Analytical Solutions to a Coupled Fluid Dynamics and Neutron Transport Problem with Application to GeN-Foam Verification

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Background

- Horizon 2020 SAMOFAR project aims to evaluate the safety of the Molten Salt Fast Reactor with legacy and modern reactor modelling tools.
- Modern tools, such as GeN-Foam, require additional verification studies to assert code correctness.

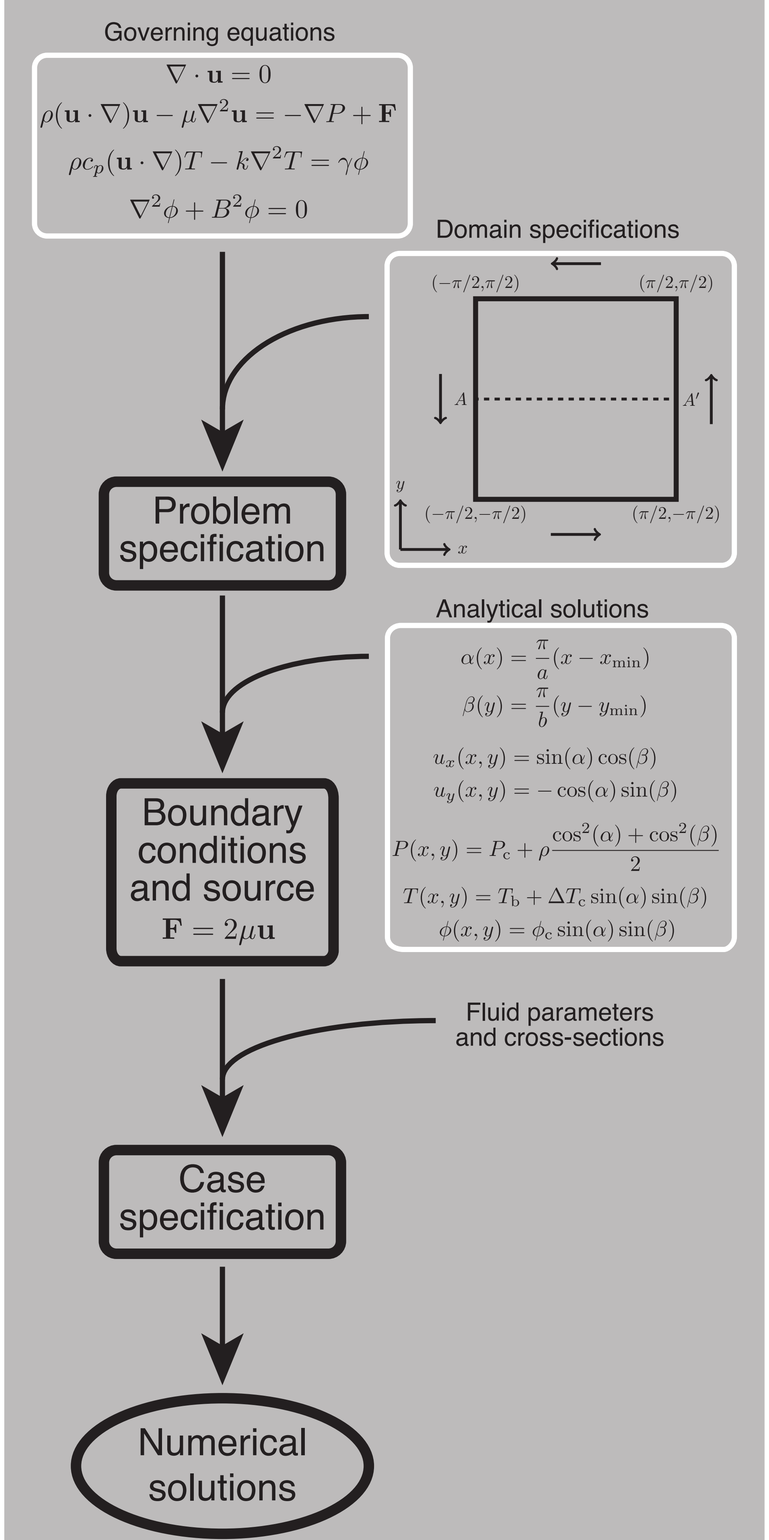
Introduction

Code verification can be divided into 2 recognized branches [1]:

1. Numerical algorithm verification, which produces evidence that the solvers are implemented correctly. This is the main objective of this study.
2. Software quality assurance (SQA), which is concerned with ensuring that further developments do not break previous ones. This is the secondary objective of this study.

