



Accuracy Verification of Multiscale Analysis for Interaction Between Electromagnetic Fields and Magnetization

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Analysis of interaction between electromagnetic fields and magnetization is important for simulating magnetization recording with ferromagnetic materials [1] and terahertz wave oscillation using antiferromagnetic materials [2]. Therefore, a multiphysics simulation combining the Maxwell's and LLG (Landau-Lifshitz-Gilbert) equations [3] [4] is indispensable and required.

We have developed a novel simulation method that can be applied to the multiphysics interaction problems in three-dimensional space. The FDTD (finite-difference time-domain) method for solving the Maxwell's equations performs highly reliable simulation using detailed computational models with the fine structure. Hence, the cost is very expensive and computational time becomes longer. In this report, we propose a remedy using the multi-scaling model [5] in which the selection of the space step size of electromagnetic field and that of magnetization is different from a conventional manner. By reducing the spatial discrete interval of magnetization relative to that of the electromagnetic field, the cost becomes cheaper under satisfying the stability condition with the same accuracy.

References

- [1] R. Ohnishi, K. Tatsuzawa, T. Yamaguchi, S. Kishimoto, Y. Ashizawa, K. Nakagawa, and S. Ohnuki, "Robustness and Local Polarization Control of Plasmonic Antennas with Fabrication Errors," *Journal of the Magnetism Society of Japan*, **44**, 2020, pp. 96–101. doi: 10.3379/msjmag.2007R003
- [2] T. Moriyama, K. Hayashi, K. Yamada, M. Shima, Y. Ohya, Y. Tserkovnyak, and T. Ono, "Enhanced antiferromagnetic resonance linewidth in Nio/Pt and NiO/Pd," *Phys. Rev. B*, **101**, 060402(R) – February 2020
- [3] A. Taflov and S. C. Hagness, *Computational Electrodynamics: the Finite-Difference Time-Domain Method* 3rd ed, Norwood, MA, USA: Artech House, 2005.
- [4] Y. Ito, T. Yasuda, S. Kishimoto S. Ohnuki "Nonlinear Property Analysis of Magnetic Materials Using Multiphysics Simulation" *IEICE Tech Rep*, **122**, 256, November 2022, pp.75-78, EMT2022-57.
- [5] S. Kishimoto, Y. Ito, T. Yasuda, K. Nakagawa, and S. Ohnuki "Analysis of Electromagnetic Fields with Magnetization Dynamics by Multiscale Modeling," *Magneto-Optical Recording International Symposium 2022 (MORIS 2022)*, Tu-P-01–02, Shimane, Japan, May 2022.