FACULTY OF NUCLEAR SCIENCES
AND PHYSICAL ENGINEERING
DEPARTMENT OF PHYSICS

BACHELOR THESIS ASSIGNMENT

Academic year: 2022/2023

Student:	Aleksandr Bogdanov
Study programme:	Physical Engineering
Specialization:	Physics of Plasma and Thermonuclear Fusion
Thesis title: (in Czech)	Aplikace strojového učení při nelokálním hydrodynamickém modelování termojaderné fúze
Thesis title: (in English)	Machine Learning-Driven Nonlocal Hydrodynamics for Thermonuclear Fusion Modeling
Language of the Thesis:	English

Instructions:

1. Get acquainted with the state-of-the-art inertial confinement fusion (ICF) research and the importance of the physical phenomena of transport [1, 2, 3].
2. Research hydrodynamic models currently used in ICF with the focus on nonlocal electron transport [4].
3. Process kinetic modeling data provided by Lawrence Livermore National Laboratory.
4. Teach a deep neural network (DNN) to learn the process of nonlocal electron transport based on physically motivated loss function [5, 6, 7].
5. Compare the DNN model with the classical heat flux limiter model used in ICF [8].

Recommended literature:

[1] H. Abu-Shawareb (Indirect Drive ICF Collaboration). Lawson criterion for ignition exceeded in an inertial fusion experiment. *Physical Review Letters*, 129(7):075001, 2022.

[2] D. T. Casey et al. Evidence of three-dimensional asymmetries seeded by high-density carbon-ablator nonuniformity in experiments at the National Ignition Facility. *Physical Review Letters*, 126(2):025002, 2021.

[3] M. D. Rosen et al. The role of a detailed cofiguration accounting (DCA) atomic physics package in explaining the energy balance in ignition-scale hohlraums. *High Energy Density Physics*, 7(3):180–190, 2011.

[4] M. Holec, J. Nikl, and S. Weber. Nonlocal transport hydrodynamic model for laser heated plasmas. *Physics of Plasmas*, 25(3):032704, 2018.

[5] PyTorch Lightning tutorial. `https://becominghuman.ai/pytorch-lightning-tutorial-1-getting-started-5f82e06503f6`.

[6] Introduction to PyTorch Lightning. `https://pytorch-lightning.readthedocs.io/en/stable/`.

[7] Regression using PyTorch Lightning, "Bike Share Regression PyTorch Lightning.ipynb". `https://github.com/shotleft/how-to-python.git`.

[8] D. A. Chapman et al. A preliminary assessment of the sensitivity of uniaxially driven fusion targets to flux-limited thermal conduction modeling. *Physics of Plasmas*, 28(7):072702, 2021.

Name and affiliation of the supervisor:

Ing. Milan Holec, Ph.D.

Lawrence Livermore National Laboratory, CA, USA

Name and affiliation of the consultant:

doc. Ing. Pavel Váchal, Ph.D.

Department of Physical Electronics, FNSPE CTU in Prague

Date of the assignment: 20.10.2022

Due date of the thesis: 02.08.2023

The assignment is valid for two years since the date of the assignment.

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Guarantor of the study programme

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Department head

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In Prague on 20.10.2022