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Spin radiation from a rotating dipole

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ABSTRACT

When the canonical spin tensor is used, a spin is detected along the axis of rotation of a rotating electric dipole. Early this spin radiation was obtained by Feynman in the frame of quantum mechanics. The magnitude of the spin flux is half the flux of the angular momentum that is emitted by a rotating dipole, according to modern electrodynamics, and this angular momentum flux is recognized here as an orbital angular momentum. Thus, the total angular momentum flux exceeds 1.5 times the value now recognized. It is shown that the torque experienced by a rotating dipole from the field is equal in magnitude to this total angular momentum flux.

1. Introduction. Radiation of energy and angular momentum by a rotating dipole, according to classical electrodynamics

As is known, a rotating electric dipole or two dipole oscillators perpendicular to each other,

$$p^x = p\exp(-i\omega t), \quad p^y = ip\exp(-i\omega t) \tag{1.1}$$

radiate electromagnetic waves. The power and the angular distribution of this power (Fig. 1) are, respectively, [[1] § 67, Problem 1; 2]

$$P = \omega^4 p^2/6\pi\varepsilon_0 c^3,\ dP/d\Omega = \omega^4 p^2(\cos^2\theta + 1)/32\pi^2\varepsilon_0 c^3, \tag{1.2}$$

where $d\Omega = \sin\theta d\theta d\phi$ (We use the system of units where div$\mathbf{E} = \rho/\varepsilon_0$). The polarization of the radiation is circular along the axis of rotation and is linear in the plane of rotation (Fig. 3).

The radiation contains angular momentum L_z, which is the moment of linear momentum. This angular momentum flux, i.e. torque, is [[1] § 72, § 75]

$$dL_z/dt = \tau_z = \omega^3 p^2/6\pi\varepsilon_0 c^3 \tag{1.3}$$

But this flux is located in the neighborhood of the plane of rotation where the polarization is near linear. The angular distribution of the angular momentum flux, according to [3–8], see Fig. 2, is

$$dL_z/dtd\Omega = \omega^3 p^2 \sin^2\theta/16\pi^2\varepsilon_0 c^3 \tag{1.4}$$

As was noted [9], "The angular momentum (1.3) is not contained in the pure wave zone, where the field strenghts are perpendicular to $\mathbf{r}$ and behave like $1/r$. In this zone, indeed, L_z vanishes: L_z is proportional to E^r and $E^r \sim 1/r^2$" . So, we must recognize that this flux is not a radiation; this is an orbital angular momentum flux.

The presence of an angular momentum in the field of a rotating dipole is naturally. This field is a multipole field of order $(l = 1,\ m = 1)$. And equalities (1.2) and (1.3) are in the agreement with formula [9, 10 (9.144)]

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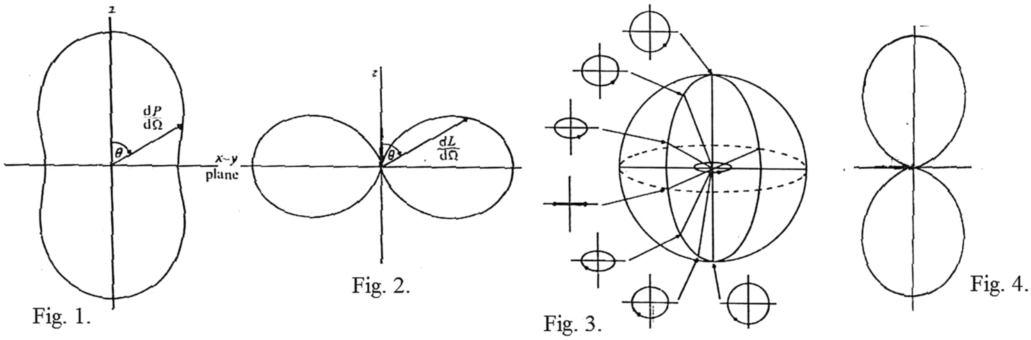


Figs. 1-4. Angular distribution of the energy flux $dP/d\Omega \propto (\cos^2\theta + 1)$. (2) Angular distribution of z-component of the moment of momentum flux $dL_z/dtd\Omega \propto \sin^2\theta$. (3) Polarization of the electric field seen by looking from different direction at a circular oscillator. (4) Angular distribution of z-component of the spin flux $dS_z/dtd\Omega \propto \cos^2\theta$.

$$dL_z/dt = mP/\omega \tag{1.5}$$

Eq. (1.5) is an additional proof that the moment of linear momentum L_z is not a spin. According to (1.5), each photon has an angular momentum $L_z = m\hbar$, not $\hbar$.

