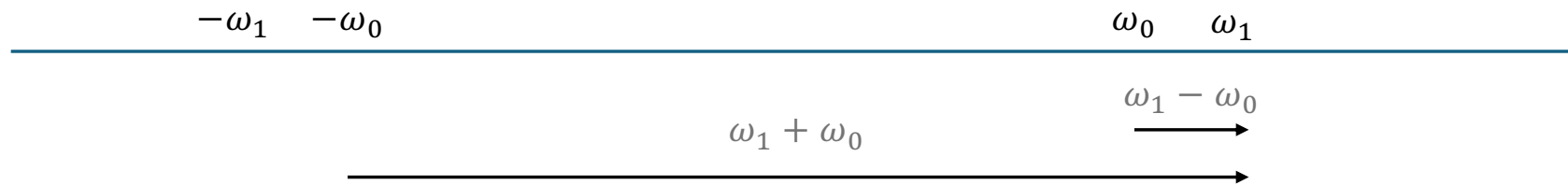


MAGO Sensitivity at $\omega_0 + \omega_1$

11.09.24, Tom Krokotsch

GWs can up-convert from $-\omega_0$ as well



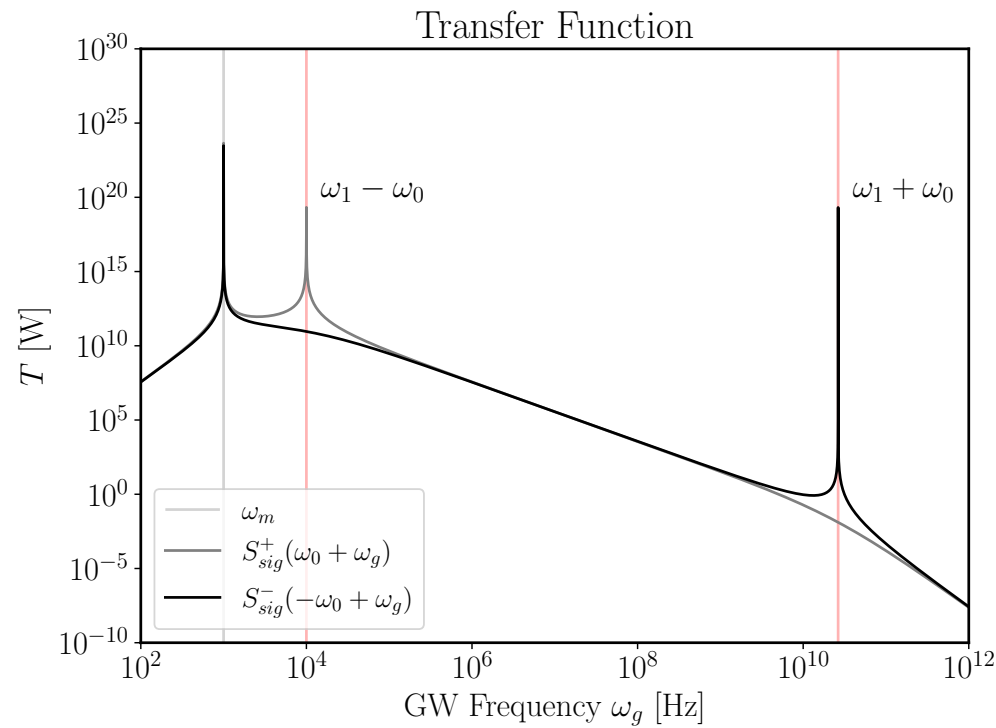
Away from mechanical resonances, the GW induced wall displacement is constant $q_{mech}(\omega) = const.$

$\Rightarrow$ A GW with $\omega_g = \omega_1 + \omega_0$ can produce the *same* power at ω_1 as a GW with $\omega_g = \omega_1 - \omega_0$.

Mathematically:

$$\begin{aligned} \text{Signal field strength } B_{sig}(t) &\propto q_{mech}(t) \cdot B_{pump}(t) \Rightarrow B_{sig}(\omega) \propto \frac{B_0}{2} [q_{mech}(\omega - \omega_0) + q_{mech}(\omega + \omega_0)] \\ &\Rightarrow B_{sig}(\omega_1) \propto \frac{B_0}{2} [q_{mech}(\omega_1 - \omega_0) + q_{mech}(\omega_1 + \omega_0)] \end{aligned}$$

