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Comments on Myron W. Evans' "REFUTATION"[6]

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(Quotations from M.W. Evans handwritten "REFUTATION" [6] in **black**, my remarks in **blue**.)

Some months ago, in the sequel of the esoteric DGEIM-Congress at Stuttgart in October 2003, where the work of the AIAS group was praised, I wrote a refutation [5] of a basic statement of AIAS director Myron W. Evans. Evans replied with a handwritten philippic [6] against me accusing me of *several elementary blunders* (among other things). So he gave rise to check the claims of his publication [6] which will be done here below. In order to give opportunity to the reader to read Evans' "REFUTATION" as a whole I have attached it here as a htm-copy in Appendix 2. References to that text are given by links.

For the reader not familiar with Evans' basics I can say that with a few words: Instead of the Cartesian basis vectors **i**, **j**, **k** Evans introduces a unitary basis consisting of certain complex basis vectors $\mathbf{e}^{(1)}$, $\mathbf{e}^{(2)}$, $\mathbf{e}^{(3)}$. The *elementary* rules in the consequence of that coordinate transform are summed up in Appendix 1.

I shall refer to formulas in Appendix 1 by the equation labels (A. ..). Vectors are denoted by bold face letters, e.g. the basis vectors **i**, **j**, **k**. The letter i in light face is the imaginary unit.

In the course of the actual email discussion Evans referred to the book [9] to justify his calculations in Appendix 2. He wrote:
«. . . my definition of circular polarization is the same as that in a standard text such as J. D. Jackson, "Classical Electrodynamics" (Wiley third edition, 1999, page 299, eq. (7.20)).»

So I give some quotes of that pages in Appendix 3. It will turn out that Evans' definition given in his REFUTATION is completely incompatible to Jackson's description of circular polarization.

Appendix 4 contains some simple questions to M. Evans on the basis of Appendix 3 he refused to reply to in the email discussion.

Checking Evans' claims in [6]

Evans' Claim 1.

The first elementary error in Bruhn's claims occurs in his equations equs. (2.3) and (2.4) .

Check 1

Let's quote some eqs. of my paper [5]. Due to the literature (e.g. [7; p.188], [8; p.702 f.]) a vector

$$\mathbf{B} = \mathbf{i}\, B_x \pm \mathbf{j}\, B_y$$

of left (+ = L) and right (− = R) circular polarization around the z-axis (direction **k**) is given by choosing

(2.1) $B_x = B_0 \cos\Phi$ and $B_y = B_0 \sin\Phi$.

Then due to Evans' basic equations (A.3) and (A.5) we obtain the components of **B** relative to the cyclic basis of the vectors $\mathbf{e}^{(r)}$ (r=1,2,3):

(2.3) $\mathbf{B}_R{}^{(1)} = \mathbf{e}^{(1)} B^{(0)} e^{i\Phi}$, $\mathbf{B}_R{}^{(2)} = \mathbf{e}^{(2)} B^{(0)} e^{-i\Phi}$

and

(2.4) $\mathbf{B}_L^{(1)} = \mathbf{e}^{(1)} B^{(0)} e^{-i\Phi}$, $\mathbf{B}_L^{(2)} = \mathbf{e}^{(2)} B^{(0)} e^{i\Phi}$

Result 1

There is no doubt about it, the equations (2.3) and (2.4) describe right and left handed circular polarization *correctly*.

Evans' Claim 1 is erroneous.

Evans' Claim 2.

It is easy to show that Bruhn has made an elementary blunder because when we add his equations equs. (2.3) and (2.4) we obtain

$$\mathbf{B}_L^{(1)} + \mathbf{B}_R^{(1)} = B^{(0)} \mathbf{e}^{(1)} (e^{i\Phi} + e^{-i\Phi})$$

$$= B^{(0)} 2^{-1/2} (\mathbf{i} - i\,\mathbf{j}) (e^{i\Phi} + e^{-i\Phi}) \qquad (1)$$

$$= B^{(0)} 2^{-1/2} (\mathbf{i} - i\,\mathbf{j}) \cos\Phi \qquad (2)$$

However, it is well known that the sum of left and right circular polarization is linear polarization. Bruhn's equ. (2) is still *circular polarization*.

Check 2

Preliminary remark (of minor importance):

In (2) a factor 2 is missing. Hence we have correctly

$$\mathbf{B}_L^{(1)} + \mathbf{B}_R^{(1)} = B^{(0)} 2^{1/2} (\mathbf{i} - i\,\mathbf{j}) \cos\Phi \qquad (2')$$

We shall use (2') instead of (2) below.

