# An accurate and scalable nonlinear multi-species Fokker-Planck operator solver

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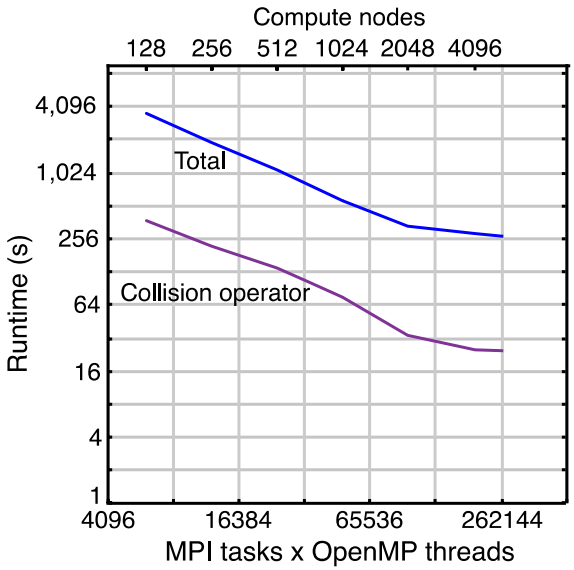
## Objectives

- Tokamak edge and other non-thermal plasmas must use a fast and accurate fully nonlinear Fokker-Planck collision operator.
- The fully nonlinear collision operator must also be practical for high performance computing of the kinetic physics.




The non-ideal scalability at the maximal node counts is artificial. It is caused by a lack of computational intensity from not using large enough problem size.

Excellent strong scalability of the new Fokker-Planck operator solver (purple line) on the maximal Edison capacity, when applied to the neoclassical particle code XGCa. The total XGCa computing time is indicated by the blue line. The weak scalability is even better, enabling its application to large problem size.

## Challenges

- It has been difficult for plasma kinetic codes to use an accurate fully nonlinear Fokker-Planck collision operator solver that satisfies conservation properties.
  - Most codes use linearized collision operator
- Must also be fast and scalable to high performance computers to handle practical kinetic problems
  - Millions of mesh vertices

## Accomplishments

- A fully non-linear, multi-species Fokker-Planck-Landau collision operator solver has been developed for strongly magnetized plasmas
  - With accurate conservation properties
  - Applicable to both continuum and particle codes
- Good scalability for high performance computing
  - Efficient load balancing
  - MPI and OpenMP parallelization, with a nested OpenMP operation

## Impact

- The new solver has been installed in XGC1 and XGCa for accurate edge physics study
- It can significantly enhance the non-thermal plasma research capability in many kinetic codes

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