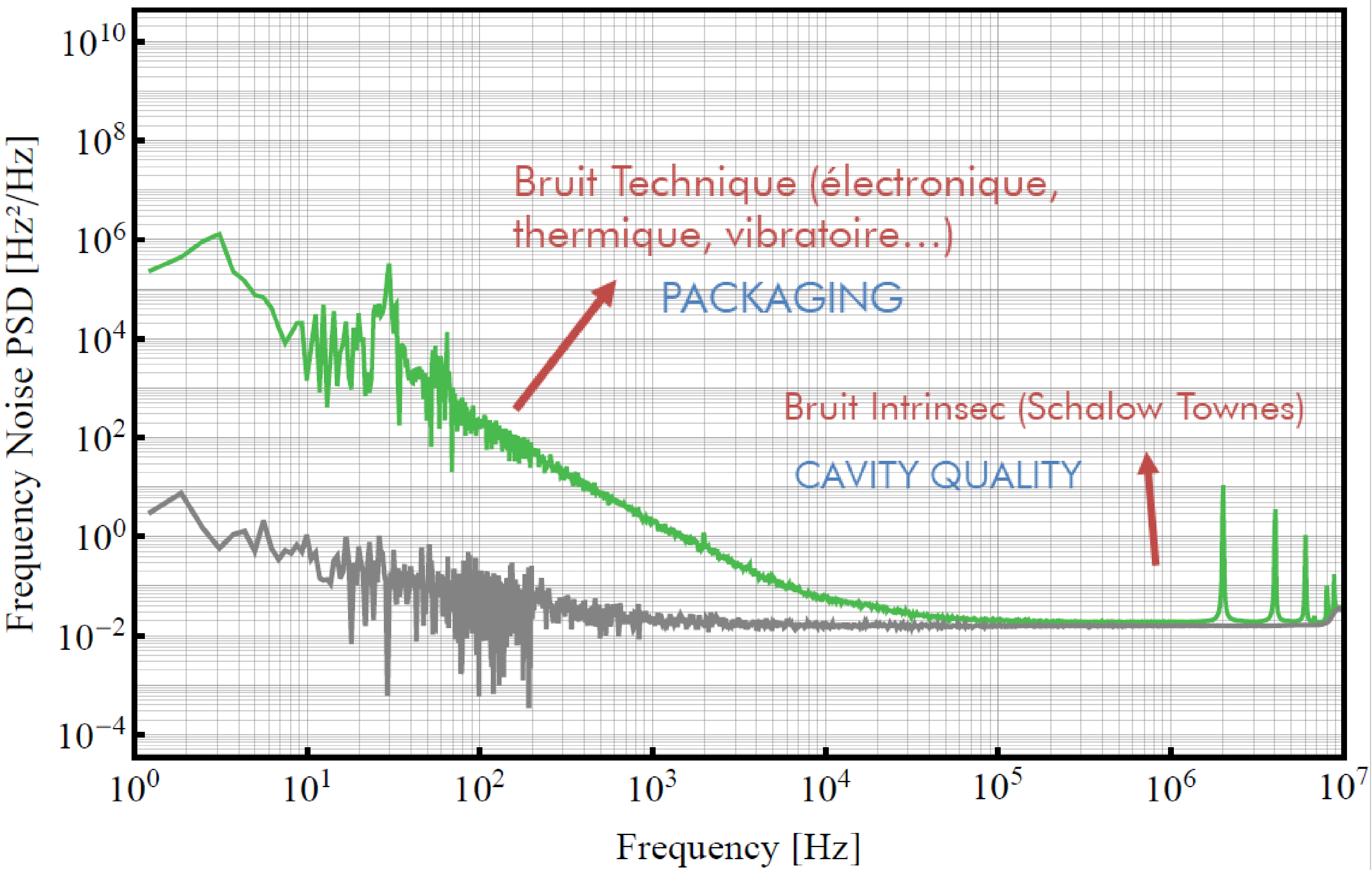




- CAVITÉ LONGUE (100m typ.), GAIN ETROIT
- ROBUSTE AUX SAUTS DE MODES
- ADAPTABLE A TOUT λ

STABILITE FREQUENCE LASER = STABILITE CAVITE BRILLOUIN

