

¹ cosmo-numba: B-modes and COSEBIs computations accelerated by Numba

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¹¹ Cosmo-numba facilitate the computation of E-/B-modes decomposition using two methods. One
¹² of them is the Complete Orthogonal Sets of E-/B-mode Integrals (COSEBIs) as presented in
¹³ P. Schneider et al. (2010). The COSEBIs rely on very high precision computation requiring
¹⁴ more than 80 decimal numbers. P. Schneider et al. (2010) propose an implementation
¹⁵ using mathematica. cosmo-numba make use of combination of sympy and mpmath to reach the
¹⁶ required precision. This python version enable an easier integration in cosmology pipeline and
¹⁷ facilitate the null tests.

Summary

⁷ Cosmic shear important probe. B-modes computation as null test This software propose at
⁸ the same time a user friendly interface and fast computation for E-/B-mode decomposition.

Statement of need

¹⁰ This software package also include the computation of the pure-mode correlation functions
¹¹ presented in Peter Schneider et al. (2022). Those integrals have less constraints than the
¹² COSEBIs but having a fast computation is necessary to computing the covariance matrix. One
¹³ can also include use those correlation function for cosmological inference in which case the
¹⁴ multiple call to the likelihood will also require a fast implementation.

COSEBIs

²³ The COSEBIs are defined as:

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

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

²⁵ where $\xi_\pm(\theta)$ are the shear correlation functions, and $T_{n,\pm}$ are the weight functions for the
²⁶ mode n . The complexity is in the computation of reside in the computation of the weight
²⁷ functions. Cosmo-numba include do the computation of the weight functions in logarithmic
²⁸ scale defined by:

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

29 where $z = \log(\theta/\theta_{\min})$, N_n is the normalization for the mode n , and \bar{c}_{jn} are defined iteratively
 30 from Bessel functions (we refer the readers to P. Schneider et al. (2010) for more details).

31 We have validating our implementation against the original version in Mathematica from P.
 32 Schneider et al. (2010). In figure Figure 1 we show the impact of the precision going from 15
 33 decimals, which correspond to the precision one could achieve using float64, up to 80, the
 34 precision used in the original implementation. We can see that classic float64 precision would
 35 not be sufficient and with a precision of 80 our code recover exactly the results from the original
 36 implementation. Similarly, the impact on the COSEBIs is shown in figure Figure 2.

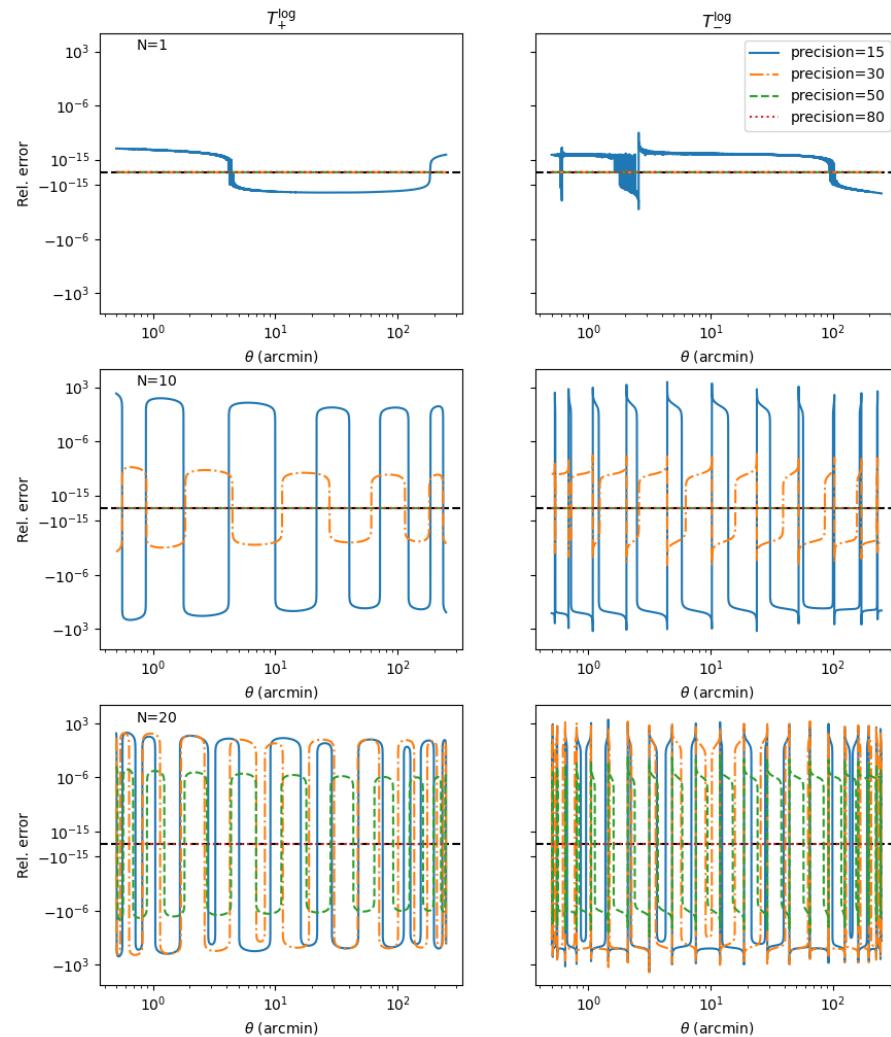


Figure 1: In this figure we show the impact of the precision in the computation of the weight functions T_{\pm}^{\log} . For comparison, a precision of 15 corresponds to what would be achieved using numpy float64. The relative error is computed with respect to the original Mathematica implementation presented in P. Schneider et al. (2010).

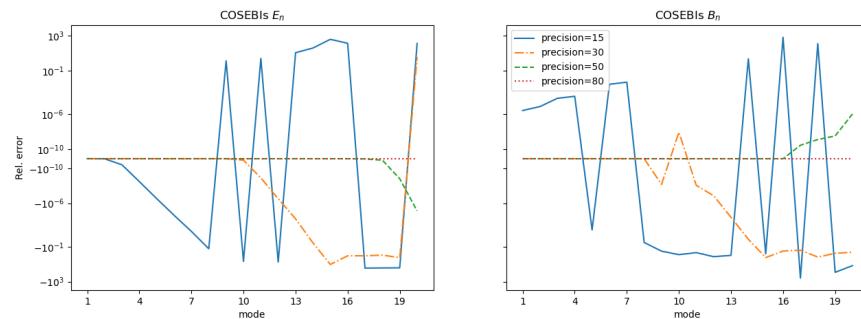


Figure 2: Same as figure Figure 1 but on the COSEBIs E- and B-mode.

37 Mathematics

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

39 Double dollars make self-standing equations:

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

40 You can also use plain L^AT_EX for equations

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

41 and refer to Equation 4 from text.

42 Citations

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

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

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

49 Figures

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

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

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