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Current numerical approaches and how to expand them

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Task-based computing is offering a break-through in our capabilities to model astrophysical phenomena, and in particular in the context of solar modeling there are several routes along which we can take advantage of this general methodology. In the context of global modeling of the solar interior, we can utilize the ability to tune resolution as a function of depth, and by engaging very low diffusion low-Mach number Riemann solvers we can model the solar interior over time-scales sufficient to cover solar cycles. Given such global models, with large extents in space-time, we can then use static and adaptive mesh refinement to zoom-in on smaller (active) regions of space-time. With initial and boundary conditions from the larger scale models, and with BIFROST-compatible physics added, we can realistically model active region phenomena, first with (non-ideal) magnetohydrodynamics, and ultimately with particle-in-cell modeling of charged particle dynamics and particle acceleration in even smaller regions of space-time. An important technical development is needed to fully utilize these opportunities; a large fraction of the near-future supercomputing capacity is based on GPU-offloading, and we need to continue to develop and integrate accelerated solvers for magnetohydrodynamics and charged particle dynamics, while also staying on top of advances in hardware, firmware, and programming language standards related to offloading and hierarchical memory architecture.

Primary author: NORDLUND, Åke (University of Copenhagen)

Presenter: NORDLUND, Åke (University of Copenhagen)

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