Spin Transferred to a Mirror Reflecting Light

Radi I. Khrapko
Physics dept.
Moscow Aviation Institute
Moscow, Russia
khrapko_ri@hotmail.com, khrapko_ri@mai.ru, http://khrapkori.wmsite.ru

***Abstract*—** We consider a plane circularly polarized electromagnetic wave which is incident upon a mirror at an angle. We have calculated the transfer of the spin angular momentum to the mirror and, accordingly, the density of the torque exerted on the mirror.

Keywords— classical spin; circular polarization; electrodynamics torque

I. INTRODUCTION

It was suggested as early as 1899 by Sadowsky [1] and as 1909 by Poynting [2], that a circularly polarized light carries not only energy and momentum but also angular momentum volume *density,* and that the angular momentum density is proportional to the energy density.

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

Now the energy and momentum are described by the energy-momentum tensor $T^{\mu\nu}$, and the angular momentum, which is spin, is described by a spin tensor $Y^{\lambda\mu\nu}$. In terms of photons, these electromagnetic energy, momentum and spin are the energy, momentum and spin of photons.

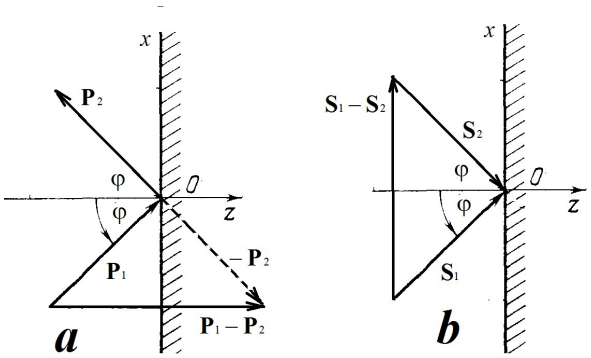

Figure 1. (***a***) Momentum of incident and reflected photons and the momentum gained by the mirror, and (***b***) Spin of incident and reflected photons and the spin gained by the mirror.

When the light, i.e. the flow of photons, is reflected from a mirror at an angle of incidence-reflection φ, the momentum $\mathbf{p}$ and the spin $\mathbf{S}$ of the photons change their directions. As a result, the mirror receives the doubled normal component of the wave momentum in the form of the pressure and the doubled tangential component of the spin in the form of the torque density (see Fig. 1). Note, the wave helicity is reversed in the process of reflection, i.e. the mutual orientation of the momentum and spin changes into the opposite one.

The pressure was calculated by Einstein [3]. The pressure is proportional to $\cos^2\varphi$. We have calculated here the torque density. The torque $d\tau^{ij}$ exerted on a surface element da_k is

$$d\tau^{ij} = \Upsilon^{ijk} da_k . \tag{1.1}$$

The material of this paper was published in [4].

II. The electromagnetic waves in question

To write the expression for a wave incident at an angle φ, we use the expression for a right-hand circularly polarized electromagnetic wave incident normally on the xy-surface in the coordinates x', y', z':

$$\begin{aligned} E_1^{x'} &= \cos(z'-t), \quad E_1^{y'} = -\sin(z'-t), \\ B_1^{x'} &= \sin(z'-t), \quad B_1^{y'} = \cos(z'-t) \end{aligned} \tag{2.1}$$

(for simplicity we put $\omega = k = c = \varepsilon_0 = \mu_0 = 1$). Then the coordinate transformations

$$\begin{aligned} x' &= x\cos\varphi - z\sin\varphi, \\ z' &= x\sin\varphi + z\cos\varphi, \quad y' = y \end{aligned} \tag{2.2}$$

give expressions

$$\begin{aligned} E_1^x &= \cos\varphi\cos(x\sin\varphi + z\cos\varphi - t), \\ B_1^x &= \cos\varphi\sin(x\sin\varphi + z\cos\varphi - t) \end{aligned} , \tag{2.3}$$

$$\begin{aligned} E_1^y &= -\sin(x\sin\varphi + z\cos\varphi - t), \\ B_1^y &= \cos(x\sin\varphi + z\cos\varphi - t) \end{aligned} , \tag{2.4}$$

$$\begin{aligned} E_1^z &= -\sin\varphi\cos(x\sin\varphi + z\cos\varphi - t), \\ B_1^z &= -\sin\varphi\sin(x\sin\varphi + z\cos\varphi - t) \end{aligned} \tag{2.5}$$

for the right-hand circularly polarized wave incident at an angle φ.

