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Physics-Informed Neural Network Analysis of an Electromagnetic Interaction Problem Including a Uniform Beam Charge Density

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The physics-informed neural network (PINN) method for modeling the electromagnetic interaction of a relativistic charged particle beam with its surrounding environments has been recently proposed [1]. This method has been successfully applied to the impedance modeling of a smooth beam charge density. However, it still has a drawback on modeling a discontinuous beam charge density.

To overcome this drawback, the PINN method based on the scattered-field formulation has been developed in [2]. This approach allows us to avoid involving a charge density distribution with discontinuities in the loss function. It is named as the scattered-field physics-informed neural networks (SF-PINN). So far, the SF-PINN has been used for the analysis of the fields of the ring or point charge.

In this study, the SF-PINN [2] is applied to the analysis of an electromagnetic interaction problem including a uniform round beam charge density with hard edges. This application is not discussed in [2]. It is assumed here that the beam has radius r_b=1.747mm and the Lorentz factor γ=100 and it moves on the axis of an infinitely long perfectly conducting vacuum chamber of circular cross section with radius R=10mm.

Fig.1 shows the averaged indirect space charge impedances of the round uniform charge density obtained with the analytical solution [3], SF-PINN [2] and BEM [4]. Good agreement among the three methods is obtained.

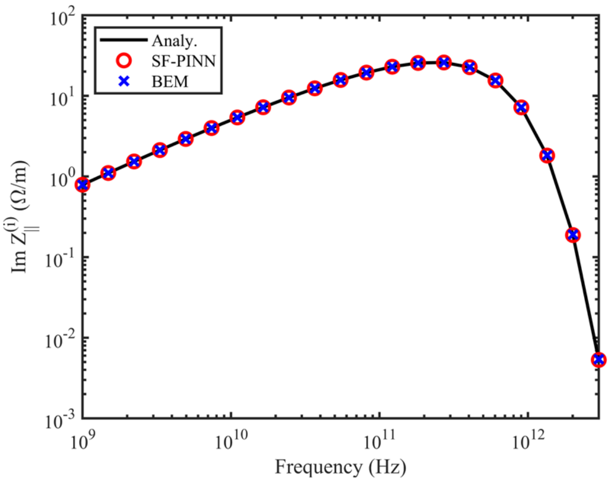

Figure 1. Indirect space charge impedances of round uniform beam charge density in the infinitely long perfectly conducting vacuum chamber obtained with the analytical solution, SF-PINN and BEM.

References

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