Due to the rule (A.7), $\mathbf{a}^{(2)} = \mathbf{a}^{(1)*}$, we obtain from (2')

$$\mathbf{B}_L^{(2)} + \mathbf{B}_R^{(2)} = B^{(0)} 2^{1/2} (\mathbf{i} + i\,\mathbf{j}) \cos\Phi$$

while $\mathbf{B}^{(3)} = \mathbf{0}$ holds by assumption.

Hence from $\mathbf{B} = \mathbf{B}^{(1)} + \mathbf{B}^{(2)} + \mathbf{B}^{(3)}$ (cf. (A.2)) we obtain

$$\mathbf{B} = 2\, B^{(0)} 2^{1/2}\, \mathbf{i} \cos\Phi = \mathbf{i}\, \mathbf{2}\, B_0 \cos\Phi\,.$$

Result 2

B is a *real* vector in *constant* direction **i** oscillating proportionally to cos Φ. Hence **B** is clearly *linear polarized*.

Evans' Claim 2 has been refuted.

Evans' Claim 3.

The correct way to represent *left and right circular polarization* is as follows

$$\mathbf{B}_L^{(1)} = 2^{-1/2} (B_x\, \mathbf{i} - i\, B_y\, \mathbf{j}) e^{i\Phi} \qquad (3)$$

$$\mathbf{B}_R^{(1)} = 2^{-1/2} (B_x\, \mathbf{i} + i\, B_y\, \mathbf{j}) e^{i\Phi} \qquad (4)$$

Check 3

The superscript $^{(1)}$ of the notations $\mathbf{B}_L^{(1)}$ and $\mathbf{B}_R^{(1)}$ in the equs. (3) and (4) means that the $\mathbf{e}^{(1)}$-components of the vectors $\mathbf{B}_L$ and $\mathbf{B}_R$ will be defined by the right sides of the equs. (3) and (4). Hence e.g. the right side of equ. (3) must be parallel to the basis vector $\mathbf{e}^{(1)}$ (cf. equs. (1) and (2), where the $\mathbf{e}^{(1)}$-component of $\mathbf{B}_L + \mathbf{B}_R$ is defined by a vector $\,||\,$ $\mathbf{i} - i\,\mathbf{j}$, i.e. $||\,\mathbf{e}^{(1)}$). Therefore the equs. (3) and (4) would imply

$$B_x\,\mathbf{i} + i\,B_y\,\mathbf{j} \;||\; \mathbf{i} + i\,\mathbf{j},$$

i.e. $B_x = B_y$. The choice in my article [5; (2.1)] which Evans is referring to (or also Jackson's book [9; (7.21)]) yields

$$B_x = B_0 \cos \Phi \qquad \text{and} \qquad B_y = B_0 \sin \Phi ,$$

$B_x = B_y$ hence implies $\cos \Phi = \sin \Phi$. That contradicts the variability of Φ and is impossible.

Result 3

The definition of $\mathbf{B}_L^{(1)}$ and $\mathbf{B}_R^{(1)}$ by the equs. (3) and (4) is inconsistent.

Evans' Claim 3 has turned out to be erroneous.

Evans' Claim 4.

Add (3) and (4) to obtain

$$\mathbf{B}_L^{(1)} + \mathbf{B}_R^{(1)} = 2^{1/2}\, B_x\, \mathbf{i}\, e^{i\Phi}$$

(5)

which is *linear polarization as required.*

Check 4

By an argumentation analogously to Check 3. we see that for $B_x \neq 0$ equ. (5) would imply

$$\mathbf{i} - i\,\mathbf{j} \;\;||\;\; \mathbf{i}$$

which is a contradiction, regardless of the rest of Evans' claim.

Result 4

Equ. (5) is inconsistent.

Evans' Claim 4 has proved to be erroneous.

Evans' Claim 5.

From equ. (3) we see that the left c.p. wave is

$$\mathbf{B}_L^{(1)} = 2^{-1/2}\,(B_x \cos \Phi\, \mathbf{i} + B_y \sin \Phi\, \mathbf{j})$$

(6)

From equ. (4) we see that the right c.p. wave is

$$\mathbf{B}_R^{(1)} = 2^{-1/2}\,(B_x \cos \Phi\, \mathbf{i} - B_y \sin \Phi\, \mathbf{j})$$

(7)

Equ. (6) is Bruhn's equ. (4.2) and equ. (7) is Bruhn's equ. (4.1).

