Issues on Template Implementation
for the BBH Inspiral Search

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BCV Templates

- Proposed by Buonanno, Chen and Vallisneri (PRD 67, 024016 (2003)).

- Non-spinning BBH of total mass \(10 - 40 M_\odot\).

- Model the Fourier transform of the time-domain BBH inspiral waveforms.

- Fitting factors in the range 0.85 - 0.97.

- \(\tilde{h}(f) = f^{-7/6} (1 - \alpha f^{2/3}) \theta(f_{\text{cut}} - f) e^{i \psi(f)}\)

\[\psi(f) = \phi_0 + 2\pi f t_0 + \psi_0 f^{-5/3} + \psi_3 f^{-2/3} = \phi_0 + \psi'(f)\]
Template Parameters

- The BCV templates are not very good for physical parameter estimation.

- Chirp mass: \( M \sim \frac{1}{\pi} \left( \frac{3}{128 \psi_0} \right)^{3/5} \)

- Extrinsic parameters: \( \phi_0, t_0, \alpha \)
  - The SNR is maximized over those.

- Intrinsic parameters: \( \psi_0, \psi_3, f_{\text{cut}} \)
  - The template bank is generated for those.
SNR Maximization

- Orthonormalize the two parts and normalize the template:

\[ I_1 = \left[ \int_0^{f_{\text{cut}}} \frac{f^{-7/3}}{S(f)} \, df \right]^{-1/2} \]
\[ I_2 = \left[ \int_0^{f_{\text{cut}}} \frac{f^{-1}}{S(f)} \, df \right]^{-1/2} \]

- Normalization factors \( a_1, b_1 \) and \( b_2 \); depend on \( I_1 \) and \( I_2 \)
- Maximize the SNR with respect to \( \phi_0 \) and \( \alpha \):

\[
\rho_{\text{max}} = \sqrt{\left| F_1 \right|^2 + \left| F_2 \right|^2 + 2 \Re F_1 F_2^*} \\
+ \sqrt{\left| F_1 \right|^2 + \left| F_2 \right|^2 - 2 \Re F_1 F_2^*} \\
F_1 = \int_0^{f_{\text{cut}}} \frac{a_1 f^{-7/6}}{S(f)} e^{i \psi'(f)} \tilde{s}^*(f) \, df \\
F_2 = \int_0^{f_{\text{cut}}} \left[ b_1 f^{-7/6} + b_2 f^{-1/2} \right] \frac{S(f)}{S(f)} e^{i \psi'(f)} \tilde{s}^*(f) \, df
\]
$\chi^2$-veto

- Assert that the chirp power is appropriately distributed over the $p$ frequency bins.

- $\chi^2$-statistic:

$$
\chi^2 = p \sum_{l=1}^{p} \left| \int_{f_l}^{f_{l+1}} \frac{a_1 f^{-7/6}}{S(f)} e^{i\psi'(f)} \tilde{s}^*(f) \, df - \frac{1}{p} F_1 \right|^2
+ p \sum_{l=1}^{p} \left| \int_{f_l}^{f_{l+1}} \frac{[b_1 f^{-7/6} + b_2 f^{-1/2}]}{S(f)} e^{i\psi'(f)} \tilde{s}^*(f) \, df - \frac{1}{p} F_2 \right|^2
$$
Current Status

- The BCV templates have been incorporated into the template bank generation code and into the search code.

- The inspiral code is ready to be run for BBH inspiral triggers.

- What total mass range can we “safely” use the BCV templates for?
Future Work

• Identify triggers and investigate:
  – Future investigation will be required using the actual PN BBH inspiral models (for example for parameter estimation).

• Use the BCV templates for BH-NS inspiral.

• Incorporate the BCV-2 templates (spinning BBH) into the search code.