MINARET: Towards a time-dependent neutron transport parallel solver

Baudron, A.-M.[d,e], Lautard, J.J.[d,e], Maday, Y.[a,b,c,e] and Mula, O.[a,d,e]

[a] *UPMC Univ Paris 06, UMR 7598, Laboratoire Jacques-Louis Lions, F-75005, Paris, France.*
[b] *Institut Universitaire de France*
[c] *Division of Applied Mathematics, Brown University, Providence RI, USA.*
[d] *CEA Saclay, DEN/DANS/DM2S/SERMA/LLPR, 91191 Gif-Sur-Yvette CEDEX - France*
[e] *LRC MANON, Laboratoire de Recherche Conventionnée – CEA/DEN/DANS/DM2S and UPMC-CNRS/LJLL.*

Abstract

The advances of computer power in the last decades have today resulted in an increased memory storage per processor and also in a raising number of available processors to compute a given task. From the numerical simulation point of view, this context has allowed the implementation of more and more accurate — and therefore more computationally expensive and time-consuming — solvers that can be run in a reasonable time if advantage is taken of launching concurrently several processors. This speed-up in the computing time requires, however, the investigation of innovative acceleration techniques such as domain decomposition methods.

In the field of nuclear core calculations and, more particularly, regarding the neutron transport equation, this context has led to significant advances from the accuracy point of view: recent developments of time-dependent neutron transport codes such as DORT-TD [1] or TORT-TD [2] have indeed overcome the traditional diffusion, improved quasi-static [3] or point kinetics traditional approximations.

However, although the problem of merging a neutron transport accurate solver with parallel computations has already been addressed before for the angular [4] and energy [5] variables in the stationnary case, no study has been done so far in order to specifically speed-up time-dependent transport calculations and this work is a step in this direction. On this purpose, a multigroup 3D kinetic transport S_n code has been implemented (in a solver called MINARET [6]) and the parallelization of the angular and time variables are currently being explored. In particular, the time variable is parallelized by a domain decomposition technique: the parareal time algorithm (see [7], [8], [9]).

In this talk, after recalling the time-depend neutron transport equation, we will explain its discretization and implementation in MINARET. This will allow to illustrate the importance of the study of speed-up methods for the solver in order to run calculations in a reasonable computing time. After a brief review of the traditional sequential accelerations used in the field of neutron transport, our talk will specifically focus on the analysis of acceleration techniques that involve the parallelization of the variables of the equation. In particular, results concerning the parallelization of the angular and the time variables in MINARET will be exposed.

Acknowledgements

This work was supported in part by the joint research program MANON between CEA-Saclay and University Pierre et Marie Curie-Paris 6.

References

[1] A. Pautz and A. Birkhofer, "DORT-TD: A transient neutron transport code with fully implicit time integration," *Nuclear Science and Engineering*, vol. 145, pp. 299–319, 2003.

[2] A. Saubert, A. Sureda, J. Bader, J. Lapins, M. BUCK, and E. Laurien, "The 3-D time-dependent transport code TORT-TD and its coupling with the 3-D thermal-hydraulic code ATTICA3D for HTGR applications," *Nuclear Engineering and Design*, vol. 251, pp. 173–180, 2012.

[3] E. Girardi, P. Guérin, S. Dulla, and P. Ravetto, "Comparison of direct and quasi-static methods for neutron kinetic calculations with the EDF R&D COCAGNE code," in *PHYSOR, Advances in Reactor Physics*, 2012.

[4] E. Jamelot, J. Dubois, J.-J. Lautard, C. Calvin, and A.-M. Baudron, "High performance 3D neutron transport on petascale and hybrid architectures within APOLLO3 code," in *International Conference on Mathematics and Computational Methods Applied to Nuclear Science and Engineering*, 2011.

[5] R. Slaybaugh, T. Evans, G. Davidson, and P. Wilson, "Rayleigh quotient iteration in 3D, deterministic neutron transport," in *PHYSOR, Advances in Reactor Physics*, 2012.

[6] J.-Y. Moller and J.-J. Lautard, "MINARET, a deterministic neutron transport solver for nuclear core calculations," in *International Conference on Mathematics and Computational Methods Applied to Nuclear Science and Engineering*, 2011.

[7] J. Lions, Y. Maday, and G. Turinici, "Résolution d'EDP par un schéma en temps pararéel," *C. R. Acad. Sci. Paris*, 2001. t. 332, Série I, p. 661-668.

[8] L. Baffico, S. Bernard, Y. Maday, G. Turinici, and G. Zérah, "Parallel in time molecular dynamics simulations," *Phys. Rev. E*, vol. 66, p. 057701, 2002.

[9] G. Bal and Y. Maday, "A parareal time discretization for nonlinear PDE's with application to the pricing of an American put," *in Recent developments in domain decomposition methods, Lect. Notes Comput. Sci. Eng.*, vol. 23, pp. L.F. Pavarino and A. Toselli eds., 189–202, Springer Verlag,, 2002.