Check 5
By an argumentation analogously to Check 3. we see that (6) would imply

$$\mathbf{i} - \mathrm{i}\,\mathbf{j} \;\; || \;\; \mathbf{i}\cos^2\Phi + \mathbf{j}\sin^2\Phi$$

which is a contradiction since the left side has an imaginary part while the right side is real.
An analoguos argumentation holds for equ. (7).

Concerning Evans' last remark we quote the equations (4.1-2) from our refutation [5]:

(4.1) $\mathbf{B}_R = B_0\,(\mathbf{i}\cos\Phi + \mathbf{j}\sin\Phi)$ and (4.2) $\mathbf{B}_L = B_0\,(\mathbf{i}\cos\Phi - \mathbf{j}\sin\Phi)$.

Equ. (4.1) describes a right polarized wave and (4.2) describes a left polarized wave.

Of course, the equations (4.1-2) are in accordance with the literature (cf. [7; p.188], [8; p.702 f.]).

Result 5
The equs. (6) and (7) are inconsistent.

Evans' Claim 5 has proved to be erroneous.

Evans' Claim 6.

This shows that my equations (3) and (4) give Bruhn's own definitions of left and right handed c.p. in his equs. (4.1) and (4.2).

Check 5
As I have just shown Evans' equs. (3) and (4) are erroneous while my (4.1) and (4.2) are correct since being in accordance with the literature.

Result 6

Evans' Claim 6 is false.

Evans' Claim 7.

Bruhn's equs. (4.1) and (4.2) therefore contradict Bruhn's equs. equs. (2.3) and (2.4), because when we add Bruhn's equs. (4.1) and (4.2) we obtain linear polarization, but when we add equs. equs. (2.3) and (2.4) we obtain circular polarization.

Check 7
As we have remarked above the equs. (4.1) and (4.2) give right and left polarization in accordance with the literature. And the equations

(2.3) $\mathbf{B}_R^{(1)} = \mathbf{e}^{(1)}\,B^{(0)}\,e^{i\Phi}$, $\mathbf{B}_R^{(2)} = \mathbf{e}^{(2)}\,B^{(0)}\,e^{-i\Phi}$

and

(2.4) $\mathbf{B}_L^{(1)} = \mathbf{e}^{(1)}\,B^{(0)}\,e^{-i\Phi}$, $\mathbf{B}_L^{(2)} = \mathbf{e}^{(2)}\,B^{(0)}\,e^{i\Phi}$

are nothing but the components of $\mathbf{B}_R$ and $\mathbf{B}_L$ relative to the basis $\mathbf{e}^{(1)}$, $\mathbf{e}^{(2)}$, as can be shown by an elementary calculation. Hence there cannot be any contradiction between these equations.

Result 7
An elementary calculation would show no contradiction between these equations.

Evans' Claim 7 is false.

Evans' Claim 8.

The glaring error in Bruhn's claims occurs in his equ. (4.5), were he asserts, that for linear polarization:

$$\mathbf{B}^{(3)} = ?\ \pm 2^{1/2}\, B^{(0)}\, \mathbf{k} \qquad (11)$$

Check 8
Evans' quotation of equ. (4.5) is *incorrect*: The correct quote is

(4.5) $\mathbf{B}^{(3)} = \mathbf{0}$ **OR** $\mathbf{B}^{(3)} = \pm 2^{1/2}\, B^{(0)}\, \mathbf{k}$

Hence (4.5) is valid, since Evans' assures the first alternative of that OR-statement to be true.

Result 8
Evans' Claim 8 is due to an incorrect quotation.

Evans' Claim 8 is unjustified.

Evans' Claim 9.

The B Cyclic theorem always applies to ***one*** sense of polarization.

Check 8

That claim is at least dubious. Since in 1994 Evans had declared in [2; p.69];

"We assert therefore that in classical electrodynamics there are three components $\mathbf{B}^{(1)}$, $\mathbf{B}^{(2)}$ *and* $\mathbf{B}^{(3)}$ *of a* ***travelling plane wave in vacuo****. These are interrelated in the circular basis by equation [2; (2)]. The third component, the ghost field*

$$\mathbf{B}^{(3)} = \mathbf{B}^{(1)} \times \mathbf{B}^{(2)} / (i\, B^{(0)}) = B^{(0)}\, \mathbf{k}$$

is real and independent of phase."

Equ. [2; (2)] are Evans' cyclic equations that were extended herewith by M. Evans himself to «waves in vacuo» [2, p. 69] ***without any restriction***. And lateron he did never qualify that statement. Thus: Evans' cyclic equations could be thought to be valid for the superposition of circularly polarized plane waves too. This was what I have checked in my refutation [5] − with negative result.

