

## Accepted Manuscript

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PII: S0377-0427(17)30294-7  
DOI: <http://dx.doi.org/10.1016/j.cam.2017.05.041>  
Reference: CAM 11172

To appear in: *Journal of Computational and Applied Mathematics*

Received date: 28 February 2017

Revised date: 27 April 2017

Please cite this article as: T. Hasegawa, H. Sugiura, Uniform approximation to Cauchy principal value integrals with logarithmic singularity, *Journal of Computational and Applied Mathematics* (2017), <http://dx.doi.org/10.1016/j.cam.2017.05.041>

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# Uniform approximation to Cauchy principal value integrals with logarithmic singularity

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## Abstract

An approximation of Clenshaw-Curtis type is given for Cauchy principal value integrals of logarithmically singular functions  $I(f; c) = \int_{-1}^1 f(x) (\log|x - c|)/(x - c) dx$  ( $c \in (-1, 1)$ ) with a given function  $f$ . Using a polynomial  $p_N$  of degree  $N$  interpolating  $f$  at the Chebyshev nodes we obtain an approximation  $I(p_N; c) \cong I(f; c)$ . We expand  $p_N$  in terms of Chebyshev polynomials with  $O(N \log N)$  computations by using the fast Fourier transform. Our method is efficient for smooth functions  $f$ , for which  $p_N$  converges to  $f$  fast as  $N$  grows, and so simple to implement. This is achieved by exploiting three-term inhomogeneous recurrence relations in three stages to evaluate  $I(p_N; c)$ . For  $f(z)$  analytic on the interval  $[-1, 1]$  in the complex plane  $z$ , the error of the approximation  $I(p_N; c)$  is shown to be bounded uniformly. Using numerical examples we demonstrate the performance of the present method.

*Keywords:* Cauchy principal value integral, logarithmic singularity, quadrature rule, Chebyshev interpolation, uniform approximation, three-term recurrence relations

*2010 MSC:* 65D30, 65D32

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