To write the expression for a wave reflected at an angle φ, we use the expression for a left-hand circularly polarized electromagnetic wave originating along the normal from the xy-surface in the coordinates x', y', z':

$$\begin{aligned} E_2^{x'} &= -\cos(z'+t), \quad E_2^{y'} = -\sin(z'+t), \\ B_2^{x'} &= -\sin(z'+t), \quad B_2^{y'} = \cos(z'+t) \end{aligned} . \tag{2.6}$$

Then the coordinate transformations

$$\begin{aligned} x' &= x\cos\varphi + z\sin\varphi, \\ z' &= -x\sin\varphi + z\cos\varphi, \quad y' = y \end{aligned} \tag{2.7}$$

give expressions

$$\begin{aligned} E_2^x &= -\cos\varphi\cos(-x\sin\varphi + z\cos\varphi + t), \\ B_2^x &= -\cos\varphi\sin(-x\sin\varphi + z\cos\varphi + t) \end{aligned} , \tag{2.8}$$

$$\begin{aligned} E_2^y &= -\sin(-x\sin\varphi + z\cos\varphi + t), \\ B_2^y &= \cos(-x\sin\varphi + z\cos\varphi + t) \end{aligned} , \tag{2.9}$$

$$\begin{aligned} E_2^z &= -\sin\varphi\cos(-x\sin\varphi + z\cos\varphi + t), \\ B_2^z &= -\sin\varphi\sin(-x\sin\varphi + z\cos\varphi + t) \end{aligned} . \tag{2.10}$$

for the wave reflected at an angle φ.

One can easily see that the boundary conditions are fulfilled on the surface of the mirror (an ideal conductor)

$$\left[E_1^x + E_2^x\right]_{z=0} = \left[E_1^y + E_2^y\right]_{z=0} = \left[B_1^z + B_2^z\right]_{z=0} = 0 \tag{2.11}$$

III. Spin tensor

To describe the spin, the canonical spin tensor [5 – 7]

$$\underset{c}{\Upsilon}{}^{\lambda\mu\nu} = -2A^{[\lambda}F^{\mu]\nu} \tag{3.1}$$

was successfully used in [8,9]. (In (3.1) A^λ is the magnetic vector potential and $F^{\mu\nu}$ is the electromagnetic field tensor). However, for this paper, it is important that the canonical spin tensor *incorrectly* describes the spin flux in the directions that do not coincide with the wave propagation direction. This was pointed out in [10,11]. Really, consider the Soper's wave [6]

$$\begin{aligned} A^x &= \cos(z-t),\ A^y = -\sin(z-t). \\ E^x &= -\sin(z-t),\ E^y = -\cos(z-t), \\ B^x &= \cos(z-t),\ B^y = -\sin(z-t), \end{aligned}$$

A calculation of components of the canonical spin tensor yields

$$\begin{aligned} \underset{c}{\Upsilon}{}^{zxy} &= A^x B^x = \cos^2(z-t), \\ \underset{c}{\Upsilon}{}^{yzx} &= A^y B^y = \sin^2(z-t). \end{aligned}$$

This result is not adequate because it means that there are spin fluxes in the directions, which are perpendicular to the direction of the wave propagation.