2. Spin radiation by a rotating dipole in the frame of the electrodynamics

At the same time, the modern electrodynamics does not notice an angular momentum flux in the direction of the axis of rotation, where the radiation is intense and the polarization is circular, although it was suggested as early as 1899 by Sadowsky [11] and as 1909 by Poynting [12] that circularly polarized light carries angular momentum volume *density,* and the angular momentum density is proportional to the energy volume density.

J.H. Poynting: If we put E for the energy in unit volume and G for the torque per unit area, we have $G = E\lambda/2\pi$ [[12], p. 565].

This sentence points that any absorption of a circularly polarized light results in a mechanical torque volume density acting on the absorber (see also [13]).

The classical experiments [14–17] confirm that the angular momentum density is proportional to energy density. In these experiments, the angular momentum of the light was transferred to a half-wave plate, which rotated. So, work was performed *in any point of the plate*. This (positive or negative) amount of work reappeared as an alteration in the frequency of the light, which resulted in moving fringes *in any point* of the interference pattern in a suitable interference experiment.

Now, according to the Lagrange formalism, this angular momentum is recognised as *spin* and is described by the canonical spin tensor [18–20]

$$\Upsilon^{\lambda\mu\nu} = -2A^{[\lambda}F^{\mu]\nu},\ \Upsilon^{xyt} = -2A^{[x}F^{y]t} = \varepsilon_0\mathbf{E}\times\mathbf{A}, \tag{2.1}$$

where A^λ is the magnetic vector potential and $F^{\mu\nu}$ is the electromagnetic field tensor. The expression $\varepsilon_0\mathbf{E}\times\mathbf{A}$ is also presented in [21,10].

The sense of the spin tensor $\Upsilon^{\lambda\mu\nu}$ is given by the equalities:

$$d^3S^{ij} = \Upsilon^{ijk}da_k dt,\ d^3S^{ij} = \Upsilon^{ijt}dV; \tag{2.2}$$

where d^3S^{ij} is the spin passing through a surface element da_k, or the spin which is contained in a volume element dV. This spin tensor was successfully used to describe the spin of plane waves [22–24].

And, since a rotating dipole radiates circularly polarized waves along its axis of rotation, it must radiate spin along this direction. A calculation of this spin radiation is presented here.

The spin volume density $\varepsilon_0\mathbf{E}\times\mathbf{A}$ is integrated over a thin spherical layer (of thickness dr), which surrounds the source of the radiation, and then the integral is divided by dt on the assumption $dr/dt = c$. So, the formula for the spin flux is

$$dS^{xy}/dt = \int \Upsilon^{xyt}r^2 d\Omega dr/dt, \tag{2.3}$$

The expression for *radiated* electric field [25,2] is used

$$\mathbf{E} = \frac{\omega^2(\mathbf{p}r^2 - (\mathbf{pr})\mathbf{r})}{4\pi\varepsilon_0 c^2 r^3}\exp(ikr - i\omega t) \tag{2.4}$$

$$E_x = \frac{\omega^2 p(r^2 - x^2 - ixy)}{4\pi\varepsilon_0 c^2 r^3}\exp(ikz - i\omega t),\quad E_y = \frac{\omega^2 p(ir^2 - xy - iy^2)}{4\pi\varepsilon_0 c^2 r^3}\exp(ikr - i\omega t) \tag{2.5}$$

$$\mathbf{A} = -\int \mathbf{E}dt = -i\mathbf{E}/\omega \tag{2.6}$$

Inserting (1.1), (2.1), (2.5), (2.6) into (2.3) yields the time averaged spin flux:

$$dS^{xy}/dt = \Re\int \varepsilon_0(E_x\bar{A}_y - E_y\bar{A}_x)cr^2d\Omega/2 = \Re\int i\varepsilon_0(E_x\bar{E}_y - E_y\bar{E}_x)cr^2d\Omega/2\omega \quad (2.7)$$

