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Computational Physics Homework 1

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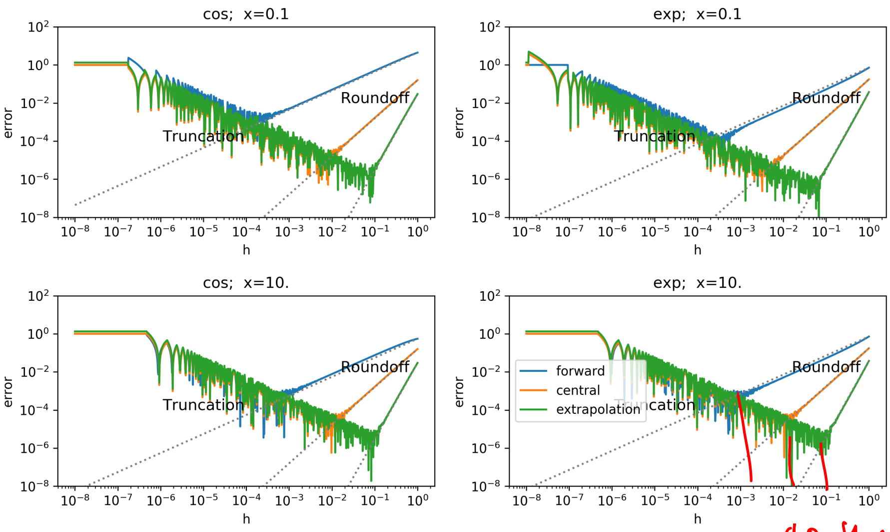
1 Derivatives

The derivative of cos and exp is computed at $x = 0.1$ and $x = 10$. At high step-size h, there is a roundoff error which is algorithmic. In this domain, the extrapolation is the most efficient method and the forward difference is the worst, as expected. Note that the truncation error slope is independent of the method. Indeed it only depends on the precision of the computer.



do these agree w/ expectations?

Figure 1: Error of the derivative versus step size for 3 different methods. The dotted lines are slopes $O(h)$, $O(h^2)$ and $O(h^4)$ excellent.

2 Integration

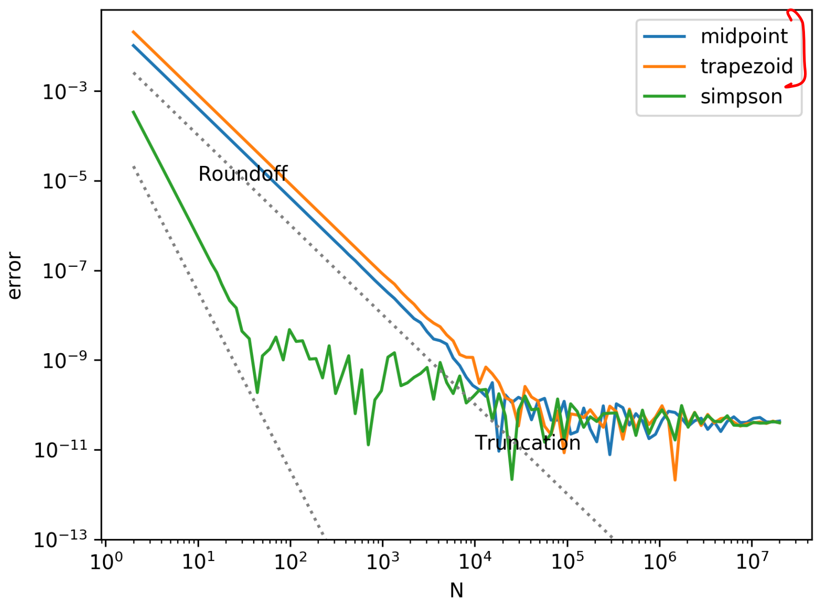
In figure 2 we use 3 integration methods to calculate $\int_0^1 e^{-x}dx$. Note that the midpoint method is more efficient than the trapezoid method. As expected, the Simpson method gives better results. We the step-size goes under 10^{-2} a truncation error appears for the Simpson method.

In order to check the non-intuitive result that the midpoint method is more efficient than the trapezoid method in a more general case we test the methods on another function defined as:

$$f(x) = a_n \sum_{0}^{N} sin(2nx/\pi + \phi_n), \qquad (1)$$

good

where a_n and ϕ_n and random numbers in $[0, 1]$ and $[0, 2\pi]$ and N=100. The resulted errors are plotted in figure 4. Even on this function which is less regular than the previous example, the midpoint method does better than the trapezoid one.