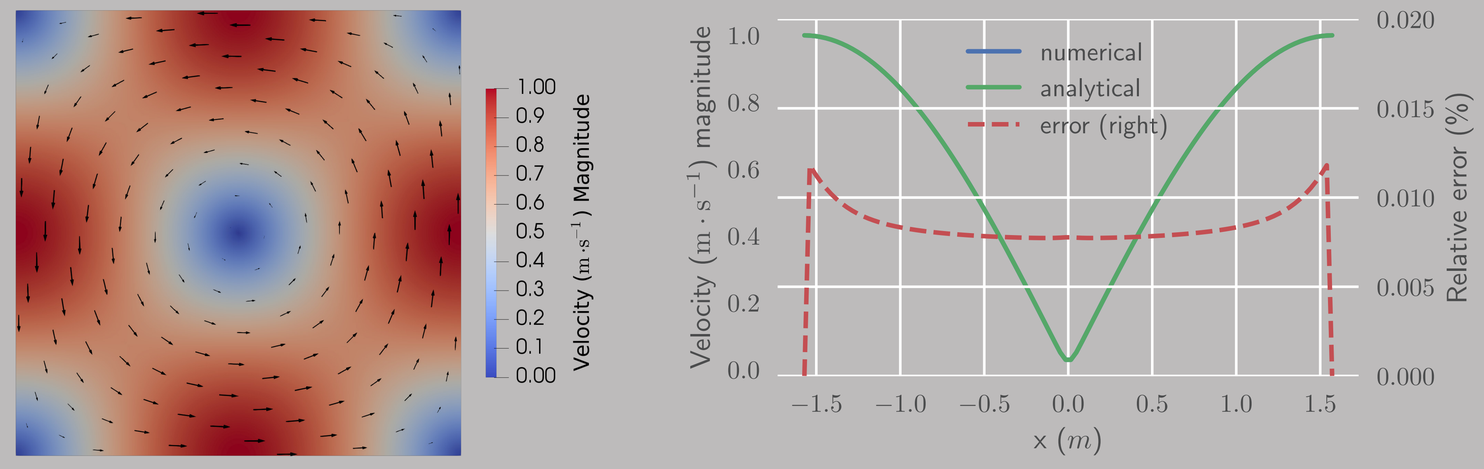
The goal is to rigorously demonstrate the correctness of the fluid dynamics and neutron transport solvers implemented in GeN-Foam as a preparation for further code developments.