Another spin tensor was obtained and was used in the works [10-12]

$$\Upsilon^{\lambda\mu\nu} A^\lambda \partial^\nu A^\mu - A^\mu \partial^\nu A^\lambda . \tag{3.2}$$

Hereafter we calculate the spin transfer to the mirror by the use of the spin tensor (3.2)

IV. Spin Angular Momentum Flux Density Transferred to the Mirror

In accordance with Fig. 1b, the S^{yz} component of the spin is transferred to the mirror. The flux density of this spin component upon the mirror is given by the component

$$\mathrm{Y}^{yzz} = A^y \partial^z A^z - A^z \partial^z A^y \qquad (4.1)$$

of the spin tensor, and, in the absence of interference, it is possible to calculate this component only for the incident wave and to double it. From the formula $\mathbf{A} = -\int \mathbf{E} dt$ we obtain the magnetic vector potentials in the incident wave:

$$\begin{aligned} A_1^y &= \cos(x\sin\varphi + z\cos\varphi - t), \\ A_1^z &= -\sin\varphi\sin(x\sin\varphi + z\cos\varphi - t) \end{aligned} . \qquad (4.2)$$

Thus, given that $\partial^z = -\partial_z$ due to the metrics signature $(+---)$, the spin flux density on the mirror is

$$\mathrm{Y}^{yzz} = 2(A_1^y \partial^z A_1^z - A_1^z \partial^z A_1^y) = \sin(2\varphi). \qquad (4.3)$$

This density manifests itself as a distributed torque.

V. The Mechanism of Occurrence of the Distributed Torque

We can express the torque $d\tau^{yz}$ acting on the area da_z of the mirror through the divergence of the spin tensor (see Fig. 2):

$$d\tau^{yz} = \mathrm{Y}^{yzz} da_z = -\oint_{\partial dV} \mathrm{Y}^{yzi} da_i = -\partial_i \mathrm{Y}^{yzi} dV . \qquad (5.1)$$

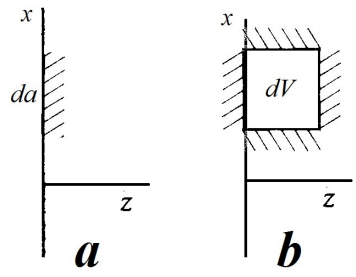

Figure 2. (***a***) Area da on the mirror and (***b***) area da forming a closed surface which is the boundary of the mirror material volume dV.

In (5.1), we mean an integration over the boundary of volume dV, which is obtained by closing the area da_z inside the mirror material with changing the external orientation to the opposite one. Since

$$-\partial_\nu \mathrm{Y}^{\lambda\mu\nu} = -2\partial_\nu (A^{[\lambda} \partial^{|\nu|} A^{\mu]}) = 2 j^{[\lambda} A^{\mu]}, \qquad (5.2)$$

and since the electromagnetic spin does not accumulate in the mirror, $\partial_t \mathrm{Y}^{yzt} = 0$, the divergence is expressed in terms of the *torque density* $\mathbf{j}\times\mathbf{A}$, which is an analogue of the Lorentz force density [13 (33.7)]: $-\partial_i T^{ki} = j_i F^{ki} = \mathbf{j}\times\mathbf{B}$.

$$\begin{aligned} -\partial_i \mathrm{Y}^{yzi} &= 2 j^{[y} A^{z]} = (\mathbf{j}\times\mathbf{A})^x, \\ d\tau^{yz} / dV &= (\mathbf{j}\times\mathbf{A})^x \end{aligned} . \qquad (5.3)$$

Here $\mathbf{j}$ is the current induced in the mirror.

VI. Conclusions

The given calculations show that spin is a natural property of a plane electromagnetic wave, similar to energy and momentum. The absorption of spin results in the torque density as well the absorption of momentum results in the Lorentz force.

It shows the advantage of the concept "Spin density is proportional to the energy density" over the concept "Spin density is proportional to gradient of the energy density" [14].

We are eternally grateful to Professor Robert Romer, having courageously published the question: "Does a plane wave really not carry spin?" [15].

