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Numerical relativity surrogate models for exotic compact objects: the case of head-on mergers of equal-mass Proca stars

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We present several high-accuracy surrogate models for gravitational-wave signals from equal-mass head-on mergers of Proca stars, computed through the Newman-Penrose scalar $\psi 4$. We also discuss the current state of the model extensions to mergers of Proca stars with different masses, and the particular challenges that these present. The models are divided in two main categories: two-stage and monolithic. In the two-stage models, a dimensional reduction algorithm is applied to embed the data in a reduced feature space, which is then interpolated in terms of the physical parameters. For the monolithic models, a single neural network is trained to predict the waveform from the input physical parameter. Our model displays mismatches below 10–3 with respect to the original numerical waveforms. Finally, we demonstrate the usage of our model in full Bayesian parameter inference through the accurate recovery of numerical relativity signals injected in zero-noise, together with the analysis of GW190521. For the latter, we observe excellent agreement with existing results that make use of full numerical relativity.

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