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XCALibre.jl: xxx

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Summary

Understanding the behaviour of fluid flow, such as air over a wing, water in a pipeline, or fuel in an engine is crucial in many engineering applications, from designing aircraft and automotive components to optimising energy systems, etc. Computational Fluid Dynamics (CFD) enables engineers to model real-world conditions, optimise designs, and predict performance under a wide range of scenarios, and it has become a vital part of the modern engineering design process for creating efficient, safe, and sustainable designs. As engineers seek to develop and optimise new designs, particularly in fields where there is a drive to push the current state-of-the-art or physical limits of existing design solutions, often, new CFD methodologies or physical models are required. Therefore, extendable and flexible CFD frameworks are needed, for example, to allow seamless integration with machine learning models. In this paper, the features of the first release of the Julia package XCALibre.jl are presented. Designed with extensibility in mind, XCALibre.jl is aiming to facilitate the rapid prototyping of new fluid models and to easily integrate with Julia's powerful ecosystem, enabling access to optimisation libraries and machine learning frameworks to enhance its functionality and expand its application potential, whilst offering multi-threaded performance CPUs and GPU acceleration.

Statement of need

- Existing CFD solvers
- Commercial and open-source
- General limitations
- Existing CFD solvers in the Julia ecosystem
- How we fill the gap
- What XCALibre.jl offers

`Gala` is an Astropy-affiliated Python package for galactic dynamics. Python enables wrapping low-level languages (e.g., C) for speed without losing flexibility or ease-of-use in the user-interface. The API for `Gala` was designed to provide a class-based and user-friendly interface to fast (C or Cython-optimized) implementations of common operations such as gravitational potential and force evaluation, orbit integration, dynamical transformations, and chaos indicators for nonlinear dynamics. `Gala` also relies heavily on and interfaces well with the implementations of physical units and astronomical coordinate systems in the `Astropy` package (Astropy Collaboration, 2013) (`astropy.units` and `astropy.coordinates`).

`Gala` was designed to be used by both astronomical researchers and by students in courses on gravitational dynamics or astronomy. It has already been used in a number of scientific publications (Pearson et al., 2017) and has also been used in graduate courses on Galactic dynamics to, e.g., provide interactive visualizations of textbook material (Binney & Tremaine, 2008). The combination of speed, design, and support for Astropy functionality in `Gala` will

enable exciting scientific explorations of forthcoming data releases from the *Gaia* mission (Gaia Collaboration, 2016) by students and experts alike.

Mathematics

Single dollars ($) are required for inline mathematics e.g. $f(x) = e^{\pi/x}$

Double dollars make self-standing equations:

$$\Theta(x) = \begin{cases} 0 \text{ if } x < 0 \\ 1 \text{ else} \end{cases}$$

You can also use plain LaTeXfor equations

$$\hat{f}(\omega) = \int_{-\infty}^{\infty} f(x) e^{i\omega x} dx \tag{1}$$

and refer to Equation 1 from text.

Citations

Citations to entries in paper.bib should be in rMarkdown format.

If you want to cite a software repository URL (e.g. something on GitHub without a preferred citation) then you can do it with the example BibTeX entry below for Smith et al. (2020).

For a quick reference, the following citation commands can be used: - `@author:2001` -> "Author et al. (2001)" - `[@author:2001]` -> "(Author et al., 2001)" - `[@author1:2001; @author2:2001]` -> "(Author1 et al., 2001; Author2 et al., 2002)"

Figures

Figures can be included like this: Caption for example figure. and referenced from text using section .

Figure sizes can be customized by adding an optional second parameter: Caption for example figure.

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