

Check a Consistency of Antisymmetric Tensor used in ECE

As in Appendix B of volume 1:

$$\epsilon^{1230} = -\epsilon^{1203} = \epsilon^{1023} = -\epsilon^{0123} = -1. \quad (1)$$

This is the same as F lower's:

$$\epsilon^{0123} = \epsilon^{0312} = \epsilon^{0231} = 1; \quad \epsilon^{1302} = \epsilon^{1023} = \epsilon^{1230} = -1. \quad (2)$$

The dual in Appendix B is defined by:

$$\int_{\mu} F^{\mu\nu} = \mu_{0c} J^{\nu} \quad (3)$$

$$\tilde{F}^{\mu\nu} = \frac{1}{2} \epsilon^{\mu\nu\rho\sigma} F_{\rho\sigma} \quad (4)$$

The only difference between eqs (3) and (4) and ECE is that a label is added in ECE theory:

$$\int_{\mu} F^{\mu\nu a} = \mu_{0c} J^{\nu a} \quad (5)$$

$$\tilde{F}^{\mu\nu a} = \frac{1}{2} \epsilon^{\mu\nu\rho\sigma} F_{\rho\sigma}^a \quad (6)$$

Eq (1) is a result of defining:

$$\epsilon^{0123} = 1 \quad (7)$$

$$\epsilon^{0132} = -1 \quad (8)$$

$$\epsilon^{0312} = 1 \quad (9)$$

$$\epsilon^{1023} = -1 \quad (10)$$

$$\epsilon^{1203} = 1 \quad (11)$$

$$\epsilon^{1230} = -1 \quad (12)$$

2) The sequence given by Flower is:

$$\left. \begin{aligned} \epsilon^{0123} &= \epsilon^{0312} = \epsilon^{0231} = 1; \\ \epsilon^{1203} &= \epsilon^{1320} = \epsilon^{1032} = 1; \\ \epsilon^{2301} &= \epsilon^{2013} = \epsilon^{2130} = 1; \\ \epsilon^{3102} &= \epsilon^{3210} = \epsilon^{3021} = 1; \end{aligned} \right\} \text{--- (13)}$$

$$\left. \begin{aligned} \epsilon^{0321} &= \epsilon^{0213} = \epsilon^{0132} = -1; \\ \epsilon^{1302} &= \epsilon^{1023} = \epsilon^{1230} = -1; \\ \epsilon^{2103} &= \epsilon^{2310} = \epsilon^{2031} = -1; \\ \epsilon^{3201} &= \epsilon^{3012} = \epsilon^{3120} = -1. \end{aligned} \right\} \text{--- (14)}$$

It can be seen that Flower's eqns. (13) and (14) give the same results as Evans' equations (2) and (7) - (10).

Conclusion

Flower has deliberately emailed disinformation concerning ECE theory. The correct ECE theory is always used throughout ECE theory.

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$\epsilon(i, j, k)$ verified by MathCad built-in function $\epsilonps(i, j, k)$

index-base=0

		k = 0			k = 1			k = 2		
		i =			i =			i =		
		0	1	2	0	1	2	0	1	2
i =	0	0	0	0	0	0	+1	0	0	0
	1	0	0	0	0	0	0	+1	0	0
	2	0	+1	0	0	0	0	0	0	0

$\epsilon(012) = \epsilon(120) = \epsilon(201) = +1$
 $\epsilon(021) = \epsilon(102) = \epsilon(210) = -1$

index-base=1

		k = 1			k = 2			k = 3		
		i =			i =			i =		
		1	2	3	1	2	3	1	2	3
i =	1	0	0	0	0	0	+1	0	0	0
	2	0	0	0	0	0	0	+1	0	0
	3	0	+1	0	-1	0	0	0	0	0

$\epsilon(123) = \epsilon(231) = \epsilon(312) = +1$
 $\epsilon(132) = \epsilon(213) = \epsilon(321) = -1$

$\epsilon(i, j, k, l)$ verified by:

- Carroll's Lecture Notes (Eq. 2.38)
- MTW's "Gravitation" text (Eq. 8.10b),
- Shiffman's function $\epsilonps4(i,j,k,l)$ in 4tensor.mcd and Heidenreich's 1A_R3_R4.mcd

contains missing elements, MWG

index-base=0

		k = 0				k = 1				k = 2				k = 3			
		i =				i =				i =				i =			
		0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
i = 0	j = 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	j = 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+1	0
	j = 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	j = 3	0	0	0	0	0	0	0	+1	0	0	0	0	0	0	0	0
i = 1	j = 0	0	0	0	0	0	0	0	0	0	0	0	+1	0	0	-1	0
	j = 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	j = 2	0	0	0	0	0	0	0	0	0	0	0	0	+1	0	0	0
	j = 3	0	0	0	+1	0	0	0	0	-1	0	0	0	0	0	0	0
i = 2	j = 0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	j = 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	j = 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	j = 3	0	0	0	+1	0	0	0	0	+1	0	0	0	0	0	0	0
i = 3	j = 0	0	0	0	0	0	0	+1	0	0	0	0	0	0	0	0	0
	j = 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	j = 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	j = 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

$\epsilon(0123) = \epsilon(0312) = \epsilon(0231) = +1$	$\epsilon(0321) = \epsilon(0213) = \epsilon(0132) = -1$
$\epsilon(1203) = \epsilon(1320) = \epsilon(1032) = +1$	$\epsilon(1302) = \epsilon(1023) = \epsilon(1230) = -1$
$\epsilon(2301) = \epsilon(2013) = \epsilon(2130) = +1$	$\epsilon(2103) = \epsilon(2310) = \epsilon(2031) = -1$
$\epsilon(3102) = \epsilon(3210) = \epsilon(3021) = +1$	$\epsilon(3201) = \epsilon(3012) = \epsilon(3120) = -1$