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PSYDAC: a high-performance IGA library in Python

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PSYDAC is a Python 3 library for the solution of partial differential equations, which combines the convenience of a domain specific language with the speed of a high-performance parallel engine. Its current focus is on isogeometric analysis using tensor-product B-spline finite elements, but extensions to other methodologies are under consideration. The library supports multi-patch mapped geometries, and finite element exterior calculus.

In order to use PSYDAC [1], the user defines the weak form of the model equations using SymPDE [2], an extension of Sympy [3] that provides the mathematical expressions and checks their semantic validity. Simple mappings can be defined analytically, while multi-patch NURBS geometries can be imported from a geometry file. Once a finite element discretization has been chosen, PSYDAC maps the abstract concepts onto concrete objects, the basic building blocks being MPI-distributed vectors and matrices. Python code is automatically generated for all the computationally intensive operations (matrix and vector assembly, matrix-vector products, matrix transpositions, etc.). Finally, the generated code is accelerated using either Numba [4] or Pyccel [5].

We present the library design, the user interface, the single-process performance, and the parallel scaling results. In addition we show a numerical application in plasma physics.

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REFERENCES

[1] PSYDAC: `https://github.com/pyccel/psydac`
[2] SymPDE: `https://github.com/pyccel/sympde`
[3] Sympy: `https://www.sympy.org`
[4] Numba: `https://numba.pydata.org`
[5] Pyccel: `https://github.com/pyccel/pyccel`