Contribution ID: **300** Contribution code: **WEZD01** Type: **Invited Oral Presentation**

Symplectic Neural Network Surrogate Models for Applications to Beam Dynamics

Wednesday 13 August 2025 14:00 (30 minutes)

Development of robust machine-learning (ML) based surrogates for particle accelerators can significantly benefit the modeling, design, optimization, monitoring and control of these systems. It is advantageous for surrogate models to incorporate fundamental physical constraints governing beam interactions and dynamics, which are essential to the operation of an accelerator.

We investigate two classes of phase space structure-preserving neural networks —SympMat for linear beam dynamics and Henon Neural Networks (HenonNets) for nonlinear beam dynamics problems. For the linear case, we introduce a simple and effective parameterization of arbitrary linear symplectic matrices. To address potential nonlinearities in the parameter space, we employ a conditional parameterization strategy. For nonlinear beam dynamics, we develop parametric HenonNets with a universal symplectic approximation theorem. We demonstrate the effectiveness of the proposed symplectic neural networks through examples involving charged particle dynamics and both linear and nonlinear beam dynamics. Our results suggest that these symplectic neural networks can serve as promising ML-based surrogate models for complex beam dynamics systems.

Please consider my poster for contributed oral presentation

No

Would you like to submit this poster in student poster session on Sunday (August 10th)

No

Footnotes

[1] E. G. Drimalas, et al. Symplectic neural network and its applications to charged particle dynamics in electromagnetic fields, submitted, 2025.
[2] C.-K. Huang, Q. Tang, et al. Symplectic neural surrogate models for beam dynamics. Journal of Physics: Conference Series, 2687(6):062026, 2024.
[3] J. W. Burby, Q. Tang and R. Maulik. Fast neural Poincare maps for toroidal magnetic fields, Plasma Physics and Controlled Fusion, 63:024001, 2020.

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Yes

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Session Classification: Beam Dynamics and EM Fields (Invited)

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