Eccentric Compact Binary Inspirals and GW Parameter Estimation

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TaylorF2: simplest, quickest GW inspiral waveform model

We introduce an "**eccentric**" waveform for CBC inspirals (implemented in LALSuite devel. branch)

$$\tilde{h}(f) = \mathcal{A} e^{i\Psi},$$

A waveform, h(f), is determined by amplitude & phase

accumulated phase error

$$\Psi_{\rm T}(f) = \phi_c + 2\pi f t_c + \frac{3}{128\eta v^5}\left[\Delta\Psi^{\rm point\ particle}_{\rm 3.5PN} + \Delta\Psi^{\rm spin}_{\rm 3PN} + \Delta\Psi^{\rm ecc}_{\rm 3PN} + \Delta\Psi^{\rm tidal}_{\rm 6PN} + \Delta\Psi^{\rm test\ mass}_{\rm 6PN}\right]$$

where t_c and ϕ_c are the coalescence time and phase, and $v \equiv (\pi M f)^{1/3}$ is the PN orbital velocity parameter.

$$\Delta\Psi^{\rm ecc.}_{\rm 3PN} = -\frac{2355}{1462} e_0^2 \left(\frac{v_0}{v}\right)^{19/3}\left[1 + v^2\left(\frac{299\,076\,223}{81\,976\,608} + \frac{18\,766\,963}{2\,927\,736}\eta\right) + v_0^2\left(\frac{2833}{1008} - \frac{197}{36}\eta\right) + \cdots + O(v^6)\right]. \quad (2.13)$$

fractional bias in the mass parameters: FM prediction

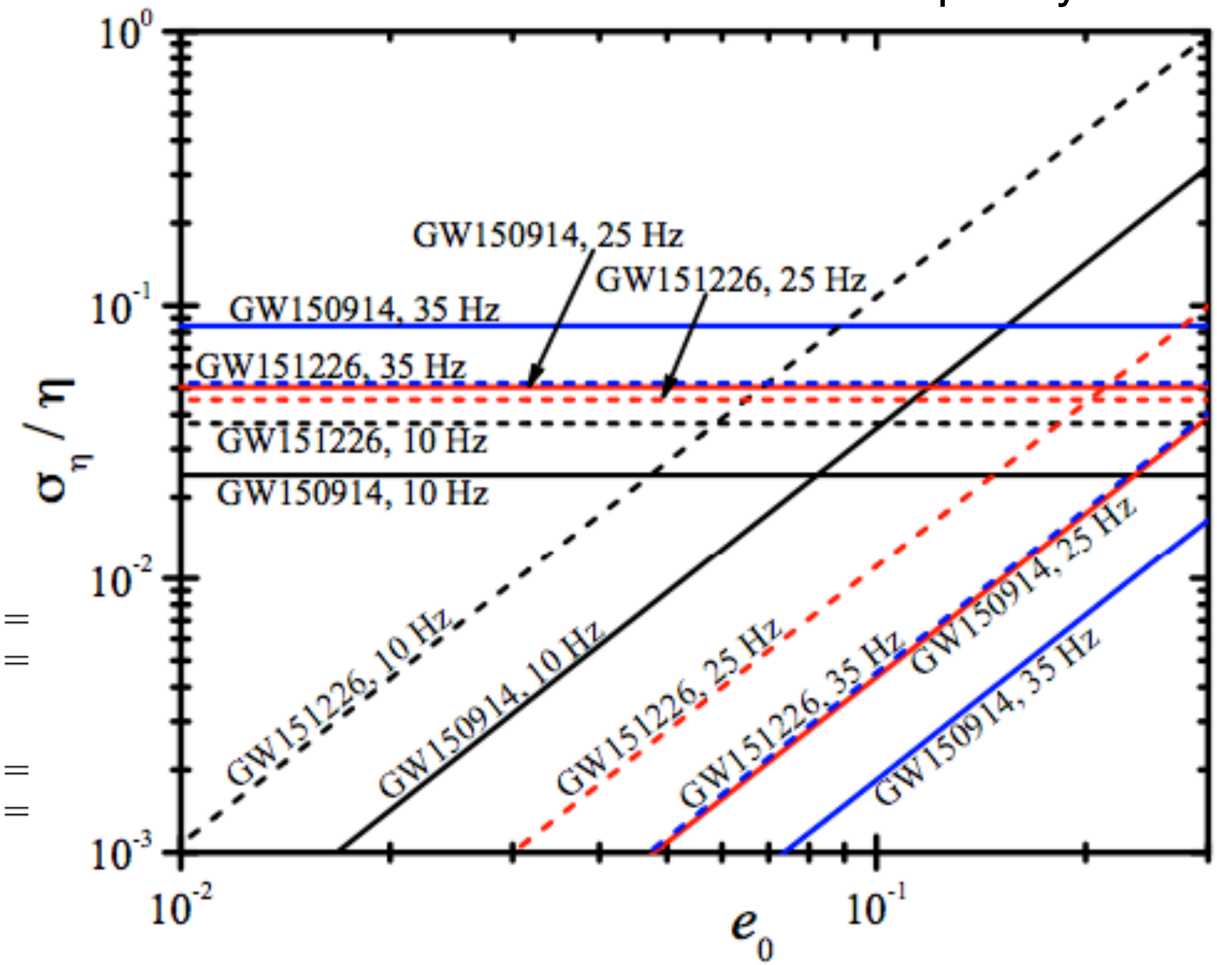
We consider two spinning, eccentric BBHs:
GW150914 and GW151226 varying e0 (eccentricity at 10Hz)

statistical error depends on SNR and the number of cycles

systematic error depends on e0 and frequency range

"inspiral eccentricity" e0 is defined at 10 Hz GW frequency

For GW151226 are "eccentric" (e0 > 0.05) systematic error due to ignoring eccentricity exceeds statistical error



(i) GW150914: $m_1 = 39.4 M_\odot$, $m_2 = 31.7 M_\odot$, $\chi_1 = 0.32$, $\chi_2 = 0.48$, $\rho = 23.6$. We integrate to $f_{\rm isco} = 166.2$ Hz.