STABILISATION OPTIQUE – SLIM LINER



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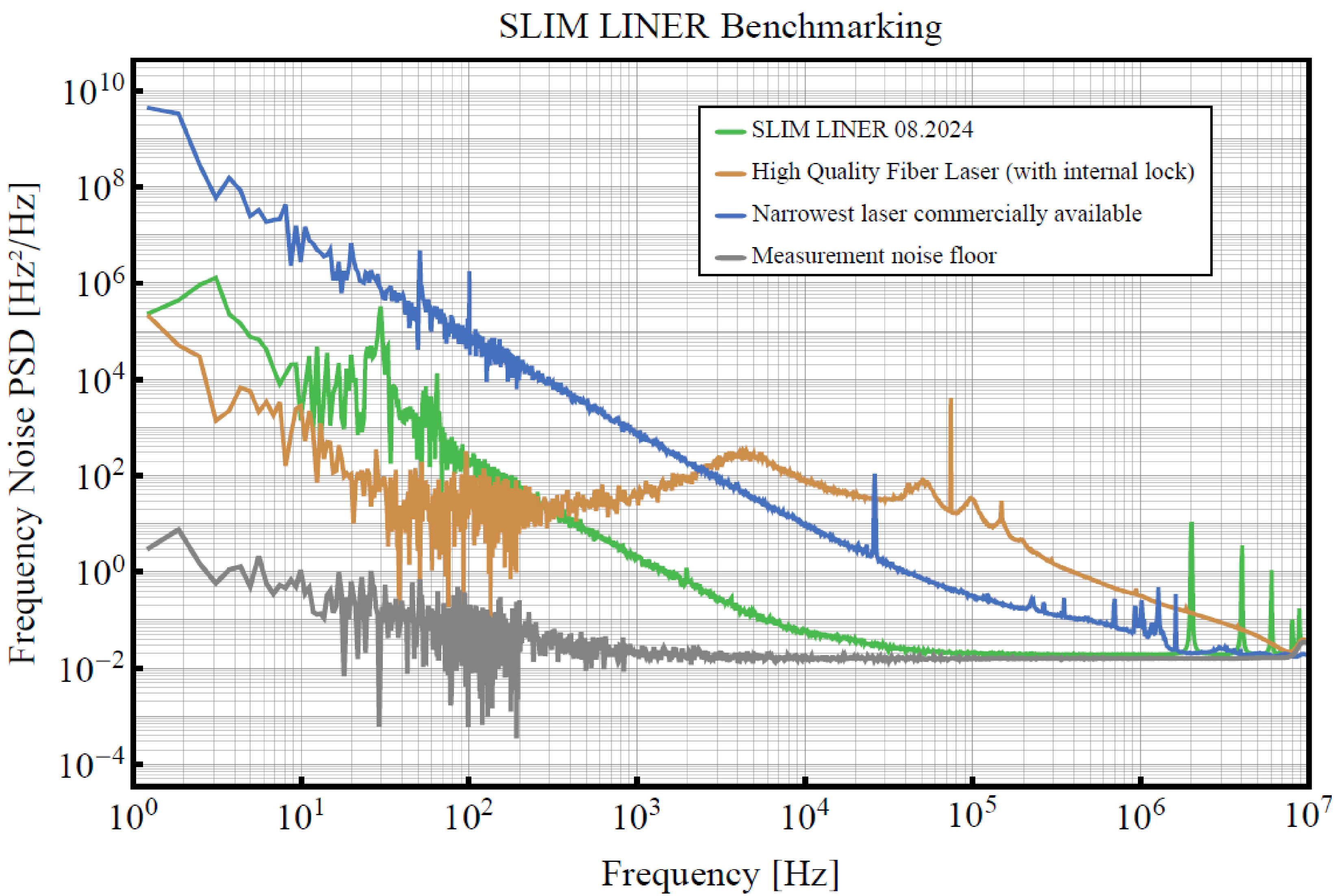
STABILISATION OPTIQUE – SLIM LINER



