The Journal of Open Source Software

cosmo-numba: B-modes and COSEBIs computations accelerated by Numba

Axel Guinot [1] and **Rachel Mandelbaum** [1]

1 Department of Physics, McWilliams Center for Cosmology, Carnegie Mellon University, Pittsburgh, PA 15213, USA

DOI: 10.xxxxxx/draft

Software

- Review
- Repository
- Archive

Editor: Open Journals

Reviewers:

- @openjournals

Submitted: 01 January 1970
Published: unpublished

Summary

Cosmic shear important probe. B-modes computation as null test This software propose at the same time a user friendly interface and fast computation for E-/B-mode decomposition.

Statement of need

`Cosmo-numba` facilate the computation of E-/B-modes decomposition using two methods. One of them is the Complete Orthogonal Sets of E-/B-mode Integrals (COSEBIs) as presented in P. Schneider et al. (2010). The COSEBIs rely on very high precision computation requirering more than 80 decimal numbers. P. Schneider et al. (2010) propose an implementation using `mathematica`. `cosmo-numba` make use of combination of `sympy` and `mpmath` to reach the required precision. This python version enable an easier integration in cosmology pipeline and facilate the null tests.

This software package also include the computation of the pure-mode correlation functions presented in Peter Schneider et al. (2022). Those integrals have less constraints than the COSEBIs but having a fast computation is necessary to computing the covariance matrix. One can also include use those correlation function for cosmological inference in which case the multiple call to the likelihood will also require a fast implementation.

COSEBIs

The COSEBIs are defined as:

$$E_n = \frac{1}{2}\int_0^\infty d\theta\theta[T_{n,+}(\theta)\xi_+(\theta) + T_{n,-}(\theta)\xi_+(\theta)] \quad (1)$$

$$B_n = \frac{1}{2}\int_0^\infty d\theta\theta[T_{n,+}(\theta)\xi_+(\theta) - T_{n,-}(\theta)\xi_+(\theta)] \quad (2)$$

where $\xi_\pm(\theta)$ are the shear correlation functions, and $T_{n,\pm}$ are the weight functions for the mode n. The complexity is in the computation of reside in the computation of the weight functions. `Cosmo-numba` include do the computation of the weight functions in logarithmic scale defined by:

$$T^{\log}_{n,+}(\theta) = t^{\log}_{n,+}(z) = N_n \sum_{j=0}^{n+1} c^{-}_{nj} z^j \quad (3)$$

The Journal of Open Source Software

whare $z = log(\theta/\theta_{\rm min})$, N_n is the normalization for the mode n, and c_{jn}^{-} are defined iterratively from Bessel functions (we refer the readers to P. Schneider et al. (2010) for morre details).

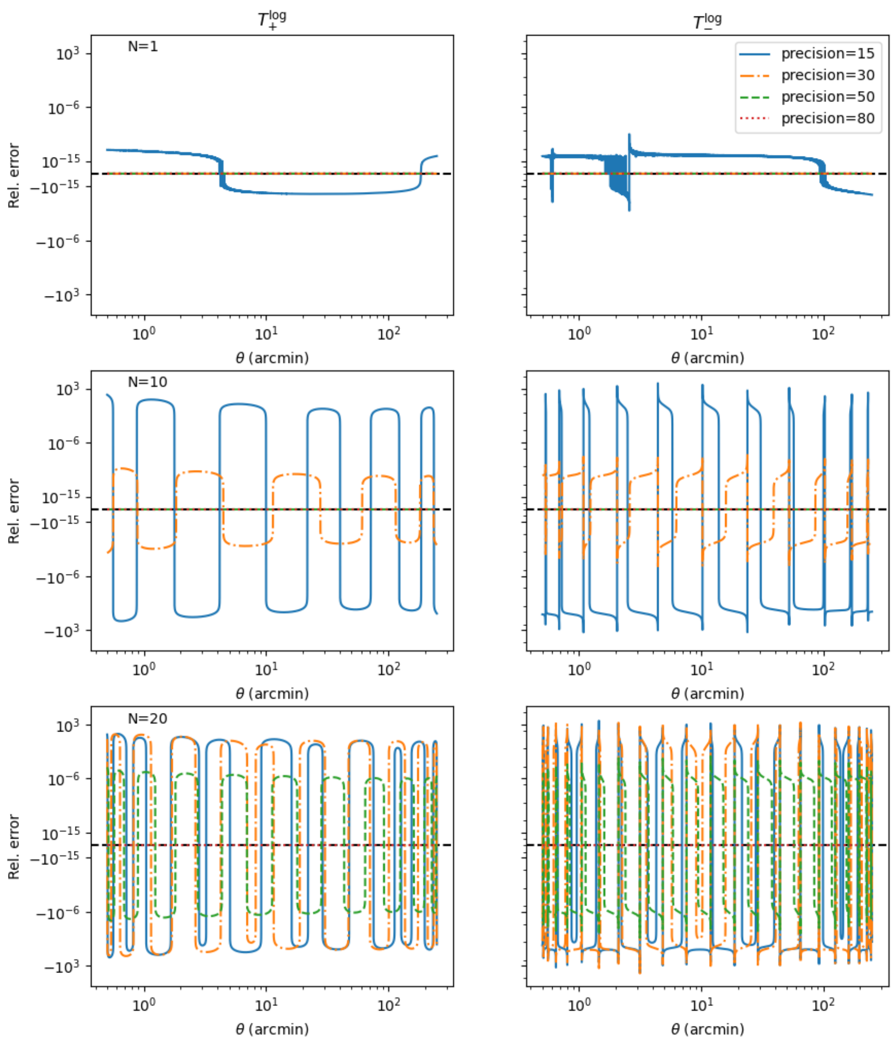

Figure 1: In this figure we show the impact of the precision in the computation weight function. For comparion, a precision of 15 correspond to what would be achieve using numpy float64. The relative error is computed with respect to the orignal mathematica implementation presented in P. Schneider et al. (2010).

Mathematics

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

Double dollars make self-standing equations:

$$\Theta(x) = \left\{\begin{array}{l} 0\textrm{ if } x < 0\cr 1\textrm{ else} \end{array}\right.$$

You can also use plain LaTeX for equations

$$\hat f(\omega) = \int_{-\infty}^{\infty} f(x) e^{i\omega x} dx \tag{4}$$

and refer to Equation 4 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 (?).

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.

Acknowledgements

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

References

Schneider, Peter, Asgari, M., Jozani, Y. N., Dvornik, A., Giblin, B., Harnois-Déraps, J., Heymans, C., Hildebrandt, H., Hoekstra, H., Kuijken, K., Shan, H., Tröster, T., & Wright, A. H. (2022). Pure-mode correlation functions for cosmic shear and application to KiDS-1000. *Astronomy &Amp; Astrophysics*, *664*, A77. https://doi.org/10.1051/0004-6361/202142479

Schneider, P., Eifler, T., & Krause, E. (2010). COSEBIs: Extracting the full e-/b-mode information from cosmic shear correlation functions. *Astronomy and Astrophysics*, *520*, A116. https://doi.org/10.1051/0004-6361/201014235