References

[1] A. Sadowsky, Acta et Comm. Imp. Universitatis Jurievensis, vol. 7, No. 1-3, 1899

[2] J. H. Poynting, "The wave motion of a revolving shaft, and a suggestion as to the angular momentum in a beam of circularly polarised light". Proc. R. Soc. Lond. vol.A 82, 1909, pp. 560-567

[3] A. Einstein, "Zur Elektrodynamik bewegter Korper", Annalen der Physik, vol. **17**, 1905, p. 891

[4] R. I. Khrapko, "Spin transferred to a mirror reflecting light" http://www.mai.ru/science/trudy/published.php?ID=34126 in Russian 2005.

[5] E. M. Corson, Introduction to tensors, spinors, and relativistic wave-equation. NY, Hafner, 1953, p.71

[6] D. E. Soper, Classical Field Theory. N.Y: Dover, 2008, p. 114

[7] A. O. Barut, Electrodynamics and Classical Theory of Particles and Fields. Macmillan, New York, 1964, p. 102.

[8] R. I. Khrapko, "Reflection of light from a moving mirror" Optik, vol. **136,** 2017, pp. 503–506

[9] R. I. Khrapko "Absorption of angular momentum of a plane wave" Optik, vol. **154,** 2018, pp. 806–810

[10] R. I. Khrapko "Mechanical stresses produced by a light beam" J. Modern Optics, vol. **55**, 2008, pp. 1487-1500

[11] R. I. Khrapko, "True energy-momentum tensors are unique. Electrodynamics spin tensor is not zero" arXiv:physics/0102084 2001.

[12] R. I. Khrapko, "Violation of the gauge equivalence" arXiv:physics/0105031 2001

[13] L. D. Landau and E. M. Lifshitz, The Classical Theory of Fields. Pergamon, N. Y. 1975

[14] R. I. Khrapko, "Absorption of Spin by a Conducting Medium," AASCIT Journal of Physics, vol. 4, No. 2, 2018, pp. 59-63

[15] R. I. Khrapko, "Does plane wave not carry a spin?" Amer. J. Phys. vol. 69, 2001,pp. 405

Rejections

22 items

Journal of Modern Optics

22.01.2019 ID TMOP-2018-0704.R1
Dear Professor Khrapko, I regret to inform you that our reviewers have now considered your revised paper "Spin transferred to a mirror reflecting light", but unfortunately feel it unsuitable for publication in Journal of Modern Optics.
The editor-in-chief is Thomas Brown.
Reviewer: 1
It is well know that when light is reflected by a highly-reflecting mirror, it does not change its orbital angular momentum: The vector J = E x dot(E), which is the vector product of the electric field and its time derivative, remains unchanged. This fact can be checked easily experimentally. See for example https://www.youtube.com/watch?v=quoySiCVFfw **(How do 3D glasses work - Sixty Symbols)** Are the results presented in this paper consistent with experiments?

JETP Letters Письма в ЖЭТФ

21.09.2018
Многоуважаемый Р.И.Храпко,
Ваша статья "Спин, передаваемый зеркалу при отражении света" pxVf-5610f
была рассмотрена на заседании Редколлегии от 20.09.2018.
Редколлегия приняла решение отклонить Вашу статью на основании полученной рецензии.
Выдержка из рецензии прилагается.
Зав.редакцией "Писем в ЖЭТФ" И. Подыниглазова
Отзыв на статью.
В своей статье автор вычисляет момент, передаваемый зеркалу при косом отражении "закрученного" света, т.е. света, обладающего угловым моментом. Это вызывает недоумениие, потому что этот результат известен, он был получен ранее для Лагерр-Гауссовых пучков, см. например, монографии J.P. Torres, L. Torner, "Twisted Photons: Applications of Light with Orbital Angular Momentum" или D.L. Andrews, M. Babiker, "The Angular Momentum of Light", или в статье PRA 84, 033813 (2011).
Поскольку полученный в статье результат уже известен и опубликован, считаю, что эту статью НЕ стоит публиковать в Письмах в ЖЭТФ [А.Л. Барабанов].

