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Innovative HPC architectures for the study of planetary plasma environments

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DEEP-ER is an European Commission founded project that develops a new type of High Performance Computer architecture. The revolutionary system is currently used by KU Leuven to study the effects of the solar wind on the global environments of the Earth and Mercury.

The new architecture combines the versatility of Intel Xeon computing nodes with the power of the upcoming Intel Xeon Phi accelerators. Contrary to classical heterogeneous HPC architectures, where it is customary to find CPU and accelerators in the same computing nodes, in the DEEP-ER system CPU nodes are grouped together (Cluster) and independently from the accelerator nodes (Booster). The system is equipped with a state of the art interconnection network, a highly scalable and fast I/O and a fail recovery resiliency system. The final objective of the project is to introduce a scalable system that can be used to create the next generation of exascale supercomputers.

The code iPic3D from KU Leuven is being adapted to this new architecture. This particle-in-cell code can now perform the computation of the electromagnetic fields in the Cluster while the particles are moved in the Booster side. Using fast and scalable Xeon Phi accelerators in the Booster we can introduce many more particles per cell in the simulation than what is possible in the current generation of HPC systems, allowing to calculate fully kinetic plasmas with very low interpolation noise.

The system will be used to perform fully kinetic, low noise, 3D simulations of the interaction of the solar wind with the magnetosphere of the Earth and Mercury. Preliminary simulations have been performed in other HPC centers in order to compare the results in different systems. In this presentation we show the complexity of the plasma flow around the planets, including the development of hydrodynamic instabilities at the flanks, the presence of the collision-less shock, the magnetosheath, the magnetopause, reconnection zones, the formation of the plasma sheet and the magnetotail, and the variation of ion/electron plasma flows when crossing these frontiers. The simulations also give access to detailed information about the particle dynamics and their velocity distribution at locations that can be used for comparison with satellite data.