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Seipt, Daniel, Ridgers, Christopher P., Del Sorbo, Dario et al. (2022) Corrigendum:Polarized QED cascades (New Journal of Physics (2021) 23 (053025) DOI: 10.1088/1367-2630/abf584). New Journal of Physics. 029501. ISSN: 1367-2630

https://doi.org/10.1088/1367-2630/ac48e9

CORRIGENDUM • OPEN ACCESS

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To cite this article: Daniel Seipt *et al* 2022 *New J. Phys.* **24** 029501

New Journal of Physics
The open access journal at the forefront of physics

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IOP Institute of Physics

Published in partnership with: Deutsche Physikalische Gesellschaft and the Institute of Physics

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Corrigendum: Polarized QED cascades (2021 *New J. Phys.* 23 053025)

Daniel Seipt[1,2,3,*], **Christopher P Ridgers**[4], **Dario Del Sorbo**[5] and **Alec G R Thomas**[3]

[1] Helmholtz Institut Jena, Fröbelstieg 3, 07743 Jena, Germany
[2] GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstrasse 1, 64291 Darmstadt, Germany
[3] The Gérard Mourou Center for Ultrafast Optical Science, University of Michigan, Ann Arbor, Michigan 48109, United States of America
[4] York Plasma Institute, Department of Physics, University of York, York YO10 5DD, United Kingdom
[5] High Energy Density Science Division, SLAC National Accelerator Laboratory, Menlo Park, CA 94025, United States of America
[*] Author to whom any correspondence should be addressed.

E-mail: d.seipt@hi-jena.gsi.de

Keywords: lepton spin, photon polarization, high-intensity laser plasmas, strong-field QED, plasma kinetic theory, radiation & particle generation in plasmas

Supplementary material for this article is available online

OPEN ACCESS

RECEIVED
3 December 2021

REVISED
24 December 2021

ACCEPTED FOR PUBLICATION
6 January 2022

PUBLISHED
7 February 2022

Abstract

In the published version of the paper we made a sign error in the calculation of the direction of the magnetic field in the rest frame of the particles, which affects the definition of the spin-up direction in the collision operators. Correcting this does not affect the main claims of the paper: (i) the reduction of the cascade growth rate, (ii) the polarization of high-energy particles being opposite to Sokolov–Ternov theory, and (iii) an excess or a shortage of particle production in the early stages of cascade development in photon seeded cascades depending on the photon polarization.

As stated in reference [1], for a particle circulating in a rotating electric field with momentum $\vec{p} = (p_x, p_y, 0)$, $\vec{e}_z$ is a global non-precessing axis. Thus, spins are quantized along the z-axis. The magnetic field in the rest frame of the particles used for the quantum rates [2] is

$$\hat{\vec{B}} = \frac{\vec{B}'}{|\vec{B}'|} = -\frac{\vec{p}\times\vec{E}}{|\vec{p}\times\vec{E}|} = \mathrm{sign}(\sin\,\varphi)\,\vec{e}_z,$$

where φ is the angle between $\vec{E}$ and $\vec{p}$. In the calculations performed in paper, the factor $\mathrm{sign}(\sin\varphi)$ was overlooked. All changes in this corrigendum are due to the omission of this sign in the collision operators in the published version of the manuscript. We have repeated all calculations with the corrected collision operators.

Corrected version of figures 1, 2 and 5 of reference [1] are exhibited in figures 1–3, respectively. The curves in figure 3 remain nearly unchanged, with the only difference being that one has to exchange ↑ and ↓ for the positrons. Figures 4(a) and (b) are basically unchanged as well, the rate difference is slightly larger for large a_0. Panel (c) is incorrect. With the new collision operator the rate difference is approximately constant at 5%. The movie of the cascade evolution in the supplementary material (https://stacks.iop.org/NJP/24/029501/mmedia) has been replaced as well.

Let us briefly discuss the deviations seen in figures 1 and 2. The most obvious difference in figure 1 is that now the spin down distributions have the largest peak values for both the electrons and positrons. As discussed in the manuscript, the produced leptons accumulate inside the separatrix due to radiative energy loss. For positrons, the separatrix lies in the region where $\mathrm{sign}(\sin\varphi) < 0$, i.e. for those positrons $\hat{\vec{B}} = -\vec{e}_z$. This has consequences. According to Sokolov & Ternov positrons tend to polarize parallel to the rest frame magnetic field. Those positrons inside the separatrix now appear as spin-down positrons because they are