Signal

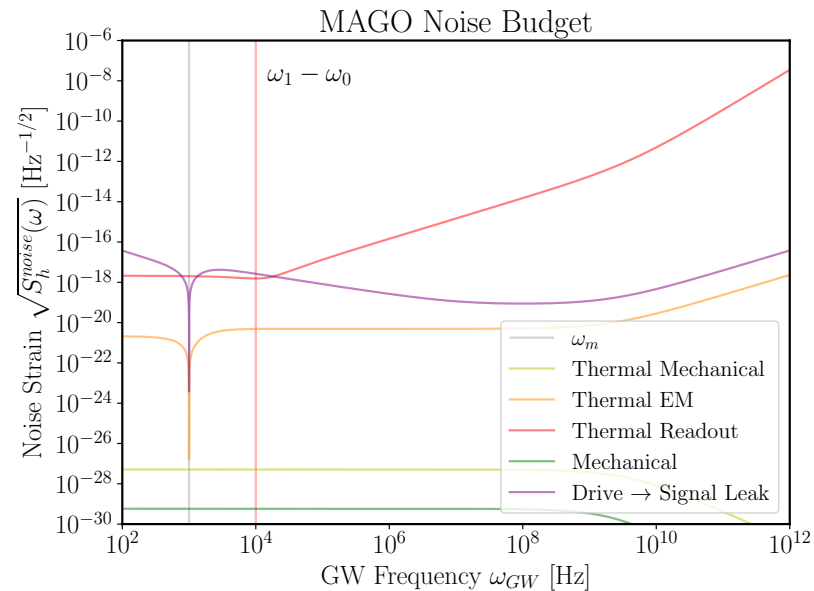
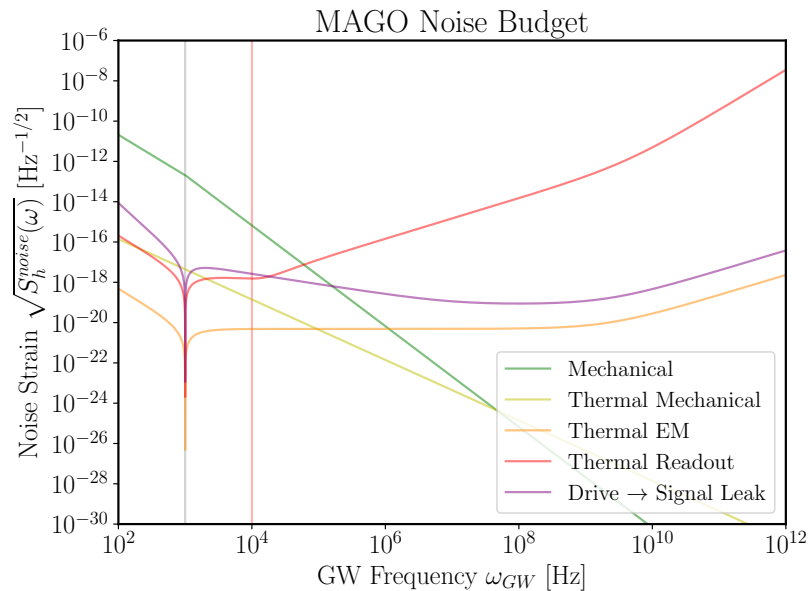


- The up-conversion from $-\omega_0$ (black) and ω_0 (grey) is shown separately and with different arguments.
- The peaks at $\omega_1 - \omega_0$ and $\omega_1 + \omega_0$ have the same height
- In the signal output, both peaks are at the same frequency

$$S_{sig}(\omega) = S_{sig}^+(\omega) + S_{sig}^-(\omega)$$

Noise

Noise coming from the $-\omega_0$ and ω_0 conversion channels is always present simultaneously. However, mechanical noise is significantly lower at $\omega_0 + \omega_1$. The mechanical noise from $\omega_1 - \omega_0$ vibrations still pollute a $\omega_0 + \omega_1$ signal in the same way.



Overall: $\omega_1 + \omega_0$ and $\omega_1 - \omega_0$ GWs give the same SNR in the readout

Could we tell if $\omega_g = \omega_1 + \omega_0$ or $\omega_1 - \omega_0$?

If at a time t the pump has a phase ϕ_0 s.t. $B_{pump}(t) \propto \cos(\omega_0 t + \phi_0)$

and the GW oscillates as $h(t) \propto \cos(\omega_g t + \phi_g)$

the forward traveling component of $B_{sig}(t) \propto e^{i\omega_1 t} \begin{cases} e^{i(\phi_h + \phi_0)} & \text{for the difference} \\ e^{i(\phi_h - \phi_0)} & \text{for the sum} \end{cases}$

$\Rightarrow \phi_0$ enters differently. But ϕ_g would need to be known to tell them apart.

$\rightarrow$ That would almost never be the case

Other idea: check for power excess at down-conversion $\omega_0 - (\omega_1 - \omega_0)$ and $\omega_0 - (\omega_1 + \omega_0)$. However, the SNR is most likely very bad there.

More ideas?

All the same for Gertsenshtein & Axion conversion

Parametric converters of axion or GW (Gertsenshtein) signals are equally sensitive to input at $\omega_1 - \omega_0$ and at $\omega_1 + \omega_0$