Physical Review A

21.11.2017 Re: AL11520 Spin transferred to a mirror reflecting light
Dear Dr. Khrapko, The Physical Review editors attempt to accept only papers that are scientifically sound, important to the field, and contain significant new results in physics. We judge that these acceptance criteria are not met by your manuscript.
We regret that consequently we cannot accept the paper for publication in the Physical Review.
Yours sincerely, Frank Narducci

Journal of Electromagnetic Waves and Applications

11-Oct-2017
Dear Professor Khrapko, Thank you for submitting your revised manuscript ‘Spin transferred to a mirror reflecting light.’ (TEWA-2017-0632.R1). I have now considered your paper, and regret to inform you that I feel it unsuitable for publication in Journal of Electromagnetic Waves and Applications. If available, any further reviewer feedback on your manuscript is included at the bottom of this email.
Professor Pankaj Kumar Choudhury Editor in Chief

Annals of Physics

04.04.2017 Ms. Ref. No.: 72795 Title: Spin transferred to a mirror reflecting light
Dear Professor Khrapko,
Thank you for submitting your manuscript for publication in Annals of Physics.
I have studied your work with care. Regretfully, I have come to the conclusion that Annals of Physics is not the appropriate journal for publication of your work.
Editorial Board

Applied Optics

31.03.2017, Manuscript ID: 291840 Spin transferred to a mirror reflecting light
Dear Dr. Khrapko, Your recent submission to Applied Optics has not been received successfully. I regret to inform you that The Optical Society is unable to consider your recent submission to Applied Optics for publication. Sincerely, Dan McDonold Editorial Director

Optics Letters

29.03.2017, Manuscript ID: 291500: Spin transferred to a mirror reflecting light
I regret to inform you that The Optical Society is unable to consider your recent submission to Optics Letters for publication. Sincerely, Dan McDonold Editorial Director, OSA Publishing

Journal of the Optical Society of America B.

25.03.2017 Manuscript ID: 287587 Title: Spin transferred to a mirror reflecting light
After editorial review, I have determined that I cannot accept your paper for publication in Journal of the Optical Society of America B.
A paper is acceptable for publication in Journal of the Optical Society of America B only if there is convincing evidence that, in addition to being correct technically, it also adds a new and important result to the field. I have found that your paper does not meet this criterion.
Kurt Busch, Editor-in-Chief.

Journal of the Optical Society A

23.02.2017, Manuscript ID: 287106 Title: Spin transferred to a mirror reflecting light.
I regret to inform you that The Optical Society is unable to consider your recent submission to the Journal of the Optical Society of America A for publication.
Sincerely, Kelly Cohen Senior Publisher

New Journal of Physics

17.02.2017 Re: "Spin transferred to a mirror reflecting light" Article reference: NJP-106540
Thank you for your submission to New Journal of 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 New Journal of 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.
In addition, we will not normally reconsider an article for our primary research journals if it has already been rejected from another IOP Publishing journal.
Editor-in-Chief Barry C Sanders

Europhysics Letters

16.02.2017 EPL G38162 Ref: G38162: Spin transferred to a mirror reflecting light
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 Optics

15.02.2017, 15:20 Re: "Spin transferred to a mirror reflecting light" JOPT-104061
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.
Editor-in-Chief: L. N. Hazra

American Journal of Physics

14.02.2017
Dear prof. Khrapko, We have reviewed your submission, "Spin transferred to a mirror reflecting light," (our manuscript #29417) and determined that it is not appropriate for publication in the American Journal of Physics. Please refer to the "Information for Contributors" and the "Statement of Editorial Policy" at the AJP home.
Sincerely, David Jackson

Journal of Physics A: Mathematical and Theoretical

07.02.2017 "Spin transferred to a mirror reflecting light" JPhysA-107572
Thank you for your submission to Journal of Physics A: Mathematical and Theoretical. 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 A: Mathematical and Theoretical 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.
Editor-in-Chief J A Minahan

