SRCL non-linearity

Formalization

$$y(t)=a\,x(t)+b\,x^2(t)$$

x: mirror displacement [m]
y: error signal [W]

Calibration

$$x_e(t)=y(t)/a=x(t)+\underbrace{(b/a)\,x^2(t)}_{\text{Non-linear part}}$$

x_e: Displacement equivalent error signal [m]

b/a: dimension is 1/m

$$x(t)=A\sin(\omega_1 t)+B\sin(\omega_2 t)$$

$$x^2(t)=A^2\sin^2(\omega_1 t)+B^2\sin^2(\omega_2 t)+\underbrace{AB\cos[(\omega_1-\omega_2)t]}_{\text{Down conversion}}-\underbrace{AB\cos[(\omega_1+\omega_2)t]}_{\text{Up conversion}}$$

Total frequency conversion noise

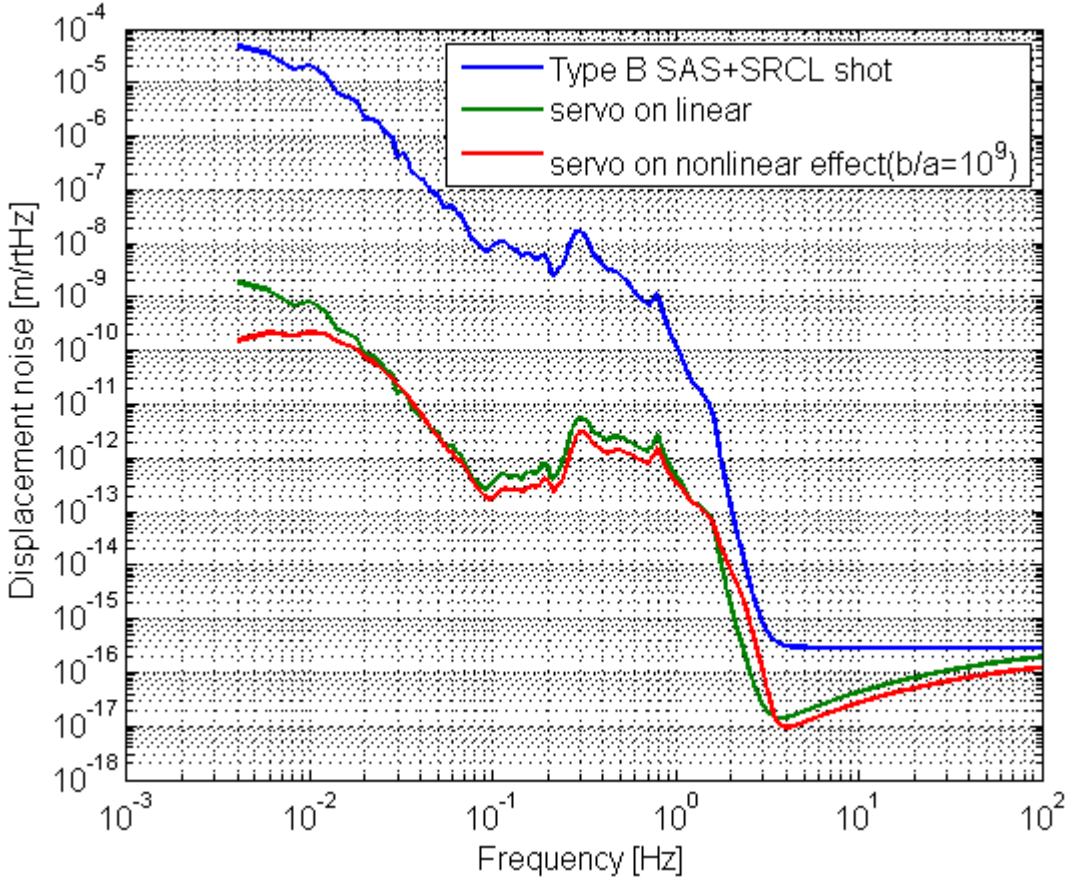
$$P_{\text{conv}}(\omega)=\frac{b}{a}\Big[\underbrace{\int_0^{\omega} P(\omega-\omega')P(\omega')\sqrt{d\omega'}}_{\text{Up Conversion}}+\underbrace{\int_{\omega}^{\infty} P(\omega+\omega')P(\omega')\sqrt{d\omega'}}_{\text{Down Conversion}}\Big]$$

P(w): Displacement equivalent noise spectrum density [m/sqrt(Hz)], one sided.

SRM up conversion noise

11.25MHz: b/a = 2.7e7 [1/m]
9MHz: b/a=1.3e8 [1/m]
16.875MHz: b/a=1.05e8 [1/m]

b/a=1e9



Calculation by Y. Michimura