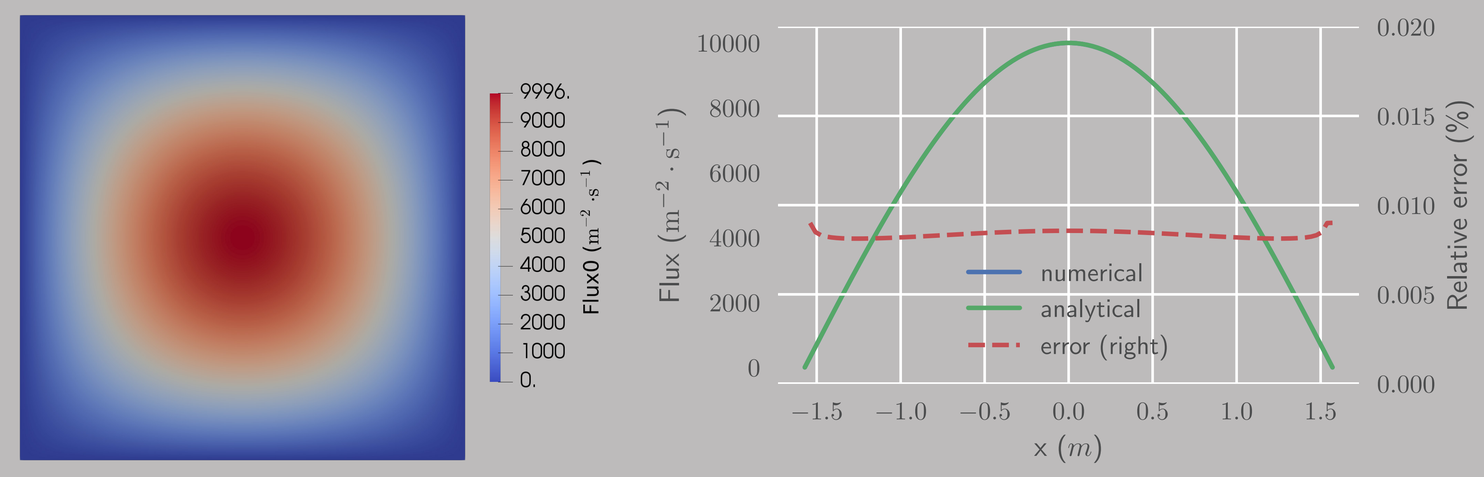
Methods



Results

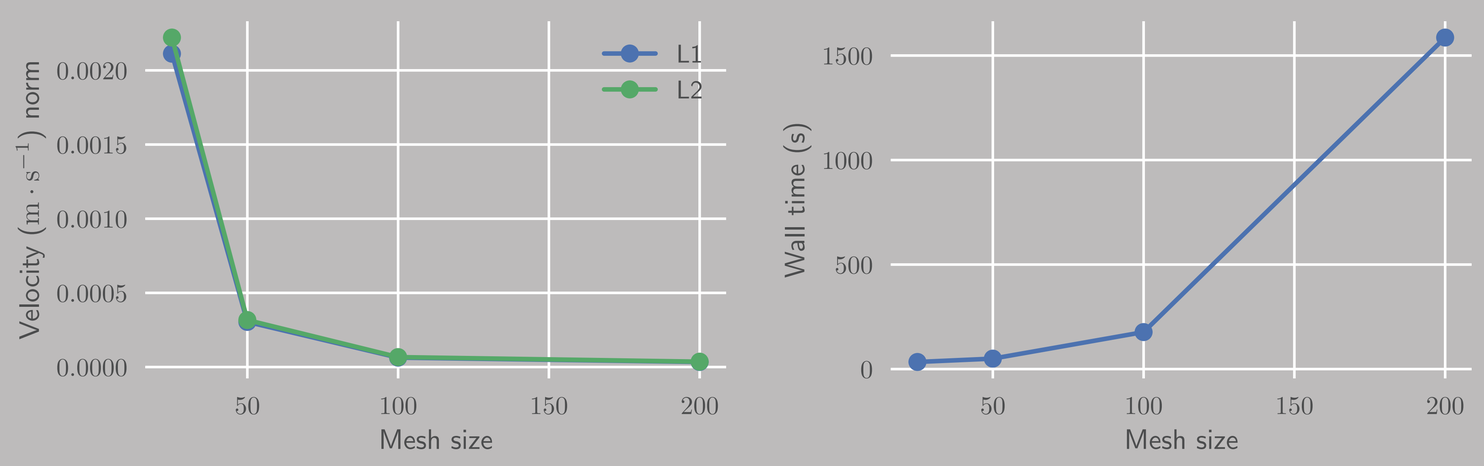
The numerical simulation successfully recover the analytical solutions imposed, with relative errors of approximately 0.01% on the centreline A-A'.





Grid convergence studies indicate that:

- At a mesh of 100 x 100 cells, norms approach an assymptotic minimum, with a run time of 180 seconds, making it a good mesh size for further developments.
- With a mesh of 50 x 50 cells, norms are also low, but with a much quicker run time of 50 seconds, making it a good mesh size for routine regression tests.



Conclusion

- Analytical solutions are proposed for verification of numerical algorithms of multiphysics solvers using the method of manufactured solutions
- Essential capabilities of GeN-Foam are correct as far as this simplified test covers
- Further code developments are enhanced by the robustness of the improved SQA
- The test coverage should be expanded to exercise more functions of the code

[1] Oberkampf, W. L., & Roy, C. J. (2010). Verification and Validation in Scientific Computing. Cambridge University Press. doi:10.1017/CBO9780511760396

All test case files are available at https://github.com/deOliveira-R/recirculatingCavity

For an in-depth explanation about the methods used, scan the QR code or access https://youtu.be/HrSePA2Tho0.