+1 extra for figuring this out.

Figure 2: Error versus number of bins in the computation of $\int_0^1 e^{-x}dx$, The dotted lines are slopes $O(h^2)$ and $O(h^4)$

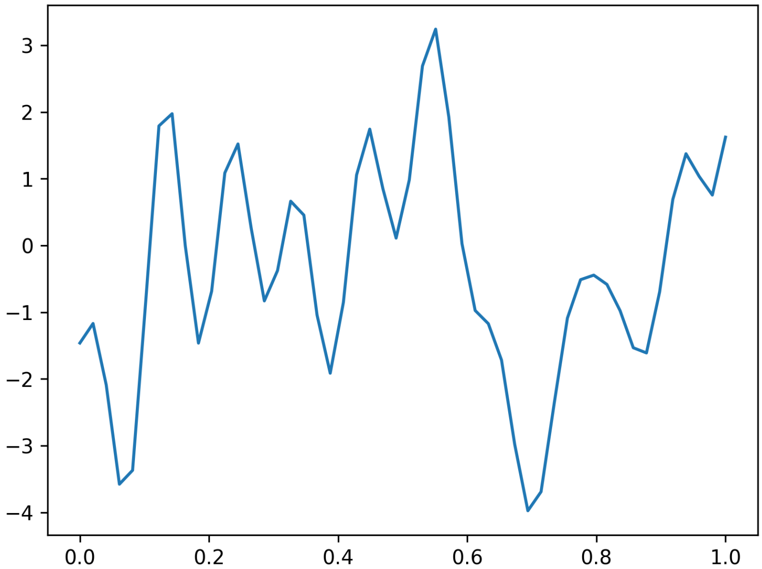


Figure 3: The random function defined in eq (1).

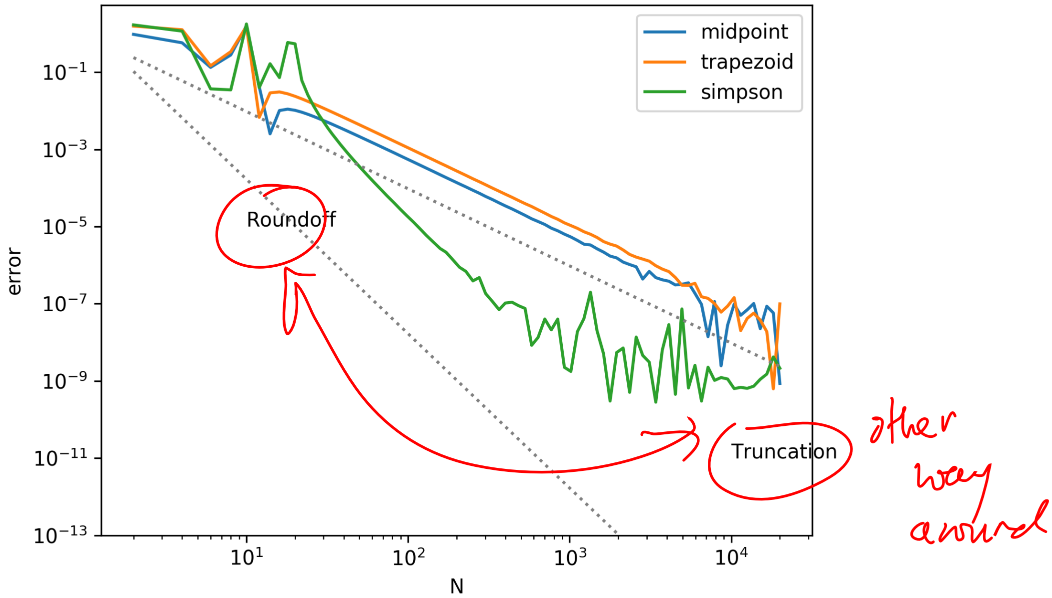


Figure 4: Error versus number of bins in the computation of the integral of eq (1). The dotted lines are slopes $O(h^2)$ and $O(h^4)$

3 Cosmic density fluctuations

We use a cubic interpolation of P to compute the integral ξ. Then we find the best number of integration bins N by testing the convergence of the error. We tolerate a relative error of 10^{-6}.

