NEURAL NETWORK APPROXIMATION OF THE TABULATED TIN PLASMA AVERAGE CHARGE

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Multiply charged ion plasma is a source of X-ray radiation, which is actively used in such areas as the study of photospheres and deep layers of stars [1, 2], indirect compression of targets for inertial thermonuclear fusion [3, 4], and in photolithography problems [5]. To model the transfer of X-ray radiation, calculations often use tabular data that can be calculated in advance. Examples of such tables are the radiation absorption coefficient, the equation of state of the plasma, and its average charge [6]. The calculation involves interpolation of tabular data.

In this paper, a method for approximating tabular data on the average charge of tin plasma using a neural network is proposed. The tabular data were obtained using the Saha-Boltzmann equations [7]. Often, the search for intermediate values is performed using bilinear interpolation or splines. However, interpolation is more labor-intensive than calculation using an explicitly specified function. In this paper, such an approximating function was obtained using a neural network. A three-layer perceptron with an activation function from the sigmoid class was constructed [8]. During the training process, the network selects the values of weights and biases to minimize the difference between the predicted and actual values.

The paper compares two activation functions and two optimization algorithms. Neural network approximation is implemented on a number of test one-dimensional and two-dimensional problems. Testing has shown the effectiveness of the proposed approach. The accuracy and speed of calculation of neural network and bilinear interpolation were compared. Neural network approximation has shown high accuracy and multiple speedup.

References

1. **Chandra, R.** Observational characteristics of Solar EUV waves [Text] / R. Chandra, P. Devi, P. F. Chen et al. // Bull. Soc. R. Sci. Liege. – 2024. – 93(2). – P. 962–982.
2. **Simoes, P. J. A.** Hydrogen recombination continuum as the radiative model for stellar optical flares [Text] / P. J. A. Simoes, A. Araujo, A. Valio, L. Fletcher // MNRAS. – 2024. – Vol. 528. – P. 2562–2567.
3. **Vronskiy, A. V.** Simulation of laser radiation transport and absorption in indirect drive ICF targets [Text] / A. V. Vronskiy, I. S. Chubareshko, A. A. Shestakov // VANT. Ser.: Mat. Mod. Fiz. Proc. – 2022. – No. 1. – P. 3–16.
4. **Abu-Shawareb, H.** Achievement of target gain larger than unity in an inertial fusion experiment [Text] / H. Abu-Shawareb et al. // Physical Review Letters. – 2024. – Vol. 132. – 065102 p.
5. **Abramenko, D. B.** Plasma-based sources of extreme ultraviolet radiation for lithography and mask inspection [Text] / D. B. Abramenko, P. S. Antsiferov, D. I. Astakhov et al. // Phys. Usp. – 2019. – Vol. 62. – P. 304–314.
6. **Ovechkin, A. A.** Plasma ionization balance in chemical-picture and average-atom models [Text] / A. A. Ovechkin, P. A. Loboda, V. V. Popova et al. // PHYSICAL REVIEW E. – 2023. – Vol. 108. – 015207 p.
7. **Santos, D. F. N**. Account of diffusion in LTE and 2T plasma models [Text] / D. F. N. Santos, M. Lisnyak, M. S. Benilov // JPhysD. – 2019. – 120722.R3.
8. **Cybenko, G.** Approximation by superpositions of a sigmoidal function [Text] // Math. Control Signals Systems. – 1989. – Vol. 2. – P. 303–314.