Now in his "REFUTATION" [6] from 2004 Evans declares as a reply on my provocing paper [5] with restrictive intention

"The B Cyclic theorem always applies to one sense of polarization."

i.e. Evans' cyclic equations do not hold for linear polarization as a superposition of right and left handed circular polarization.

Result 9
Now, in 2004, M. Evans agrees with the result of my refutation [5].

Much ado about nothing!

Conclusion

All claims in Myron W. Evans' "REFUTATION" [6] have turned out to be erroneous or dubious at least. Therefore publications of that author should be read with greatest caution and scepticism.

References

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[4] M.W. Evans e.a. : Explanation of the **M**otionless **E**lectromagnetic **G**enerator (MEG) with O(3) Electrodynamics; Foundations of Physics Letters, Vol. **14** No. 1 (2001)

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Appendix 1 Evans' Basics

Circular basis:
(A.1) $\mathbf{e}^{(1)} = (\mathbf{i} - i\,\mathbf{j})/2^{1/2}$, $\mathbf{e}^{(2)} = (\mathbf{i} + i\,\mathbf{j})/2^{1/2}$, $\mathbf{e}^{(3)} = \mathbf{k}$. (Cartesian unit vectors **i**, **j**, **k**)

Coordinate representations of all vectors **a**:

(A.2) $a_x\,\mathbf{i} + a_y\,\mathbf{j} + a_z\,\mathbf{k} = \mathbf{a} = a^{(1)}\,\mathbf{e}^{(1)} + a^{(2)}\,\mathbf{e}^{(2)} + a^{(3)}\,\mathbf{e}^{(3)}$

Transformation rule for coordinates

(A.3) $a^{(1)} = 2^{-1/2} (a_x + i\, a_y)$, $a^{(2)} = 2^{-1/2} (a_x - i\, a_y)$, $a^{(3)} = a_z$.

(A.4) $|a^{(1)}|^2 + |a^{(2)}|^2 + |a^{(3)}|^2 = a_x^{\ 2} + a_x^{\ 2} + a_x^{\ 2} = |\mathbf{a}|^2$.

Vector components of **a** relative to the circular basis

(A.5) $\mathbf{a}^{(1)} = a^{(1)}\, \mathbf{e}^{(1)}$, $\mathbf{a}^{(2)} = a^{(2)}\, \mathbf{e}^{(2)}$, $\mathbf{a}^{(3)} = a^{(3)}\, \mathbf{e}^{(3)}$.

The suffix * denotes the conjugate complex of the quantity where it is attached.

(A.6) $\mathbf{e}^{(1)*} = \mathbf{e}^{(2)}$, $\mathbf{e}^{(2)*} = \mathbf{e}^{(1)}$, $\mathbf{e}^{(3)*} = \mathbf{e}^{(3)}$

(A.7) $\mathbf{a}^{(1)*} = \mathbf{a}^{(2)}$, $\mathbf{a}^{(2)*} = \mathbf{a}^{(1)}$, $\mathbf{a}^{(3)*} = \mathbf{a}^{(3)}$

(A.8) $a^{(1)} = a^{(2)*}$, $a^{(2)} = a^{(1)*}$, $a^{(3)} = a^{(3)*}$.

(A.9) $\mathbf{e}^{(1)} \times \mathbf{e}^{(2)} = i\mathbf{e}^{(3)*}$, $\mathbf{e}^{(2)} \times \mathbf{e}^{(3)} = i\, \mathbf{e}^{(1)*}$, $\mathbf{e}^{(3)} \times \mathbf{e}^{(1)} = i\, \mathbf{e}^{(2)*}$.

Remark The rules (A.1-8) have an important consequence that was not explicitly pointed out in Evans' book [3]: The vector coordinates a_x, a_y and a_z have to be ***reals***, in other words, the vectors **a** subject to the above rules must be ***real***: Due to (A.2) and (A.7) we obtain

$$\mathbf{a}^* = \mathbf{a}^{(1)*} + \mathbf{a}^{(2)*} + \mathbf{a}^{(3)*} = \mathbf{a}^{(2)} + \mathbf{a}^{(1)} + \mathbf{a}^{(3)} = \mathbf{a}$$

which implies the reality of the coordinates a_x, a_y, a_z by using (A.2) again.

