Multiscale simulations of the plasma interaction with solar cells

ANTOINE BRUNET - ONERA - DESP

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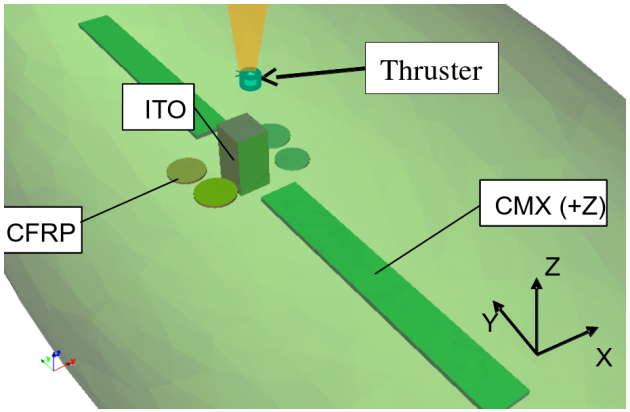
cnes

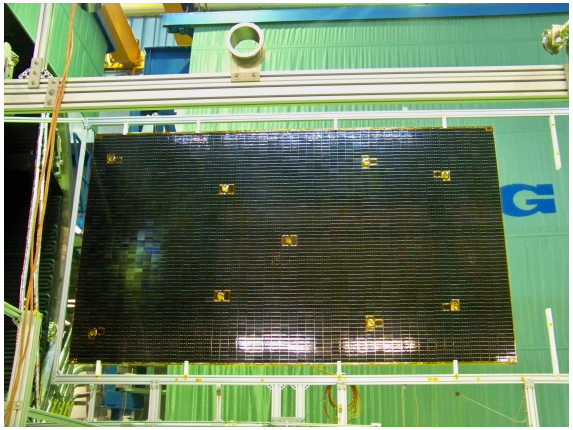
Needs for multiscale simulations with SPIS

- Small scales (solar array interconnects, scientific instruments, . . .)
- Large scales (wakes, jet effects, . . .)

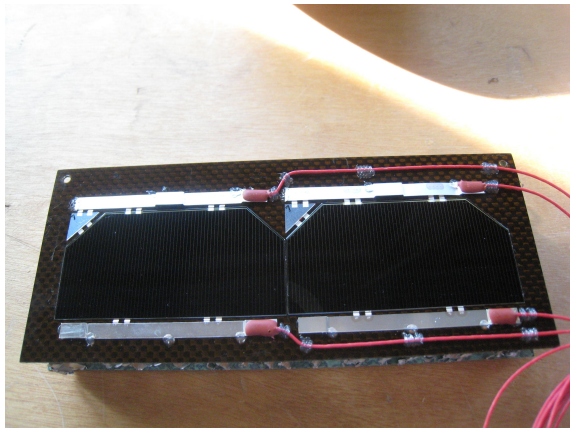
Artist's view of the Neosat mission
(©ESA-P. Carril, 2012)



SPIS model of GEO satellite with EP(©Onera)



Standard solar array generator (4m x 8m, 52x56 solar cells)(©Onera)



Solar cells with interconnects(©Onera)

Needs for multiscale simulations with SPIS

- Small scales (solar array interconnects, scientific instruments, . . .)
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$\Rightarrow$ Require local mesh refinements

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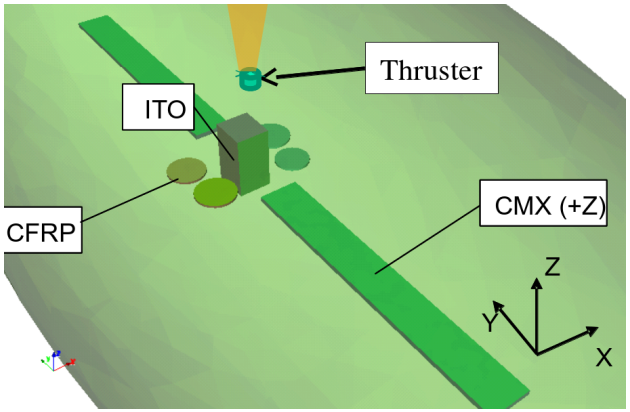