Редакция журнала *«Успехи физических наук»*

7 февраля 2017 г. Р.И. Храпко
Уважаемый Радий Игоревич!
Редколлегия УФН ознакомилась с Вашими статьями:

1. Отражение света от движущегося зеркала
2. Использование канонического тензора спина
3. Поглощение момента импульса плоской электромагнитной волны
4. **Спин, передаваемый зеркалу при отражении света**

Данные статьи посвящены явной проверке законов сохранения в классической электродинамике. Для читателей УФН они интереса не представляют.
Поэтому редколлегии УФН не может принять Ваши статьи «Отражение света от движущегося зеркала», «Использование канонического тензора спина», «Поглощение момента импульса плоской электромагнитной волны», «Спин, передаваемый зеркалу при отражении света» к рассмотрению.
Главный редактор журнала «Успехи физических наук»
академик РАН В. А. Рубаков

Journal of Physics B: Atomic, Molecular and Optical Physics

02.02.2017 "Spin transferred to a mirror reflecting light": JPHYSB-103495

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.

Editor-in-Chief Marc Vrakking

Journal of the Optical Society A

September 13, 2006 FW: RE: Khrapko 70174

I am writing to inform you that your submission "A mirror reflecting a circularly polarized plane wave receives spin " submitted to The Journal of the Optical Society A, is no longer under consideration for publication by the Journal. I have reviewed the history of this paper in the other OSA journals, as well as your public responses on the web. There are two major problems. First, and least important, the paper does not come close to following the style of a JOSA A paper. It presents its findings in an argumentative style and includes direct rebuttals of referee comments from previous journals. This is not what is expected when one resubmits a paper that has been previously rejected. Rather you should be using the previous reviews to strengthen your reasoning and your presentation. Second, Like most scientific publishers nowadays, OSA is especially sensitive to the strain on our peer reviewers caused by rapidly increasing levels of submissions. There are a limited pool of experts for this expanding pool of articles. In the case of your article, many of the experts who review this topic have already been asked for their opinions, and provided them in the many rejections which you mention. Asking the same people again would not change the outcome, especially since no new experimental results or arguments are presented. Thus, we will not be arriving at new conclusions concerning the appropriateness of your paper for publication in JOSA A. Thus, I am rejecting your paper from further consideration.

Stephen A. **Burns**, Ph.D. Editor JOSA A

Applied Optics

May 8, 2006 RE: 70174

Dear Dr. Khrapko, I have taken a closer look at your manuscript and determined it is outside the scope of Applied Optics. Consequently, I plan to reject your manuscript as being out of scope for Applied Optics. Alternatively, you could still accept my offer to transfer it to JOSA A, which I can do very easily.

Sincerely, T. Y. Fan Division Editor, Applied Optics

Physical Review A

March 28, 2006 Subject : To_author AQ10179 Khrapko Mirror reflecting a circularly polarized plane wave receives spin

Dear Dr. Khrapko, We have examined your manuscript and also shown it to an editor of Physical Review PRA concluding that the paper is not suited for publication in The Physical Review. We make no judgment on the correctness or technical aspects of your work. However, from our understanding of the paper's physics results, context, and motivation, we conclude that your paper does not have the importance and broad interest needed for publication in our journals. This judgment results in part from our reading of the abstract, introduction, and conclusions, which are crucial for our readership. In view of our assessment, we are not sending your manuscript out for

review. We regret that we must suggest that you submit the manuscript to a more appropriate journal.
Yours sincerely, Gordon W.F. Drake

Journal of Optics A: Pure and Applied Optics

September 26, 2005 JOPA/208356/PAP/66439 A mirror reflecting a circularly polarized plane wave receives spin.
Dear Dr Khrapko We have received your paper submitted to Journal of Optics A: Pure and Applied Optics. I am sorry to tell you that we are unable to consider it for our journal as it has previously been rejected. **It is company policy** that once an article has been rejected from one Institute of Physics journal, we cannot consider it for another. Your paper has therefore been withdrawn from consideration. Yours sincerely August Head Senior Publishing Administrator Journal of Optics A: Pure and Applied Optics Publishing Team August Head - Senior Publishing Administrator Claire Bedrock - Publisher, Jill Membrey - Managing Editor Rachel Kriefman - Production Editor