Appendix 2

REFUTATION OF THE CLAIMS OF G. BRUHN

(Copy of the handwritten original [6])

Myron W. Evans

The relevant e-mail posting by G. Bruhn is appended. Bruhn posted it without my knowledge, and apparently it was an unrefereed document. Bruhn refers to none of my recent work which is now universally acclaimed and accepted. Here I comment on Bruhn's posting section by section.

Section 1

This is merely a quote by Bruhn of some of my earliest work on $B^{(3)}$, almost a decade ago.

Section 2

The first elementary error in Bruhn's claims occurs in his equations equs. (2.3) and (2.4).
It is easy to show that Bruhn has made an elementary blunder because when we add his equations equs. (2.3) and (2.4) we obtain

$$\mathbf{B}_L^{(1)} + \mathbf{B}_R^{(1)} = B^{(0)}\, \mathbf{e}^{(1)} (e^{i\Phi} + e^{-i\Phi})$$

$$= B^{(0)}\, 2^{-1/2} (\mathbf{i} - i\, \mathbf{j}) (e^{i\Phi} + e^{-i\Phi}) \quad (1)$$

$$= B^{(0)}\, 2^{-1/2} (\mathbf{i} - i\, \mathbf{j}) \cos \Phi \quad (2)$$

However, it is well known that the sum of left and right circular polarization is linear polarization. Bruhn's equ. (2) is still *circular polarization*.

The correct way to represent left and right circular polarization is as follows:

$$\mathbf{B}_L^{(1)} = 2^{-1/2} (B_x\, \mathbf{i} - i\, B_y\, \mathbf{j})\, e^{i\Phi} \quad (3)$$

$$\mathbf{B}_R^{(1)} = 2^{-1/2} (B_x\, \mathbf{i} + i\, B_y\, \mathbf{j})\, e^{i\Phi} \quad (4)$$

Add (3) and (4) to obtain

$$\mathbf{B}_L^{(1)} + \mathbf{B}_R^{(1)} = 2^{1/2}\, B_x\, \mathbf{i}\, e^{i\Phi} \quad (5)$$

which is *linear polarization as required.*

In fact I have mentioned the chirality question in my writings many times (e.g. Adv. Chem. Phys. Vol. 85). This shows that Bruhn is almost completely ignorant of my work. The rest of Bruhn's claim is sequentially erroneous, and furthermore, contains other elementary blunders.

Section 3

In this section, Bruhn quotes my well known B Cyclic Theorem.

Section 4

From equ. (3) we see that the left c.p. wave is

$$\mathbf{B}_L^{(1)} = 2^{-1/2} (B_x \cos \Phi\, \mathbf{i} + B_y \sin \Phi\, \mathbf{j}) \quad (6)$$

From equ. (4) we see that the right c.p. wave is

$$\mathbf{B}_R^{(1)} = 2^{-1/2} (B_x \cos \Phi\, \mathbf{i} - B_y \sin \Phi\, \mathbf{j}) \quad (7)$$

Equ. (6) is Bruhn's equ. (4.2) and equ. (7) is Bruhn's equ. (4.1).

This shows that my equations (3) and (4) give Bruhn's own definitions of left and right handed c.p. in his equs. (4.1) and (4.2).

Bruhn's equs. (4.1) and (4.2) therefore contradict Bruhn's equs. equs. (2.3) and (2.4), because when we add Bruhn's equs. (4.1) and (4.2) we obtain linear polarization, but when we add equs. equs. (2.3) and (2.4) we obtain circular polarization.

These errors already make nonsense of Bruhn's unrefereed claim, but his main error is to confuse what is meant by $\mathbf{B}^{(3)}$. I have written many times that $\mathbf{B}^{(3)}$ is equal and opposite for left and right handed circular polarization, and for this reason vanishes in linear polarisation. Mathematically:

$$\mathbf{B}_R^{(3)} = -\,{}^{i}/_{B(0)}\ \mathbf{B}_R^{(1)} \times \mathbf{B}_R^{(2)} = \ldots = i^2\, B^{(0)}\, \mathbf{k} = -\,B^{(0)}\, \mathbf{k} \qquad (8)$$

$$\mathbf{B}_L^{(3)} = -\,{}^{i}/_{B(0)}\ \mathbf{B}_L^{(1)} \times \mathbf{B}_L^{(2)} = \ldots = -\,i^2\, B^{(0)}\, \mathbf{k} = B^{(0)}\, \mathbf{k} \qquad (9)$$

