

Peer Review

Review of: "Rapid Eccentric Spin-Aligned Binary Black Hole Waveform Generation Based on Deep Learning"

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This manuscript presents *SEOBNREAIq5e2*, a deep-learning surrogate model for eccentric, spin-aligned BBH waveforms. The work is important for GW data analysis and timely, given the strong interest in accelerating parameter estimation. The inclusion of eccentricity is particularly valuable, as detecting eccentric systems is a current priority in GW astronomy. While the restriction to spin-aligned systems is an approximation, it does not diminish the significance of this contribution.

There is already another review for this paper, so I will add to this some other points.

Strengths:

- Novel surrogate approach not relying on ROM, combining MLP–CNN with adaptive resampling.
- Strong performance: $\sim 500\times$ speed-up relative to SEOBNRE with low mismatch ($\sim 10^{-3} \sim 10^{-3}$).
- Significant potential impact for Bayesian inference and large-scale GW data analysis.

Points for Improvement:

- The parameter space is restricted (aligned spins, $q \leq 5q$, $e \leq 0.2e$, $|\chi| \leq 0.6$). This limitation should be emphasized more clearly.
 - The authors could make this limitation more explicit in both the **abstract and conclusion**, e.g., by stating: *"The present work is restricted to spin-aligned binaries with modest eccentricities and mass ratios; extending to higher eccentricities, mass ratios, and precessing spins is an important next step."*
- Validation is against SEOBNRE. I think benchmarking against NR eccentric simulations could strengthen the conclusions.

- **Comparison with available eccentric NR waveforms** (e.g., SXS catalog entries with nonzero eccentricity) would demonstrate whether the surrogate inherits SEOBNRE's systematic deviations or whether it generalizes well.
- Authors could report **mismatch values between SEOBNRE and NR**, and then between SEOBNRE_A1q5e2 and NR, to show whether the surrogate adds additional error beyond SEOBNRE.
- Mismatches increase in specific regimes (high q , high e , high spins). Further discussion of these limitations would be helpful.
- Would be interesting to see a systematic comparison with other surrogate models (e.g., SEOBNRE_S, NRSur2dq1Ecc); a performance comparison and speed would be very interesting

The paper provides a valuable contribution, and the above clarifications would improve its impact and clarity.

Declarations

Potential competing interests: No potential competing interests to declare.