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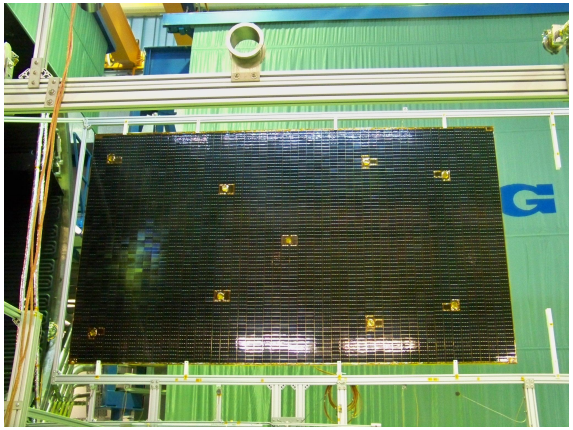

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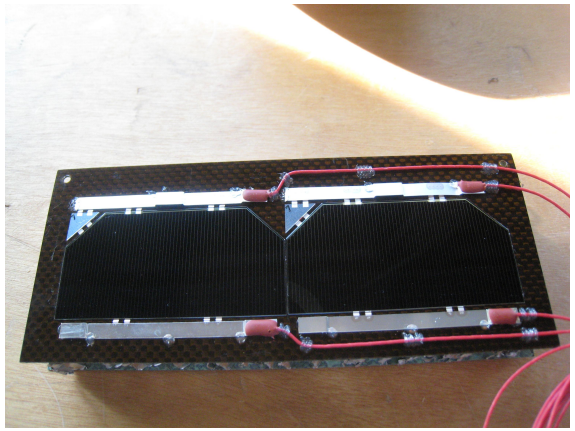
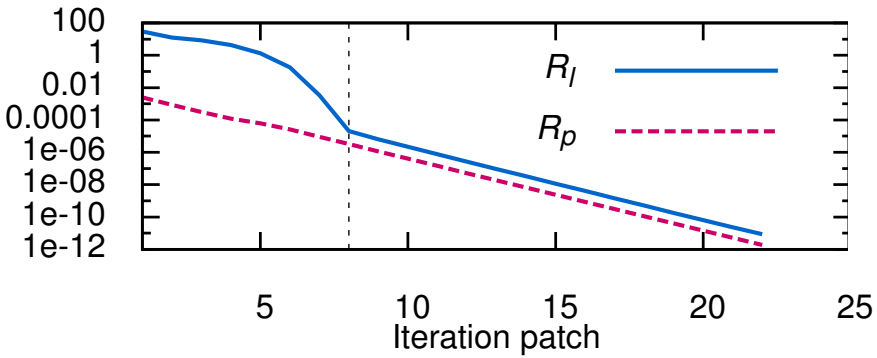
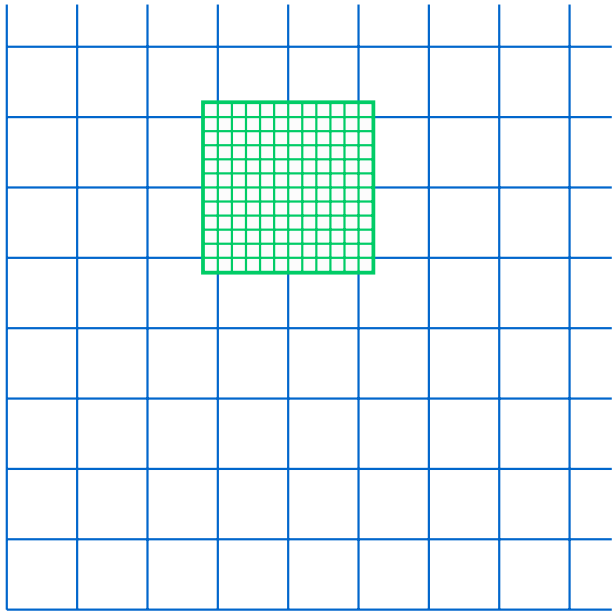