Thus:

$$\mathbf{B}_R^{(3)} = -\,\mathbf{B}_L^{(3)} \qquad (10)$$

The glaring error in Bruhn's claims occurs in his equ. (4.5), were he asserts, that for linear polarization:

$$\mathbf{B}^{(3)} = ?\ \pm\, 2^{1/2}\, B^{(0)}\, \mathbf{k} \qquad (11)$$

The reason for the erroneous equ. (11) appears to be confusion about what is meant by $\mathbf{B}^{(3)}$. The latter is well-defined in my work as existing for one photon. One photon is either left handed, in which case we obtain equ. (9) or right handed, in which case we obtain equ. (8). If we superimpose one left handed photon with one right handed photon we obtain

$$\mathbf{B}^{(3)} = \mathbf{B}_R^{(3)} + \mathbf{B}_L^{(3)} = \mathbf{0}.$$

The B Cyclic theorem always applies to ***one*** sense of polarization.

Therefore the claim by Bruhn is false, and unreasonable, i.e. it is made in ignorance of the literature.

Appendix 3

Some remarks on

J. D. Jackson's Chapter 7 from [9] on polarized plane waves

Firstly a quote from an Evans' email:
«I have briefly glanced at your "second refutation". It is nonsense. For example you claim that my definition of circular polarization leds to a contradiction. However, ***my definition of circular polarization is the same as that in a standard text such as J. D. Jackson, "Classical Electrodynamics" (Wiley third edition, 1999, page 299, eq. (7.20))****. Jackson is no supporter of AIAS but is a good scholar. For your further information the right and left circularly polarized waves are defined in detail by Jackson on page 300 ff. ...»*
At the end of this appendix we shall compare both Evans' and Jackson's definitions.

Real basis

. . . the most general homogeneous plane wave . . .

$$\mathbf{E}(\mathbf{x},t) = (\mathbf{e}_1 E_1 + \mathbf{e}_2 E_2)\, e^{-i\Phi} \qquad \text{where} \qquad \Phi = \omega t - \mathbf{k}\cdot\mathbf{x} \qquad (7.19)$$

with the Cartesian basis vectors $\mathbf{e}_1, \mathbf{e}_2, \mathbf{k}$, c.f. Fig. 7.1, p.297 (identical with the usual Cartesian basis denoted by **i**, **j**, **k**).

We should realize that (7.19) is *not the original wave vector* which is real: The imaginary part was supplemented in order to get arithmetical advantages and has no physical meaning.

Complex Wave representation

If E_1 and E_2 have the *same phase* (7.19) represents a *linearly polarized* wave. . . .

. . . *circular polarization*. Then E_1 and E_2 have the same magnitude, but differ in phase by 90°.

$$\mathbf{E}(\mathbf{x},t) = E_0 (\mathbf{e}_1 \pm i\, \mathbf{e}_2)\, e^{-i\Phi} \qquad \text{where} \qquad \Phi = \omega t - \mathbf{k}\cdot\mathbf{x} \qquad (7.20)$$

. . . while $\mathbf{e}_1$ and $\mathbf{e}_2$ are in the x and y directions, respectively. Then the components of the actual electric field, obtained by taking the ***real part*** of (7.20), are

$$E_x = E_0 \cos\Phi$$
$$E_y = \pm E_0 \sin\Phi \qquad (7.21)$$

... For the upper sign $(\mathbf{e}_1 + i\, \mathbf{e}_2)$ the rotation is counterclockweise when the observer is facing into the oncomming wave. This wave is called *left circularly polarized* in optics. ...
For the lower sign $(\mathbf{e}_1 - i\, \mathbf{e}_2)$ the rotation of **E** is clockwise when looking into the wave is *right circularly polarized* (optics) ...

. . . We introduce the complex orthogonal unit vectors:

$$\mathbf{e}_\pm = 2^{-1/2} (\mathbf{e}_1 \pm i\, \mathbf{e}_2) \qquad (7.22)$$

. . . Then a general representation, equivalent to (7.19), is

$$\mathbf{E} = (E_+ \mathbf{e}_+ + E_- \mathbf{e}_-)\, e^{-i\Phi} \qquad (7.24)$$

where E_+ and E_- are complex amplitudes.