Here

$$\begin{aligned}&(E_x\bar{E}_y - E_y\bar{E}_x)\\&= \tfrac{\omega^4p^2}{16\pi^2\varepsilon_0^2c^4r^6}[(r^2 - x^2 - iyx)(-ir^2 - xy + iy^2) - (ir^2 - xy - iy^2)(r^2 - x^2 + iyx)]\\&= \tfrac{-i\omega^4p^2z^2}{8\pi^2\varepsilon_0^2c^4r^4} = \tfrac{-i\omega^4p^2}{8\pi^2\varepsilon_0^2c^4r^2}\cos^2\theta.\end{aligned} \quad (2.8)$$

Inserting (2.8) into (2.7) yields

$$dS^{xy}/dt = \int\frac{\omega^3p^2}{16\pi^2\varepsilon_0c^3}\cos^2\theta d\Omega. \quad (2.9)$$

So, the angular distribution of the spin flux (see Fig. 4) is

$$dS_z/dtd\Omega = \omega^3p^2\cos^2\theta/16\pi^2\varepsilon_0c^3. \quad (2.10)$$

Integration of equality (2.9) gives the spin flux

$$dS_z/dt = \omega^3p^2/12\pi\varepsilon_0c^3. \quad (2.11)$$

The results (2.10), (2.11) were presented in the works [6–8].

Thus the total angular momentum flux, orbital + spin, (1.3) + (2.11), is

$$dJ_z/dt = dL_z/dt + dS_z/dt = \omega^3p^2/6\pi\varepsilon_0c^3 + \omega^3p^2/12\pi\varepsilon_0c^3 = \omega^3p^2/4\pi\varepsilon_0c^3. \quad (2.12)$$

Note that for $\theta = 0$, i.e. where there is no orbital angular momentum (1.3), according to (1.2) and (2.10), the photon relation is valid:

$$(\text{energy}) = \omega(\text{spin}),\ dPdt = \omega dS_z = \omega^4p^2/16\pi^2\varepsilon_0c^3d\Omega dt. \quad (2.13)$$

3. Spin radiation by a rotating dipole in the frame of the quantum mechanics

It is remarkable that the result (2.10), $dS_z/dtd\Omega \propto \cos^2\theta$, for the angular distribution of z-component of the spin flux was obtained by Feynman [26] beyond the standard electrodynamics. Really, the amplitudes that a RHC photon and a LHC photon are emitted in the direction θ into a certain small solid angle $d\Omega$ are [26, (18.1), (18.2)]

$$a(1 + \cos\theta)/2 \text{ and } -a(1 - \cos\theta)/2. \quad (3.1)$$

So, in the direction θ, the spin flux density is proportional to

$$[a(1 + \cos\theta)/2]^2 - [a(1 - \cos\theta)/2]^2 = a^2\cos\theta. \quad (3.2)$$

The projection of the spin flux density on z -axis is

$$dS_z/dtd\Omega \propto a^2\cos^2\theta. \quad (3.3)$$

Note that the Feynman's method gives the power distribution (1.2) as well:

$$dP/d\Omega \propto [a(1 + \cos\theta)/2]^2 + [a(1 - \cos\theta)/2]^2 = a^2(1 + \cos^2\theta)/2. \quad (3.4)$$

4. Reaction to the dipole emitting the angular momentum flux

When emitting the angular momentum flux (2.12), the rotating dipole must experience the torque of the opposite direction. Here is the calculation of this torque, which is experienced by the dipoles (1.1).