Solar cells with interconnects(©Onera)

Patch finite element method

- Domain decomposition method:
  - Global coarse mesh
  - Refined local patches
- Iterative, but flexible
- Efficient in non-linear case





Convergence for a 2D plasma simulation around a negatively biased interconnect

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Nonlinear patch method and application, A. Brunet, P. Sarrailh, F. Rogier, J.-F. Roussel, and D. Payan, Proceedings of ECCOMAS Congress 2016

Patches in SPIS – Workflow

User input:

- Define meshes

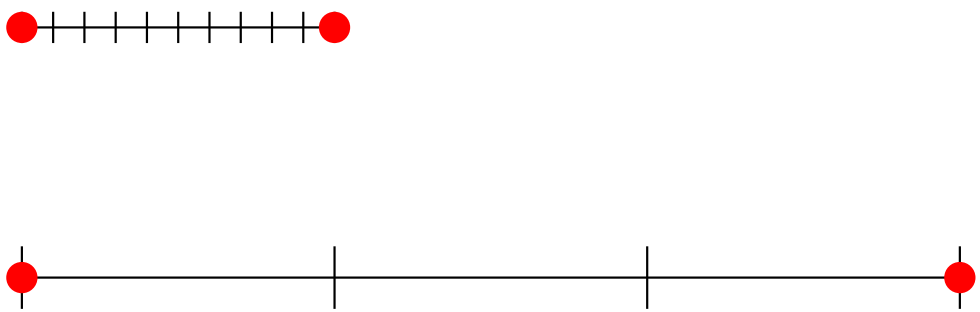
Numerical steps:

Patches in SPIS – Workflow

User input:

- Define meshes
- Define appropriate boundary conditions

Numerical steps:

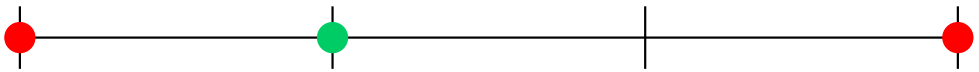


Patches in SPIS – Workflow

User input:

- Define meshes
- Define appropriate boundary conditions
- Flag meshes and boundaries

Numerical steps:



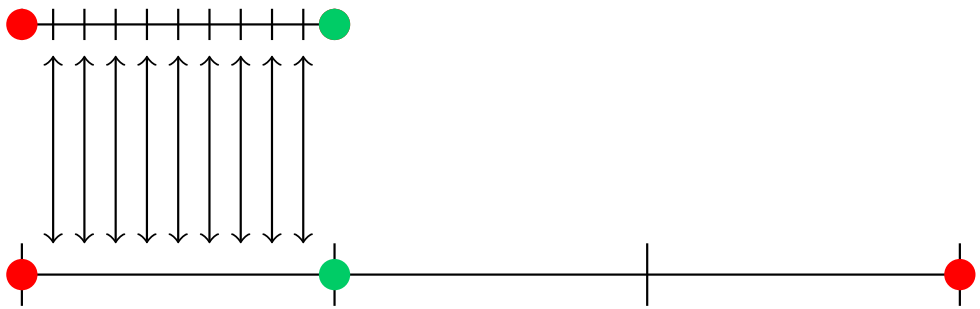
Patches in SPIS – Workflow

User input:

- Define meshes
- Define appropriate boundary conditions
- Flag meshes and boundaries

Numerical steps:

- Compute mesh interactions



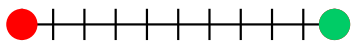
Patches in SPIS – Workflow

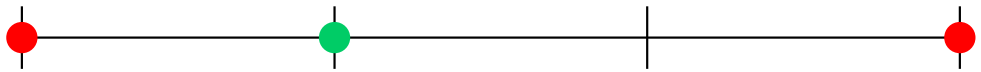
User input:

- Define meshes
- Define appropriate boundary conditions
- Flag meshes and boundaries

Numerical steps:

- Compute mesh interactions
- Split into sub-problems





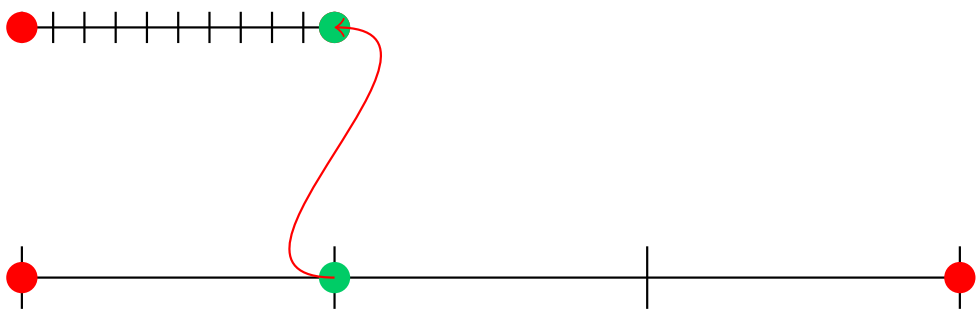
Patches in SPIS – Workflow

User input:

- Define meshes
- Define appropriate boundary conditions
- Flag meshes and boundaries

Numerical steps:

- Compute mesh interactions
- Split into sub-problems
- Redirect particles



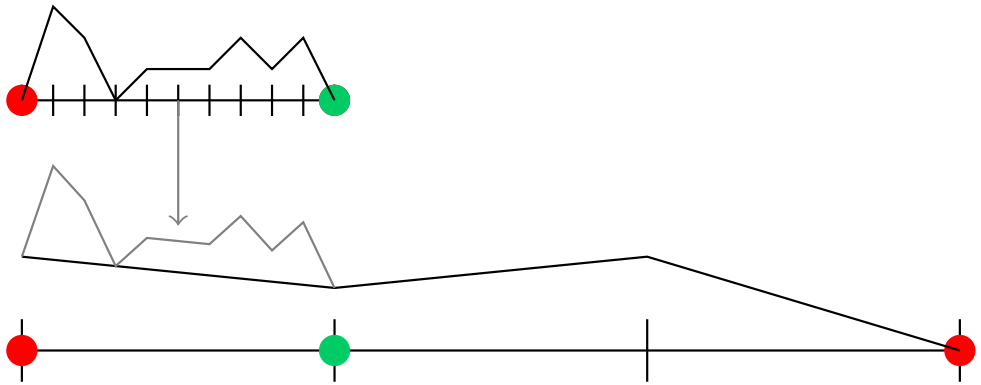
Patches in SPIS – Workflow

User input:

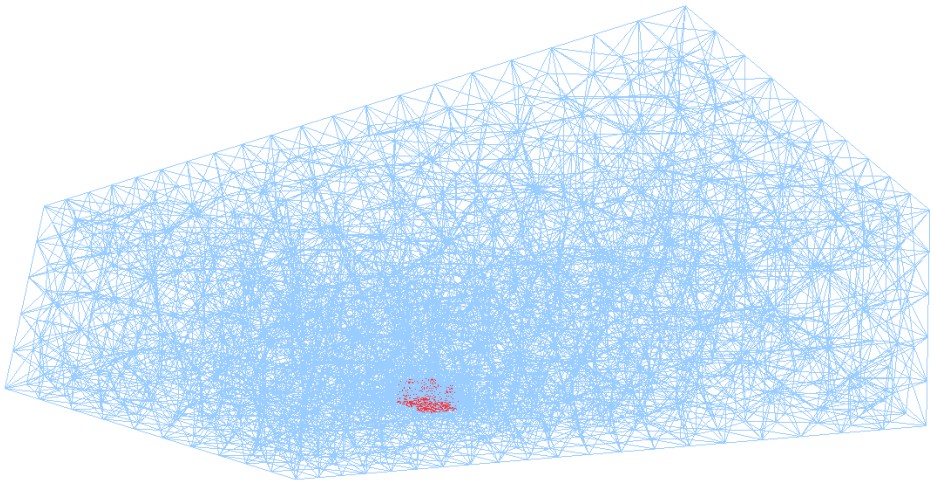
- Define meshes
- Define appropriate boundary conditions
- Flag meshes and boundaries