Examples

For the pupose of comparison with Evans' formulas we replace Jackson's notation with that one of Evans:

$$\mathbf{e}_1 \to \mathbf{i}, \qquad \mathbf{e}_2 \to \mathbf{j}, \qquad \mathbf{e}_- \to \mathbf{e}^{(1)}, \qquad \mathbf{e}_+ \to \mathbf{e}^{(2)}, \qquad \mathbf{E} \to \mathbf{B}, \ldots$$

A linearly polarized wave is given if the quotient B_+/B_- is real, in which case, by changing the coordinate system, we can attain the standard form

$$\mathbf{B}_{lin} = B_0\, \mathbf{i}\, e^{-i\Phi}$$

with some real constant B_0. Circularly polarized waves can be described by means of the complex basis vectors $\mathbf{e}^{(1)}$ and $\mathbf{e}^{(2)}$:

$$\mathbf{B}_L^{(1)} = B_0\, \mathbf{e}^{(1)}\, e^{-i\Phi}$$

is Jackson's standard form of a left circularly polarized wave, strictly speaking, its $\mathbf{e}^{(1)}$-component, while

$$\mathbf{B}_R^{(2)} = B_0\, \mathbf{e}^{(2)}\, e^{-i\Phi}$$

is Jackson's standard form of a right circularly polarized wave, more exactly, its $\mathbf{e}^{(2)}$-component. The $\mathbf{e}^{(1)}$-component of $\mathbf{B}_R$ can be obtained by taking the conjugate complex expression, i.e.

$$\mathbf{B}_R^{(1)} = B_0\, \mathbf{e}^{(1)}\, e^{i\Phi}\,.$$

For a comparison we have to take into account that *the last representations are not the original real wave vectors* but are the result of complex supplementation. However, it is easy to reconstruct the original physical wave vectors: We merely have to take the corresponding real parts. By doing so we obtain

$\mathbf{B}_{lin}^{phys} = B_0\, \mathbf{i} \cos\Phi$ for linear polarization,

$\mathbf{B}_L^{phys} = \mathrm{Re}\,\{B_0\, \mathbf{e}^{(1)}\, e^{-i\Phi}\} = B_0\, (\mathbf{i}\cos\Phi - \mathbf{j}\sin\Phi)/2^{1/2}$ for left circular polarization

and

$\mathbf{B}_R^{phys} = \mathrm{Re}\,\{B_0\, \mathbf{e}^{(2)}\, e^{i\Phi}\} = B_0\, (\mathbf{i}\cos\Phi + \mathbf{j}\sin\Phi)/2^{1/2}$ for right circular polarization.

We have to compare Jackson's standard forms of polarized waves with that ones given by Evans in his "REFUTATION" equs. (3-5):

Evans	Jackson
$\mathbf{B}_L^{(1)} = 2^{-1/2}\,(B_x\,\mathbf{i} - i\,B_y\,\mathbf{j})\,e^{i\Phi}$,	$\mathbf{B}_L^{(1)} = B_0\,\mathbf{e}^{(1)}\,e^{-i\Phi}$
$\mathbf{B}_R^{(1)} = 2^{-1/2}\,(B_x\,\mathbf{i} + i\,B_y\,\mathbf{j})\,e^{i\Phi}$,	$\mathbf{B}_R^{(1)} = B_0\,\mathbf{e}^{(1)}\,e^{i\Phi}$.

Let's quote Evans again: «***. . . my definition of circular polarization is the same as that in a standard text such as J. D. Jackson, "Classical Electrodynamics" (Wiley third edition, 1999, page 299, eq. (7.20))***.»

No, Dr. Evans, not at all. There is a considerable disagreement between Evans' and Jackson's formulas. Possibly, Evans' formulas are erroneous due to rather simple errors. However, Evans intended to give a refutation of my calculations. For that purpose Evans should have proceeded much more carefully.

Additionally I can state that my formulas (2.3) and (2.4) for circular polarization completely agree with the Jackson's formulas above.

Appendix 4

Some questions that M.W. Evans refused to reply to

Instead of replying to the questions Evans broke off the discussion:
Quotation from Evans' email: «*The simple questions you are asking are irrelevant to the definition of the conjugate product that I and many others habitually use and irrelevant to physics. So I intend not to answer them because you are confused, and your questions will cause further confusion. What you are doing has been attempted many times before, to disingenuously set up a false paradigm , or to set up a straw man to knock over. I conclude that you know nothing about the inverse Faraday effect and nothing about electrodynamics.*»

1.1) Do you admit, that the *physical* vectors $\mathbf{B}_{lin}$ for linear polarization, $\mathbf{B}_L$ for left-handed and $\mathbf{B}_R$ for right-handed polarization are *real* vectors?

