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Investigating New Computational Techniques for Solving Black Hole Perturbation Equations.

Physics-informed neural networks (PINNs) have recently emerged in machine learning as a tool for solving differential equations governing various physics phenomena. The present research will apply them specifically to solving black hole perturbation equations – differential equations describing quasinormal modes (QNMs) induced on the surface of a black hole by perturbing fields. Generally, these equations are difficult to solve by algebraic means owing to the nature of the effective potential in them, and thus they have no known exact, closed-form solutions. Several approximation techniques have been applied throughout the literature to compute the complex-valued quasinormal frequencies (QNFs) corresponding to black hole QNMs for different perturbation scenarios. The same will be attempted with PINN models constructed with the DeepXDE library in Python (created by Lu et al. (2021)); however, this full-fledged study of black hole QNMs will follow after an ongoing preliminary project focused on implementing PINNs to solve a one-dimensional Schrödinger equation with a symmetric Pöschl-Teller potential. For this problem, the exact solutions given by Legendre functions have been used to gauge the accuracy of PINN approximations. 5-digit accuracies were achieved for the first energy level. Given that a black hole effective potential is closely approximated by an upside-down Pöschl-Teller potential (as was shown by Ferrari & Mashhoon (1983)), these results indicate that PINNs have the potential to solve black hole perturbation equations. After the pilot project, PINNs will be implemented to solve the perturbation equations of Schwarzschild and Reisnerr-Nordström black holes. An empirical search for optimal PINN set-ups will be conducted to maximize their performance. The computation of QNFs with PINNs will then be compared, in terms of accuracy and efficiency, with previously implemented approximation techniques.

Apply to be considered for a student ; award (Yes / No)?

Yes

Level for award;(Hons, MSc, PhD, N/A)?

MSc

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