Optics Letters

July 29, 2005 Manuscript ID: 63329: A mirror reflecting a circularly polarized plane wave receives spin
Dear Dr. Khrapko: We are returning the comments of the reviewers.- In view of their recommendations, I cannot accept your manuscript for publication in Optics Letters. Thank you for the opportunity to consider your contribution.- We regret that it was not possible for us to send you a more favorable report.
Sincerely, Grover Swartzlander Topical Editor, Optics Letters
Reviewer comments are provided here:
Reviewer 1 This manuscript describes a theoretical consideration for so-called trasfer of a spin angular momentum of a circularly polarized beam reflected by a mirror. I think his theory is not clear and his theoretical result is questionable**.** The spin angular momentum of light may be transferred to isotropic objects by refraction as shown in reference [1], because refraction (with reflection) could change the ellipticity of the input light. I doubt a pure reflection unchanging the ellipticity of the input light could result in any transfer of spin angular momentum. There is no experiment report supporting his result up to now. On the other hand, his model is something too simple for real experiments. If he could further take account of a real situation such as an isotropic sphere by use of his theory and compare his results with known experiments, his revised work may be suitable for publication in JOSA A
Reviewer 2 A mirror reflecting a circularly polarized plane wave receives spin Radi I. Khrapko
This paper presents a detailed analysis of the interaction of circularly polarized light with a reflector based on electromagnetic tensors.- Its main conclusion seems to be that a torque is exerted on the mirror.
I am not qualified to comment on the detailed mathematical derivation nor the underpinning assumptions upon which it is based.- However, independently of the correctness or otherwise of these workings I believe it is essential that the conclusions be related to a basic appreciated of the experimental implication particularly so if, as in this case, the conclusion seems to be in conflict with known results and **perceived wisdom**.
It is clearly accepted that upon reflection, the handedness of circularly polarized light is reversed.- Given that both incident and reflected light can have perfect circular polarization it is clear that the angular momentum flux in the light beam corresponds to hbar per photon.- The question is whether the change in handedness results in a net torque on the reflector
The terms right- and left-circular polarization refer to the alignment of the spin vector with respect to the linear momentum vector, which can be parallel or anti- parallel (I always forget which is which!).- Upon reflection, the direction of the spin vector remains unchanged rather it is the reverse in propagation direction that is responsible for the change in handedness of the polarization.- Hence from a perfect reflector (or any type) there is a linear force (i.e. radiation pressure) but no torque**.**- -

Obviously if the reflector is changes the polarization state or is partially absorbing then there can be a torque transfer, easily calculable from the absorption coefficient or the change in Stokes parameters.- It may be that I have missed the point of this paper and that the torque predicted is indeed arising from these imperfections in the reflector.- However, as written, the paper implies that the torque arises even for a perfect reflector that is a prediction which I believe to be non-physical and hence in all likelyhood is wrong.
I cannot recommend publication of this paper.-

Journal of Modern Optics

September 9, 2005
From : Chris Knight j.mod.opt@imperial.ac.uk

Dear Professor Khrapko,

Thank you for submitting your paper to the Journal of Modern Optics. The manuscript was sent to a reviewer and we have received the attached report: the referee does not recommend publication in the Journal of Modern Optics. I am sorry I cannot be of more help.

Yours sincerely, Chris Knight

Referee report on JMO paper "**A mirror reflecting....**" Khrapko

This paper hinges on the use of an equation (eq(1) for the spin tensor which has not been accepted by the physics community and indeed, as noted in the acknowledgments, was already rejected by the Journal of Modern Optics as well as a large number of other peer-reviewed journals. As the current paper builds on this unaccepted form, I cannot see how this paper itself can be regarded as acceptable and recommend rejection forthwith with no possibility of resubmission.