(ii) GW151226: $m_1 = 15.6 M_\odot$, $m_2 = 8.2 M_\odot$, $\chi_1 = 0.49$, $\chi_2 = 0.52$, $\rho = 13.0$. We integrate to $f_{\rm isco} = 506.7$ Hz.

Constraints on eccentricity with advanced LIGO : MCMC results (single aLIGO, uniform prior e0=[0,1])

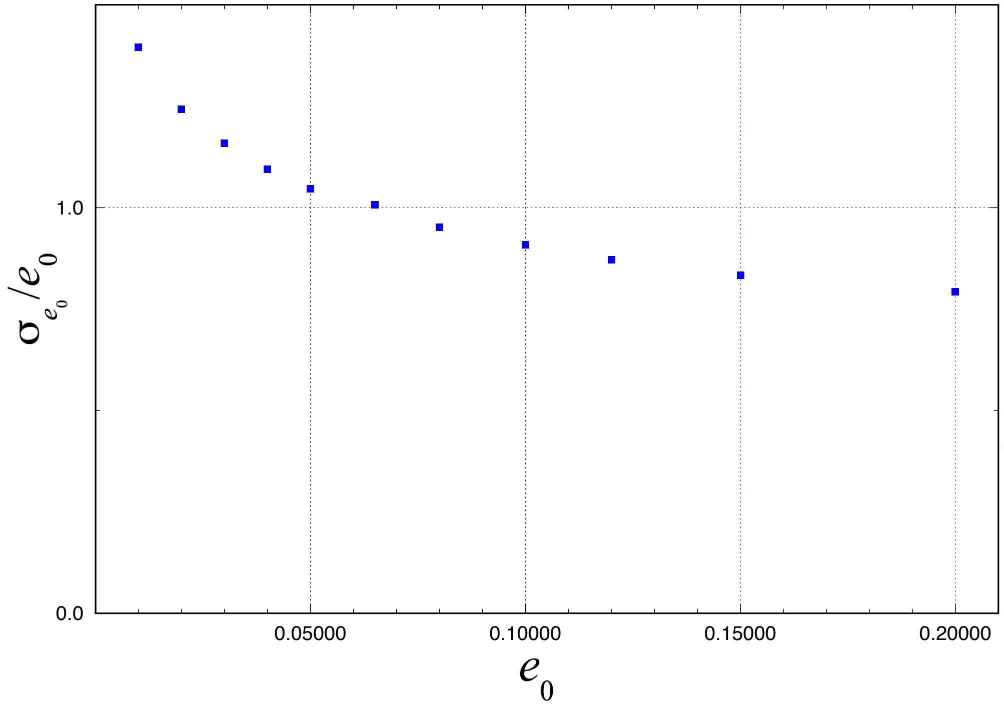
Software injection simulation

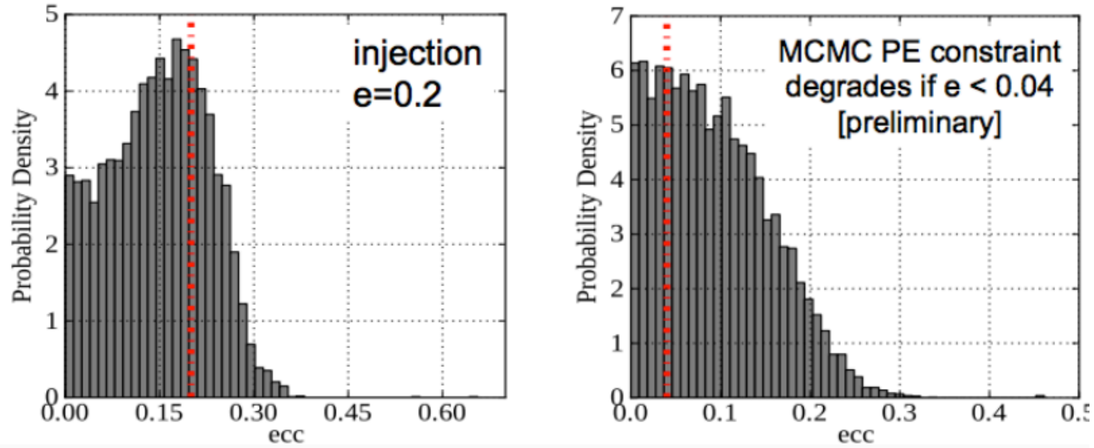
eccentric injection vs eccentric templates

GW151226 mass parameters
m_1= 15.6 M_{sun} , m_2= 8.2 M_{sun} , **eta= 0.2258**

Assign eccentricity @ 10 Hz

overlap calculation f_{gw}=[25 Hz, ISCO]





Computation time: 2016 June -August
for ~ 10 data points

KISTI GSDC clusters (Korea)

Summary
MCMC and FM results are roughly consistent. Analysis is underway

with aLIGO (O3), eccentric templates can be useful for exotic CBC inspirals (e0 ~ 0.1 or higher)