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Implementation of thermal conduction energy transfer codes in the Bifrost Solar atmosphere MHD solver

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Thermal conductivity provides important contributions to the energy evolution of the upper solar atmosphere, behaving as a non-linear concentration-dependent diffusion equation. Computational discretisation limits the operation of solving such terms due to numerical instabilities and other error build-up. Recently, different methods have been offered as best-fit solutions to these problems in specific situations, but their limitations and total range in other scenarios is rarely discussed. Therefore, we rigorously test the different implementations of solving the conductivity flux, in the massively parallel MHD solver code, Bifrost. We compare the differences and limitations of explicit vs. implicit methods, and analyse the convergence of a hyperbolic approximation. Among the tests, we use a newly derived 1st-order self-similar approximation to compare the efficacy of each method analytically in a 1D pure-thermal scenario. The results give guidelines for when to use each method, and the variables that might affect a certain method's efficiency or accuracy. We discuss the optimisation of parameters in each method, and weaknesses that are not covered suitably by the current implementations.

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