$$p^x = p\exp(-i\omega t), \quad p^y = ip\exp(-i\omega t),$$

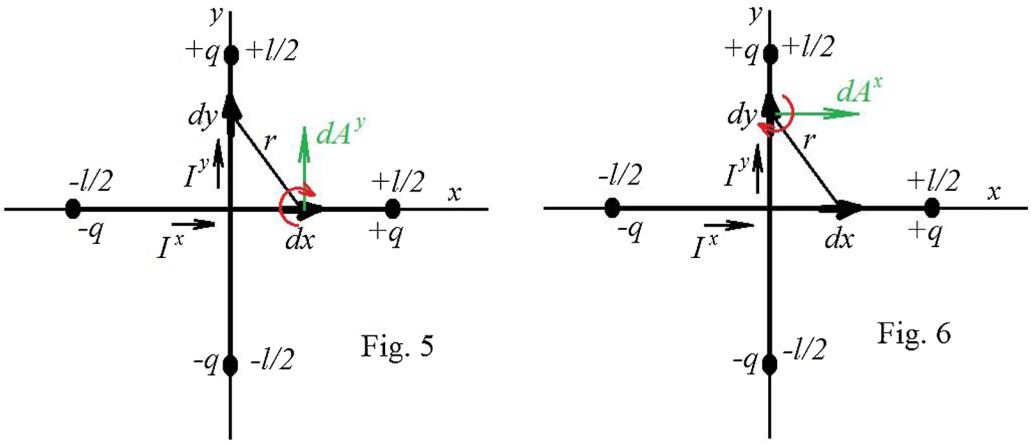
For this calculation, we use the result obtained by considering the absorption of a circularly polarized wave [13,24,27,28]. The mechanical stresses indicated in [13] arise from the action of the volume torque density $\tau_\wedge$ on the absorber. If the absorber is an electrically conductive medium, then the torque density is given by a formula similar to the formula for the density of the Lorentz force $f_\wedge = \mathbf{j}\times\mathbf{B}$:

$$\tau_\wedge = \mathbf{j}\times\mathbf{A}, \quad (4.1)$$

where $\mathbf{j}$ and $\mathbf{A}$ are the electric current density and the magnetic vector potential, respectively, and $\wedge$ means "density". This formula is used in this article in the form

$$d\tau = Id\mathbf{l}\times\mathbf{A} \quad (4.2)$$

to calculate the action on the dipoles (1.1). Here $d\tau$ is the torque acting on an element $d\mathbf{l}$ of wire that carries the current I.



Figs. 5 and 6. (5) Retarded vector potential dA^y of y-dipole acts on dx-element of x-dipole by the torque. (6) Retarded vector potential dA^x of x-dipole acts on dy-element of y-dipole by the torque.

The dipoles considered here are "elementary vibrators" in the sense that the current is the same at all points of the dipole, and the charges are only at the ends. The current of the dipoles is obtained by differentiating the relation $p = ql$. From (1.1), it turns out

$$I^x = \partial_t p^x/l = -ip\omega\exp(-i\omega t)/l, \quad I^y = \partial_t p^y/l = p\omega\exp(-i\omega t)/l. \tag{4.3}$$

To calculate the action on x -dipole (it is located in the Fig. 5 horizontally), an element dy of y -dipole is considered. The current I^y of the element dy creates a retarded vector potential dA^y [1 (66.2)] near element dx of x -dipole:

$$dA^y = I^y dy\exp(i\omega r)/4\pi r = p\omega dy\exp[i\omega(r-t)]/4\pi rl. \tag{4.4}$$

According to formula (4.2), the torque acting on element dx of x -dipole is equal to

$$d^2\tau^{xy} = \Re\{(I^x)^* dx dA^y\}\frac{1}{2} = \Re\{i\exp(i\omega t)\exp[i\omega(r-t)]\}\frac{p^2\omega^2 dxdy}{8\pi rl^2} = -\sin\omega r\frac{p^2\omega^2 dxdy}{8\pi rl^2}, \tag{4.5}$$

where * means complex conjugation. For a small dipole, we replace $\sin\omega r \to \omega r$, reduce by r (!), integrate over x, y within $-l/2$, $l/2$, and get

$$\text{for } x\text{-dipole: } \tau^{xy} = -p^2\omega^3/8\pi. \tag{4.6}$$

The same torque is experienced by y -dipole (Fig. 6). Really

$$dA^x = I^x dx\exp(i\omega r)/4\pi r = -ip\omega dx\exp[i\omega(r-t)]/4\pi rl. \tag{4.7}$$

