

Gala: A Python package for galactic dynamics

13 August 2017

Summary

The forces on stars, galaxies, and dark matter under external gravitational fields lead to the dynamical evolution of structures in the universe. The orbits of these bodies are therefore key to understanding the formation, history, and future state of galaxies. The field of “galactic dynamics,” which aims to model the gravitating components of galaxies to study their structure and evolution, is now well-established, commonly taught, and frequently used in astronomy. Aside from toy problems and demonstrations, the majority of problems require efficient numerical tools, many of which require the same base code (e.g., for performing numerical orbit integration).

Statement of need

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, Price-Whelan, and Johnston 2017) and has also been used in graduate courses on Galactic dynamics to, e.g., provide interactive visualizations of textbook material (Binney and 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 \LaTeX for equations

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

and refer to Equation 1 from text.

Citations

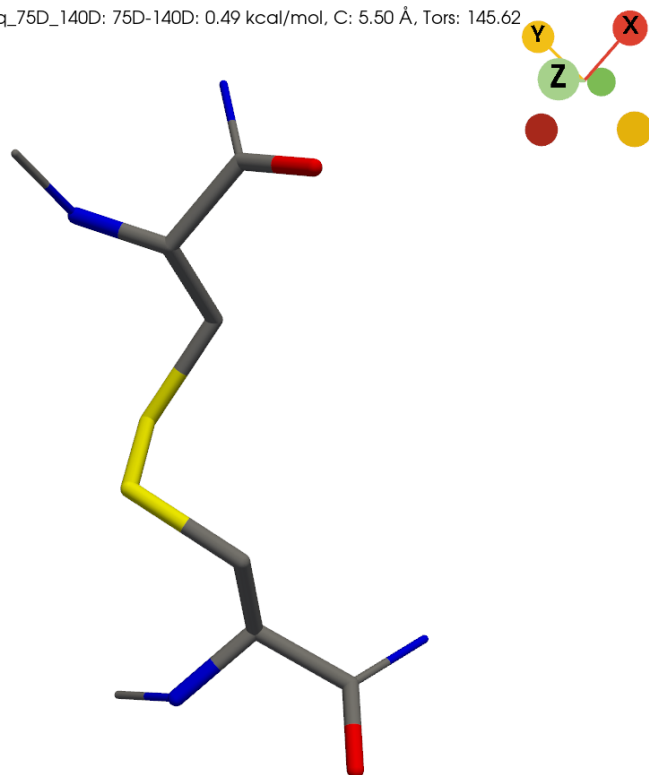
Citations to entries in paper.bib should be in rMarkdown format.

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, Thaney, and Hahnel (2020).

For a quick reference, the following citation commands can be used: - `@Pearson:2001` -> “Author et al. (2001)” - `[@Binney:2008]` -> “(Author et al., 2001)” - `[@author1:2001; @author2:2001]` -> “(Author1 et al., 2001; Author2 et al., 2002)”

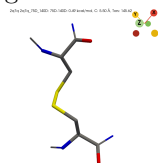
Figures

2q7q 2q7q_75D_140D: 75D-140D: 0.49 kcal/mol, C: 5.50 Å, Tors: 145.62



Figures can be included like this:
and referenced from text using ??.

Figure sizes can be customized by adding an optional second parameter:



Acknowledgements

We acknowledge contributions from Brigitta Sipocz, Syrtis Major, and Semyeong Oh, and support from Kathryn Johnston during the genesis of this project.

References

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- Pearson, S., A. M. Price-Whelan, and K. V. Johnston. 2017. “Gaps in Globular Cluster Streams: Pal 5 and the Galactic Bar.” *ArXiv e-Prints*, March. <http://adsabs.harvard.edu/abs/2017arXiv170304627P>.
- Smith, A. M., K. Thaney, and M. Hahnel. 2020. “Fidgit: An Ungodly Union of GitHub and Figshare.” *GitHub Repository*. GitHub. <https://github.com/arfon/fidgit>.