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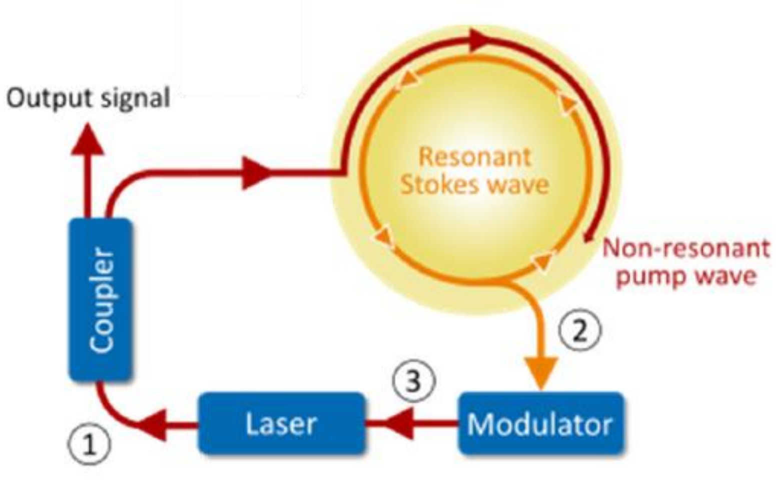
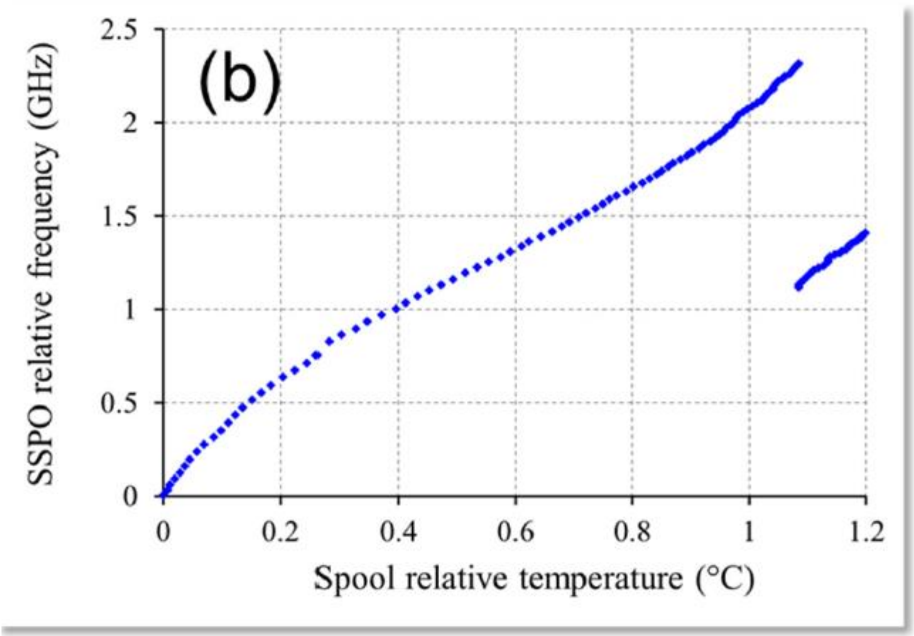
STABILITE FREQUENCE LASER = STABILITE CAVITE BRILLOUIN





ACCORDABILITE via la température de la cavité BRILLOUIN : référencement long terme


OPTICAL
OUT
NTC 10kΩ
Ext Temp IN
SLIM LINER
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