$\mathbf{B}_L = B_0\,(\mathbf{i}\cos\Phi - \mathbf{j}\sin\Phi)$

$\mathbf{B}_R = B_0\,(\mathbf{i}\cos\Phi + \mathbf{j}\sin\Phi) \qquad (\Phi = \omega t - \mathbf{k}\cdot\mathbf{x})$

$\mathbf{B}_{lin} = 2\,B_0\,\mathbf{i}\cos\Phi$

(Y / N)

1.2) Due to Jackson's equs. (7.19) and (7.20)
(J.D. Jackson: Classical Electrodynamics 3.Ed. 1999)
(with exchange of characters $\mathbf{E} \to \mathbf{B}$ and $\mathbf{e}_1, \mathbf{e}_2 \to \mathbf{i}, \mathbf{j}$), e.g.

$$\mathbf{B}(\mathbf{x},t) = B_0\,(\mathbf{i} \pm i\,\mathbf{j})\,e^{-i\Phi} \qquad (\Phi = \omega t - \mathbf{k}\cdot\mathbf{x}) \qquad (7.20)$$

the Jackson-vectors have *nonvanishing* imaginary parts, i.e.
Jacksons' equs. do ***not agree*** with the above *real physical* representation formulas in 1.1.

(Y / N)

1.3) Can you explain the physical meaning and origin of these imaginary parts?

(Y / N)

If Y, please, give an explanation.

2) Why just these imaginary parts? I know other ones that would fit.

3.1) Do you know that all physical vectors **a** that fulfil your basic rules in Vol. 5 of your photon-books must be real? $\mathbf{a} = \mathbf{a}^*$

(Y / N)

3.2) Which of the vectors **B** defined in 1.1 or 1.2 could fulfil the Evans basic rules?

(1.1 / 1.2 / both)

4) Consider three important polarized waves using the *real* representations of the wave vector **B** according to Jackson (7.21):

Left circular: (L) $B_x = B_0 \cos\Phi, \qquad B_y = -B_x = -B_0 \sin\Phi$

Right circular: (R) $B_x = B_0 \cos\Phi, \qquad B_y = +B_x = +B_0 \sin\Phi$

Linear in x-dir.: (lin) $B_x = 2\,B_0 \cos\Phi, \qquad B_y = 0$

Addition yields (L) + (R) = (lin).

Now insert that into Evans' equs. [Enigm.Photon Vol 5; ((1.1.6)] (cf. Evans basic rule A.3) for circular vector coordinates which are

$B^{(1)} = (B_x - i\, B_y)/\mathrm{sqr}(2)$, $B^{(2)} = (B_x + i\, B_y)/\mathrm{sqr}(2)$

to obtain

(L) $B^{(1)} = B_0\, e^{-i\Phi}/\mathrm{sqr}(2)$, $B^{(2)} = B_0\, e^{+i\Phi}/\mathrm{sqr}(2)$,

(R) $B^{(1)} = B_0\, e^{+i\Phi}/\mathrm{sqr}(2)$, $B^{(2)} = B_0\, e^{-i\Phi}/\mathrm{sqr}(2)$,

(lin) $B^{(1)} = B^{(2)} = \mathrm{sqr}(2)\, B_0 \cos\Phi$.

That result contradicts Evans' formulas in his "REFUTATION" equs. (3-5) who claims

(L) $\mathbf{B}^{(1)} = (B_x\, \mathbf{i} - i\, B_y\, \mathbf{j})\, e^{i\Phi}/\mathrm{sqr}(2)$,

(R) $\mathbf{B}^{(1)} = (B_x\, \mathbf{i} + i\, B_y \mathbf{j})\, e^{i\Phi}/\mathrm{sqr}(2)$,

(lin) $\mathbf{B}^{(1)} = \mathrm{sqr}(2)\, B_x\, \mathbf{i}\, e^{i\Phi}$.

One should have [Enigm.Photon Vol 5; (1.1.5)] (cf. A.5)

$\mathbf{B}^{(1)} = B^{(1)}\, \mathbf{e}^{(1)}$

e.g. in the case (lin) we obtain the *different* results for $\mathbf{B}^{(1)}$:

$\mathrm{sqr}(2)\, \mathbf{e}^{(1)}\, B_0 \cos\Phi$

and

$\mathrm{sqr}(2)\, B_x\, \mathbf{i}\, e^{i\Phi} = \mathrm{sqr}(2)\, \mathbf{i}\, B_0\, e^{i\Phi} \cos\Phi$

respectively.

Thus, there is a contradiction *within* Evans' original formulas. Should there exist "ghosts" that have been produced by using the "Jackson-method" of complex supplementation? (Y / N)

If N: *Where* is the error? (???)