$$d^2\tau^{xy} = -\Re\{(I^y)^* dy dA^x\}\frac{1}{2} = \Re\{\exp(i\omega t)i\exp[i\omega(r-t)]\}\frac{p^2\omega^2 dxdy}{8\pi rl^2} = -\sin\omega r\frac{p^2\omega^2 dxdy}{8\pi rl^2}, \tag{4.8}$$

$$\text{for } y\text{-dipole: } \tau^{xy} = -p^2\omega^3/8\pi. \tag{4.9}$$

Adding the results (4.6) and (4.9), we obtain

$$\text{for a roating dipole } \tau^{xy} = -p^2\omega^3/4\pi. \tag{4.10}$$

This coincides in magnitude with the total angular momentum flux, orbital + spin, emitting from the rotating dipole (2.12).

The Coulomb interaction between the charges of dipoles due to the electric field, as well as the action of the Lorentz force on the dipoles due to the magnetic field, can not produce a nonzero result because these fields, unlike that the field **A**, increase as $1/r^2$ with decreasing the size of the dipoles, and this action would tend to infinity.

5. Conclusion

The previously unknown spin radiation by a rotating dipole is presented, and it is shown that, according to the standard paradigm, a rotating dipole radiates orbital angular momentum only. The successful use of the canonical spin tensor confirms that a classical spin tensor truly represents spin of electromagnetic waves, what was previously stated [13,24,29]. The radiation reaction acting on the rotating dipole is calculated

I am eternally grateful to Professor Robert Romer for the courageous publication of my question: "Does a plane wave really not carry spin?" (was submitted on 07 October 1999) [30].

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Rejections

15 items

Journal of Electromagnetic Waves and Applications

18-Nov-2018 ID TEWA-2018-0596
Dear Professor Khrapko,
Thank you for submitting your manuscript ‘Spin radiation from a rotating dipole’
I have considered your paper, but I regret to inform you that I feel it unsuitable for publication in Journal of Electromagnetic Waves and Applications.
Professor Mohamad Abou El-Nasr Editor in Chief;

Optics Communications

13.10.2018 MB-2942 Spin radiation from a rotating dipole
Dear Professor Khrapko,
Thank you for submitting your work to Optics Communications, but your article is not sufficiently close to the main focus of Optics Communications to warrant reviewing or publication. I recommend that you send to a more appropriate journal. The main remit of the journal is to report advances in modern optical science research. By publishing it in an appropriate journal targeting the right audience, the work will get more attention.
Editor-in-Chief: B.J. Eggleton

Journal of the Optical Society of America A

24.09.2018 **JOSA A submission (346620)** Title: Spin radiation from a rotating dipole
Author: Radi Khrapko;
Your recent submission to the Journal of the Optical Society of America A has not been received successfully. I regret to inform you that The Optical Society is unable to consider your recent submission to JOSA A for publication.
Editor-in-Chief P. Scott Carney

Journal of Optics

21 Sept. 2018 JOPT-105742 Re: "Spin radiation from a rotating dipole"
Dear Professor Khrapko,
Thank you for your submission to Journal of Optics. We have assessed your manuscript and have considered its suitability for the journal very carefully. We regret to inform you that your article will not be considered for review as it does not meet our strict publication criteria.
The quality and presentation of any research published in Journal of Optics must be of the highest standard. Submissions should clearly demonstrate scientific rigour, extensive literature research and a careful assessment of the validity of any conclusions presented in the manuscript. Your manuscript does not meet these key publication criteria and we are unable to consider it further.
We are grateful for your interest in Journal of Optics.
Editor-in-Chief: L. N. Hazra

JETP ЖЭТФ

14.09.2018 Глубокоуважаемый Радий Игоревич!
Бюро редколлегии ЖЭТФ рассмотрело Вашу статью «Unexpected radiation from a rotating dipole». Хотя в ЖЭТФ публикуются статьи по всем разделам физики, но при отборе статей, принимаемых для опубликования, редакция вынуждена проводить где-то границу между статьями, имеющими **более общий интерес**, и статьями более специального характера, которые целесообразно направлять в соответствующие специализированные журналы.
Ваша данная статья относится, по мнению редакции, к последней категории.
С уважением, Редакция ЖЭТФ. Главный редактор: акад. А. Ф. АНДРЕЕВ