The BOA is found by searching the maximum of the correlation function in the right half of the r domain.

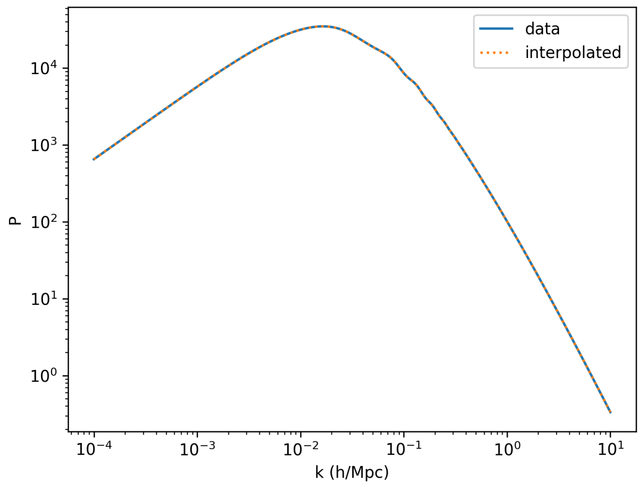


Figure 5: Power spectrum. We ensure that the interpolation stays coherent.

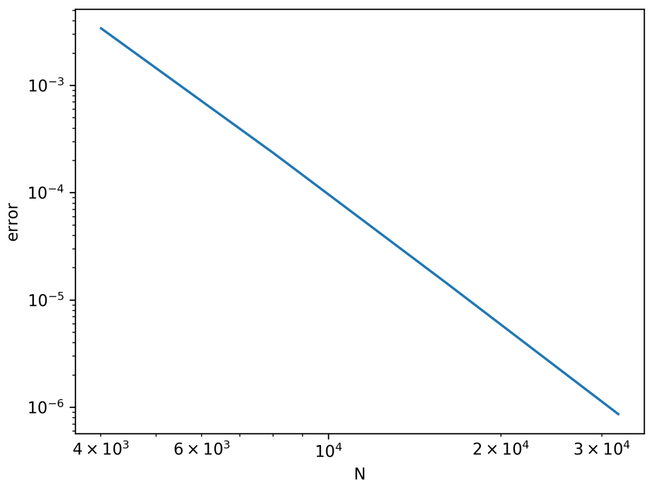


Figure 6: Error in the computation of $\xi(r = 100Mpc/h)$ versus number of integration bins.

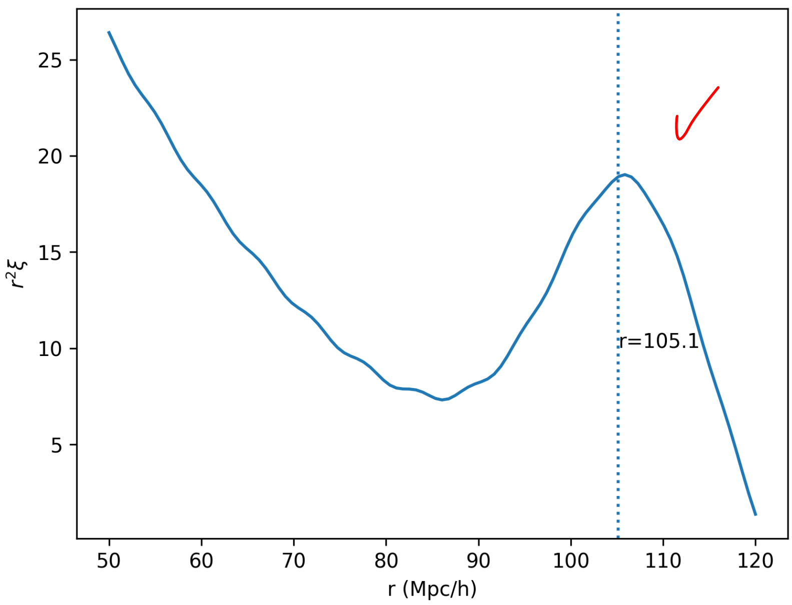


Figure 7: $r^2\xi$ versus r. The vertical line shows the local maximum of ξ corresponding to the BOA. The peak appears to be slightly translated because of the x^2 factor.