Figures of Merit for Stochastic Background Searches

Jennifer Barré jlbarre@loyno.edu
John T. Whelan jtwhelan@loyno.edu
Loyola University New Orleans

Presented at the 15th LSC Meeting
2004 March 18

G040153-00-Z

Overview

Several measures of stochastic sensitivity:

1. Instantaneous overall sensitivity

2. Instantaneous sensitivity by frequency

3. Cumulative sensitivity over the run

Detectable Ω_{GW}

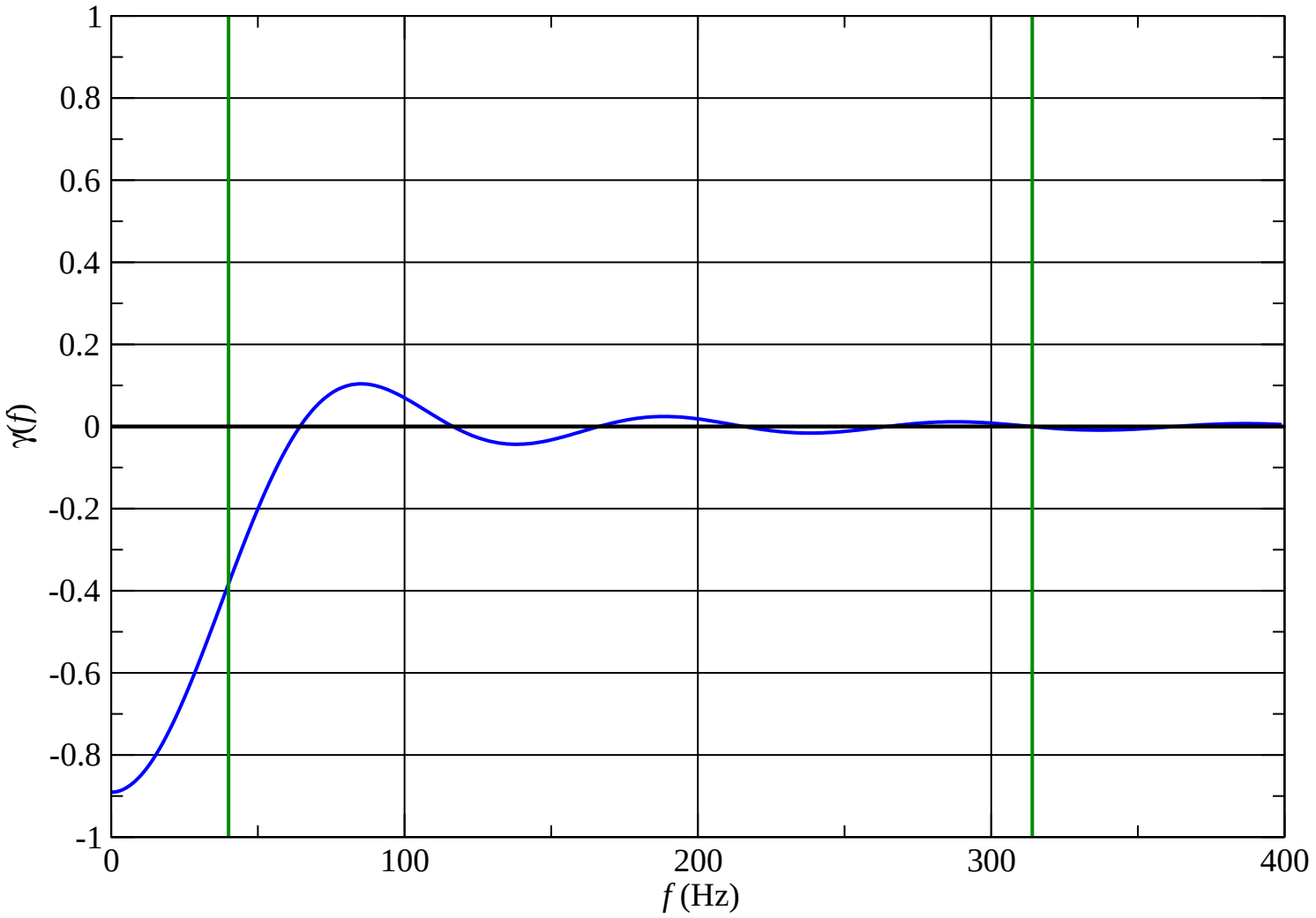
Basis for all figures of merit: Assuming flat GW spectrum ($\Omega_{GW}(f) = \text{constant}$),
the stochastic background strength we could detect in time T is Ω_s:

$$\frac{1}{\Omega_s^2} \propto T \left(\int_{f_{min}}^{f_{max}} df \frac{\gamma^2(f)}{f^6 P_1(f) P_2(f)} \right)$$

- Use Ω_s^{-2} instead of Ω_s so FOM large when sensitive
- $P_1(f)$ & $P_2(f)$ are (calibrated) noise PSDs of two detectors
- $\gamma(f)$ is the overlap reduction function
  (known function of frequency, $\equiv 1$ for H1-H2)

Overlap Reduction Function

LIGO-Livingston / LIGO Hanford



(For correlations between LHO 2km & LHO 4km, $\gamma(f) \equiv 1$)

Figures of Merit

Three planned FOMs:

1. Instantaneous sensitivity: value of integral for Ω_s^{-2}
   (analogous to inspiral range)

2. Instantaneous sensitivity by frequency:
   value of integrand $\frac{\gamma^2(f)}{f^6 P_1(f) P_2(f)}$ in arbitrary units
   (analogous to inspiral range integrand)

3. Cumulative sensitivity:
   stoch BG we could detect using all the data from the run
   Sum of all Ω_s^{-2} values so far:

$$\frac{1}{\Omega^2_{\text{cume}}} = \frac{1}{\Omega_s(1)^2} + \frac{1}{\Omega_s(2)^2} + \cdots$$

Choice of Power Spectrum

FOM measures sensitivity for a pair of instruments (H1/H2, H1/L1 or H2/L1). Could use

1. Current PSDs from both instruments: combined sensitivity (definitely appropriate for cumulative measurement)

2. Current PSD from one instrument, reference PSD from other may be more useful for control-room diagnosis
   LLO may not want to wonder if the drop in sensitivity was due to L1 or H1
   (Also, if other IFO not in lock, combined $\Omega_s^{-2} = 0$.)

Implementation

- DMT monitor StochMon being written for use in S4
- Calculation similar to that used for SenseMonitor
  much of the code can be cannibalized.
- Technical issue: Transfer of PSDs between LLO & LHO

Lazzarini Differential Sensitivity Measure

$$d\left(\Omega_{\mathsf{s}}^{-2}\right) \propto T\left(\int_{f_{\mathsf{min}}}^{f_{\mathsf{max}}} df \frac{\gamma^2(f)}{f^6 P_1(f) P_2(f)}\left[-\frac{dP_1(f)}{P_1(f)} - \frac{dP_2(f)}{P_2(f)}\right]\right)$$