Europhysics Letters

13 Sept 2018 EPL G40526 Title: Spin radiation from a rotating dipole
Dear Professor Khrapko***,
Thank you for having submitted the above manuscript for publication in EPL.
Unfortunately we cannot accept your submission in regard to your past behaviour.
Best regards, The EPL Editorial Office

Journal of Physics B: Atomic, Molecular and Optical Physics

11 Sept. 2018 JPHYSB-104832 Re: "Spin radiation from a rotating dipole"
Dear Professor Khrapko,
Thank you for your submission to Journal of Physics B: Atomic, Molecular and Optical Physics.
We have assessed your manuscript and have considered its suitability for the journal very carefully. We regret to inform you that your article will not be considered for review as it does not meet our strict publication criteria.
The quality and presentation of any research published in Journal of Physics B: Atomic, Molecular and Optical Physics must be of the highest standard. Submissions should clearly demonstrate scientific rigour, extensive literature research and a careful assessment of the validity of any conclusions presented in the manuscript. Your manuscript does not meet these key publication criteria and we are unable to consider it further.
We are grateful for your interest in Journal of Physics B: Atomic, Molecular and Optical Physics.
Editor-in-Chief Marc Vrakking

Optics Letters

30.08.2018 Manuscript ID: 342022, Title: Spin radiation from a rotating dipole
Your recent submission to Optics Letters has not been received successfully.   I regret to inform you that The Optical Society is unable to consider your recent submission to Optics Letters for publication.
Editor-in-Chief Xi-Cheng Zhang

American Journal of Physics

July 27, 2018 Manuscript 30742 was rejected on , 2 days after its submission on July 25, 2018
EDITOR: Richard H. Price

New Journal of Physics

25 July 2018 Re: "Unexpected radiation from a rotating dipole" Article reference: NJP-109085
Dear Professor Khrapko,
Thank you for your submission to New Journal of Physics. To be publishable in this journal, articles must be of high quality and scientific interest, and be recognised as an important contribution to the literature. Your Paper has been assessed and has been found not to meet these criteria. It therefore does not warrant publication in New Journal of Physics and has been withdrawn from consideration. We are sorry that we cannot respond more positively and wish you luck in publishing your article elsewhere.
Editor-in-Chief Barry C Sanders

Теоретическая и математическая физика

14:07.2018   tmph@mi.ras.ru
Глубокоуважаемый автор Р.И.Храпко!
Ваша статья "Излучение спина и воздействие на излучатель" не   представляет интереса для журнала ТМФ. Отв. секретарь В.В.Жаринов
Главный редактор   академик Славнов Андрей Алексеевич

Physical Review A

21.05.2018 SR10075A Re: Unexpected radiation from a rotating dipole.
Your manuscript has been considered. We regret to inform you that we have concluded that it is not suitable for publication in any APS journal.
Yours sincerely, Daniel T. Kulp, Ph.D. Editorial Director American Physical Society

Письма в ЖЭТФ JETP Letters

11 мая 2018 г
Многоуважаемый Р.И. Храпко,
Ваша статья "Незамеченное излучение вращающегося диполя" **itnJ-5927w** была рассмотрена на заседании Редколлегии от 10.05.2018. Редколлегия приняла решение отклонить Вашу статью на основании полученной рецензии. Выдержка из рецензии прилагается[1].
Зав.редакцией "Писем в ЖЭТФ" И. Подыниглазова

Physics Letters A

17.04.2018, Ref. Ms. No. PLA-D-18-00839 Unexpected radiation from a rotating dipole
Dear Professor Khrapko,
Thank you for submitting your manuscript for publication in Physics Letters A.
I have studied your work with care and unfortunately I have to inform you that we are unable to accept your manuscript for publication.