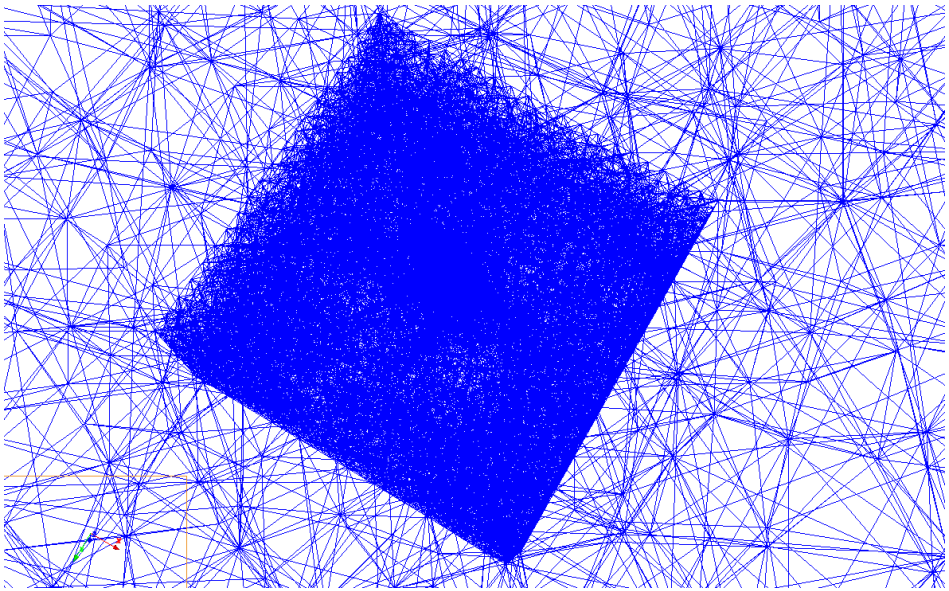
Numerical steps:

- Compute mesh interactions
- Split into sub-problems
- Redirect particles
- Compute vector/scalar interpolations