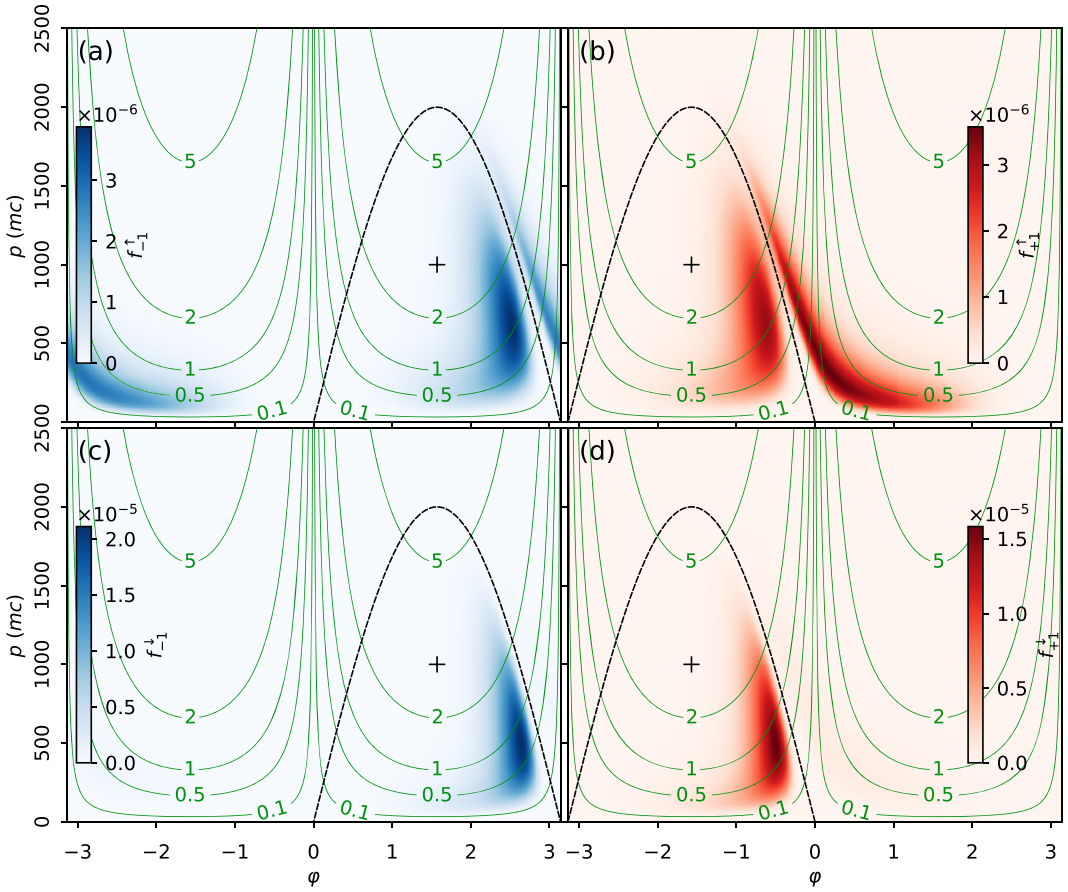

Figure 1. Correction of figure 1 of reference [1], calculated with the corrected collision operator. Because $\vec{\hat{B}} = -\vec{e}_z$ for $-\pi < \varphi < 0$ positrons are more likely to be found in a spin down state.

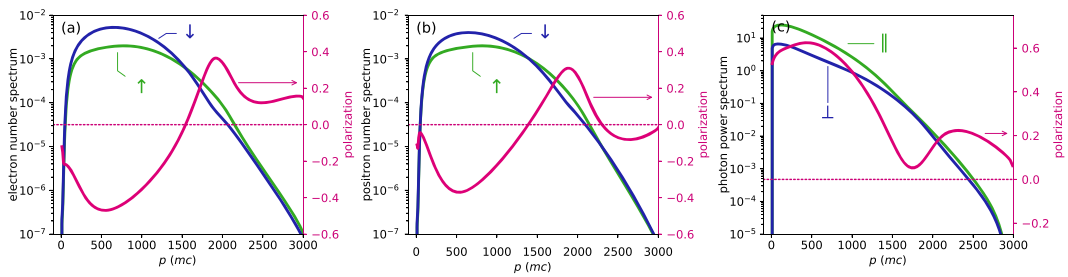

Figure 2. Replacement for figure 2 of the published manuscript, calculated with the corrected collision operator.

polarized anti-parallel to the z-axis. As another consequence of this the up-distributions outside the separatrices in panels (a) and (b) appear relatively stronger because they are now compared to a smaller peak inside the separatrix [compare the colorbars of panels (b) and (d)].

In figure 2 we find both qualitative and quantitative changes for the polarization degree (pink curves). Qualitatively, as discussed above, positrons tend to polarize in a spin down state. Quantitatively, the overall degree of lepton polarization is reduced compared to what was reported in the submitted manuscript. We still find an opposite polarization of high-energy particles compared to the bulk. However, we now find the largest difference in the region around $p \gtrsim 2a_0$. For even higher energies the polarization degree decreases for electrons, and even reverses sign again in case of the positrons. Note that the differences between the behaviours of electrons and positrons seen here is a relic of the cascade being seeded by electrons. Moreover, we now find that there is an excess of parallel photons over perpendicular photons throughout the whole spectrum.

Although the results of the corrected calculations show some differences in the details, the main conclusions of the paper are unchanged.

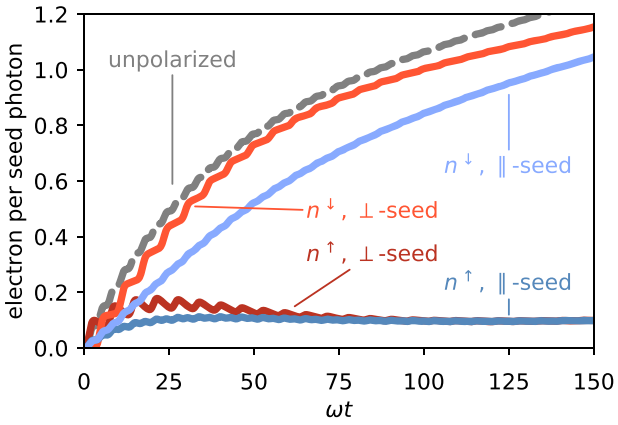

Figure 3. Correction of the right panel of figure 5 of the published manuscript, calculated with the corrected collision operator.

Data availability statement

The data that support the findings of this study are available upon reasonable request from the authors.

ORCID iDs

Daniel Seipt https://orcid.org/0000-0003-3695-0051
Dario Del Sorbo https://orcid.org/0000-0003-0390-7540
Alec G R Thomas https://orcid.org/0000-0003-3206-8512

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