---

[1] **Рецензия на статью Р.И. Храпко "Незамеченное излучение вращающегося диполя"**

В работе Храпко есть откровенные ошибки технического характера (не говоря уже об обычной идейной путанице). Формулы (3) и (4) нужно умножить на 4\pi, чтобы получился правильный ответ (в (3) также потерян угол \theta под синусом, но это просто опечатка).

Формула (4) - это должно быть следствием формулы (75.7) 2-го тома Ландау-Лифшица, если диполь d (у Храпко p) вращается в плоскости с частотой \omega, причем поразительно, что Храпко ссылается на (75.7)! Но хуже всего то, что в работе нет ничего последовательно выведенного.

Дело в том, что в классической электродинамике не получается "хорошее" (интуитивно понятное) выражение для дифференциального потока углового момента электромагнитного поля (для дифференциального потока энергии такое выражение существует - это вектор Пойнтинга). Неоднозначность в записи дифференциального потока углового момента связана с неоднозначностью тензора углового момента (аналогичной неоднозначности тензора энергии-импульса).

Отсутствие "хорошего" выражения приводит к кажущимся парадоксам. Но именно кажущимся: каким бы выражением мы ни пользовались, если аккуратно применить закон сохранения углового момента, то всегда все сходится.

Мы рекомендуем автору сравнить свои формулы с формулами статьи А. Барабанова (УФН, 1993). В статье Барабанова формула (75.7) из Л.-Л. Записана в форме (2.2), а аналогом формулы (3) Храпко является дифференциальный поток, определенный выражениями (3.3), (3.4). Неприятность, связанная с этим дифференциальным потоком, которую автор упоминает перед формулой (3), у Барабанова обсуждается после (3.3), (3.4).

В принципе, воспользовавшись неоднозначностью тензора углового момента, можно ввести другой дифференциальный поток углового момента. В статье Барабанова (УФН, 1993) - это поток "канонического углового момента", определенный формулой (2.13). Но это не решает полностью ту неприятность, о которой шла речь выше. Об этом написано в монографии Барабанова 2010 года. Можно предположить, что Храпко, записывая формулу (5), что-то такое и имеет в виду. Однако представляется, что это просто часть потока "канонического углового момента", имеющая "нужную" зависимость от \theta (такая часть действительно существует), однако куда делась другая часть? Т.е. это как раз то, о чем написано выше: нет ничего последовательно выведенного. Кроме того, не имеет никакого смысла складывать потоки угловых моментов, которые были по-разному определены (как это делается в формуле (7)).

Формула (5) дана без вывода, ее предваряют только ссылки на неопубликованные статьи автора 21, 22, 24, 25.

Окончание статьи про "отрицание тензора спина" - также ошибочное. В статье Барабанова (УФН, 1993) этот тензор выписан - формула (4.2) - со ссылками. Этот вопрос обсуждается также, в монографиях Боголюбова и Ширкова, Ахиезера и Берестецкого. Этот тензор возникает там, где пользуются каноническим тензором углового момента (не тем, который используется у Л.-Л.).

Не рекомендую публиковать рецензируемую статью.

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With my best regards, Dr. Eva Novakova Managing Editor Physics Letters A

Успехи физических наук UFN

16 марта 2018 г.

Глубокоуважаемый Радий Игоревич!

Спасибо Вам за Вашу «Методическую заметку» «Излучение спина и воздействие на излучатель», представленную в журнал «Успехи физических наук» (УФН). К сожалению, при обсуждении Вашей заметки ряд членов редколлегии высказал о ней критические замечания, что не позволяет нам рекомендовать Вашу статью в печать. В настоящее время в УФН очень большой портфель уже одобренных рукописей, что вынуждает нас особо строго относиться к отбору статей, которые мы можем рекомендовать в печать, причём исключительно на конкурсной основе (см. обращение редколлегии к авторам и читателям в первом номере журнала УФН за 2013 год). В связи с вышеизложенным Ваша статья не проходит по конкурсу и не может быть опубликована в УФН, возможно, что Ваша заметка могла бы быть опубликована в каком-либо специализированном журнале.

Благодарим Вас за интерес к журналу УФН! С уважением,

Главный редактор журнала «Успехи физических наук» академик РАН В.А. Рубаков