Demo





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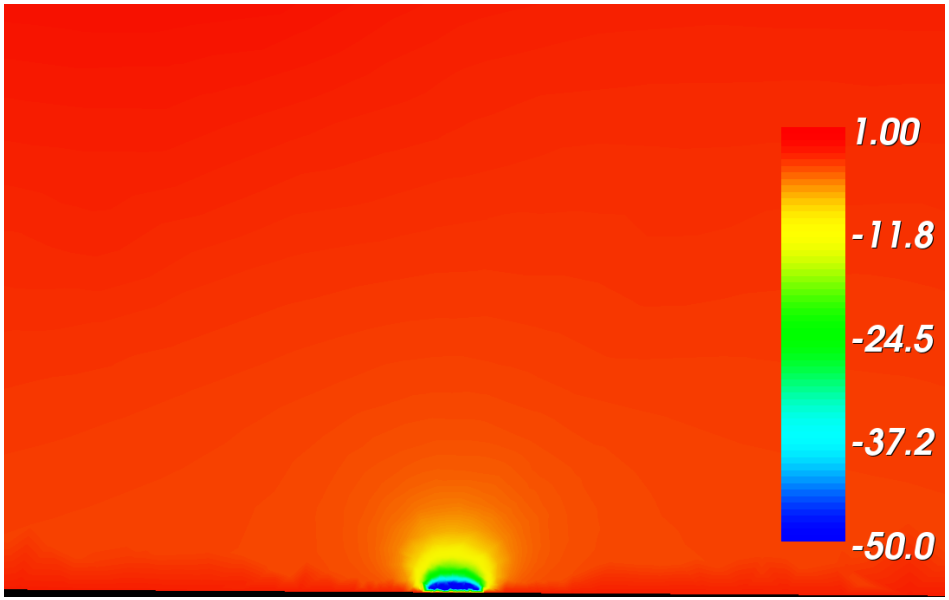
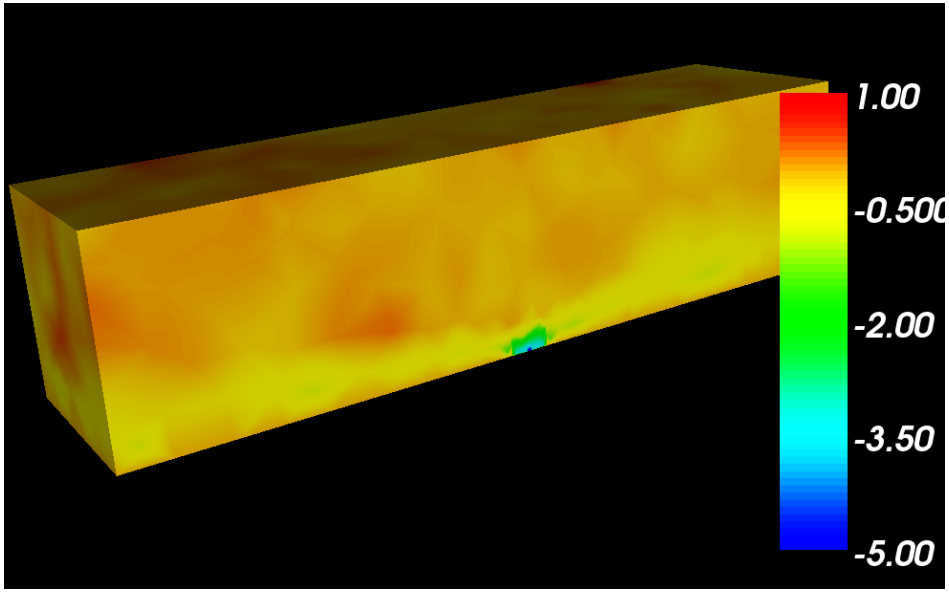
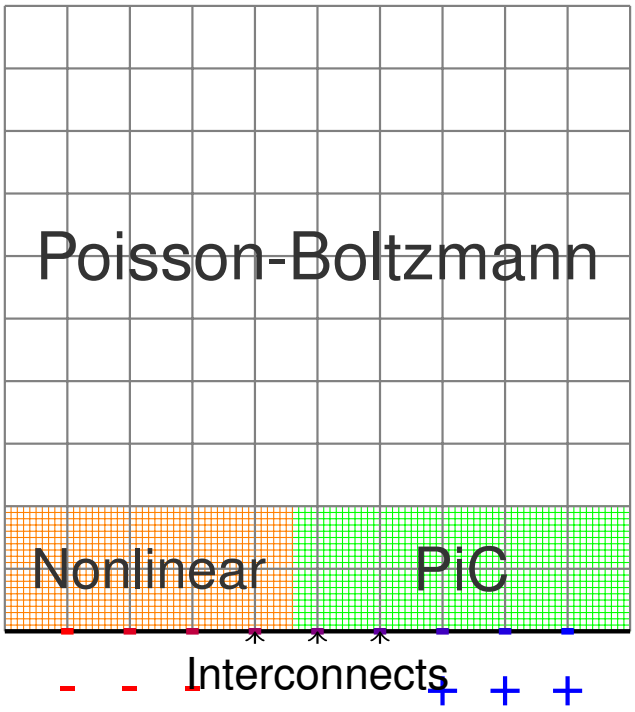




Current and future works

- Multimodel simulation (in progress)
  - Boltzmann model on coarse mesh
  - Full PiC in patches
- Experimental validation
- Mesh generation methods
  - Intersection computation
  - Mesh sharing
- Many-patch: model reduction, interpolation methods



Questions?