Computer Physics Communications 312 (2025) 109605

Contents lists available at ScienceDirect

Computer Physics Communications

journal homepage: www.elsevier.com/locate/cpc

New Version Announcement

Evaluation of the generalized Fermi-Dirac integral and its derivatives for moderate/large values of the parameters. New version announcement

Amparo Gil [a,*], Andrzej Odrzywołek [b], Javier Segura [c], Nico M. Temme [d]

[a] Depto. de Matemática Aplicada y Ciencias de la Comput., Universidad de Cantabria, 39005-Santander, Spain
[b] Instytut Fizyki Teoretycznej, Uniwersytet Jagielloński, Kraków, Poland
[c] Depto. de Matemáticas, Estadistica y Comput., Universidad de Cantabria, 39005-Santander, Spain
[d] Valkenierstraat 25, 1825 BD Alkmaar, the Netherlands

ARTICLE INFO

The review of this paper was arranged by Prof. J. Ballantyne

ABSTRACT

A revised version of the Matlab implementations of the expansions for the Fermi-Dirac integral and its derivatives is presented. In the new version, our functions for computing the Kummer functions $M(a,b,x)$ and $U(a,b,x)$ are incorporated into the software. The algorithms for computing the Kummer functions are described in [1,2]. In this way, the implementations of the expansions for the Fermi-Dirac integral can be used in earlier Matlab versions and can be easily adapted to GNU Octave. The efficiency of the computations is also greatly improved.

New version program summary

Program Title: FermiDiracExpans
CPC Library link to program files: https://doi.org/10.17632/sk34wtcxhh.2
Licensing provisions: GPLv3
Programming language: Matlab
Journal reference of previous version: Comput. Phys. Commun. 283 (2023) 108563
Does the new version supersede the previous version?: Yes
Reasons for the new version: With the new version, the implementations of the expansions for the Fermi-Dirac integral can be used in earlier Matlab versions and can be easily adapted to GNU Octave. The efficiency of the computations is also greatly improved.
Summary of revisions: The built-in Matlab functions `kummerU` and `hypergeom` are replaced by our functions `Uabx` and `Mabx`, respectively. These functions improve both the accuracy and efficiency of the built-in Matlab functions for computing the Kummer functions. A few relations satisfied by the Kummer functions are used to adapt the expressions in the expansions involving Kummer functions with negative parameters into expressions with real positive parameters and arguments, as used in our algorithms for Kummer functions.
Nature of problem: The evaluation of the relativistic Fermi-Dirac function and its partial derivatives is needed in different problems in applied and theoretical physics, such as stellar astrophysics, plasma physics or electronics.
Solution method: Convergent and asymptotic expansions are provided to approximate the relativistic Fermi-Dirac function and its derivatives for moderate/large values of its parameters.

References

[1] A. Gil, D. Ruiz-Antolin, J. Segura, N.M. Temme, Numer. Algorithms 94 (2023) 669–679.
[2] A. Gil, D. Ruiz-Antolin, J. Segura, N.M. Temme, Lecture Notes in Computer Science, vol. 14477, Springer, Cham, 2025.

* Corresponding author.
E-mail addresses: amparo.gil@unican.es (A. Gil), andrzej.odrzywolek@uj.edu.pl (A. Odrzywołek), javier.segura@unican.es (J. Segura), nic@temme.net (N.M. Temme).

https://doi.org/10.1016/j.cpc.2025.109605
Received 27 March 2025; Accepted 1 April 2025

Available online 2 April 2025

CRediT authorship contribution statement

Amparo Gil: Methodology, Software, Writing – original draft, Writing – review & editing. **Andrzej Odrzywołek:** Writing – review & editing, Writing – original draft. **Javier Segura:** Writing – review & editing, Methodology, Software, Writing – original draft. **Nico M. Temme:** Writing – original draft, Writing – review & editing, Methodology, Software.

Declaration of competing interest

None declared.

Acknowledgements

AG, JS and NMT thank financial support from project PID2021-127252NB-I00 funded by MCIN/AEI/10.13039/501100011033/FEDER, UE.

Data availability

The code is available in the CPC program library.