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(一社)ドレスト光子研究起点
〒221-0022 神奈川県横浜市神奈川区守屋町3-13-19

URL: http://jpn.rodrep.org/

まえがき

(一般社団法人)ドレスト光子研究起点（Research Origin for Dressed Photon：RODreP）ではドレスト光子をはじめとするオフシェル科学の基礎研究を推進しておりますが、おかげさまで気鋭の研究者の皆様がご趣旨に賛同下さり、共同研究が順調に進展しております。

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令和3年3月

大津元一
Off-shell archive編集委員会　委員長
(一般社団法人)ドレスト光子研究起点　代表理事

目次

18 History, current developments, and future directions of near-field optical science

M. Ohtsu

Research Origin for Dressed Photon,
3-13-19 Moriya-cho, Kanagawa-ku, Yokohama, Kanagawa 221-0022, Japan

Abstract

This paper reviews the science of the optical near-field (ONF), which is created and localized in a nanometer-sized material (NM) or on its surface. It is pointed out that work on near-field optics was started in order break through the diffraction limit in optical microscopy and had already come to an end without giving answers to the essential questions on the origin of the near-field optical interaction. However, recent studies have reincarnated these studies and identified the ONF as an off-shell quantum field. Based on this identification, a novel science called off-shell science has started on the basis that the dispersion relation between energy and momentum is invalid for the ONF. This quantum field is called the dressed photon because it is created as a result of the interaction between photons and electrons (or excitons) in a NM and, thus, it accompanies the energies of electrons or excitons. In reviewing current developments, this paper presents fifteen novel phenomena that are contrary to the common views in conventional optical science. Novel technologies developed by applying these phenomena are also reviewed. These include: nanometer-sized optical devices, nano-fabrication technology, and energy conversion technology. High-power Si light emitting diodes, Si lasers, and SiC polarization rotators are reviewed as examples of electrical to optical energy conversion. For future directions, this paper also reviews novel theoretical studies that have commenced recently by relying on physical and mathematical bases.

19 Note on the physical meaning of the cosmological term

Hirofumi Sakuma[1] and Hiroyuki Ochiai[2]

[1]Research Origin for Dressed Photon,

[2]Institute of Mathematics for Industry, Kyushu University

Abstract

At first glance, the issue of dressed photon in the field of nano-optics seems to have nothing to do with cosmology which deals with phenomena with the largest spatial scales in nature. However, recent preliminary analyses on the mathematical structure of Clebsch dual field introduced as a part of explaining the generating mechanism of dressed photon imply the possibility that the emergence of the cosmological constant λ as the coefficient of the cosmological term λg_{ab} may be explained by the dynamical process of simultaneous conformal symmetry breaking of electromagnetic and gravitational fields. In this short note, as a supplemental explanation of this conjecture, we give a new explanation of the physical meaning of the cosmological term λg_{ab} by proving the hitherto unnoticed identity (1) in section 1.

20 The present and future of numerical simulation techniques for off-shell science

M. Ohtsu

Research Origin for Dressed Photon,
3-13-19 Moriya-cho, Kanagawa-ku, Yokohama, Kanagawa 221-0022 Japan

Abstract

The first part of this article presents experimental results on novel devices that were fabricated and operated by utilizing dressed photons. The fabricated devices were photovoltaic devices having an Ag-electrode with a unique surface morphology, light-emitting diodes using silicon crystals, and nano-droplets in which pairs of nanometer-sized semiconductor particles were confined. The second part reviews the results of the numerical simulations for these devices using a random walk model. This model relies on statistical mechanics and complex-systems science. The third part describes the problems with these simulations and presents some suggestions for solving them. Finally, the need for a three-dimensional off-shell scientific model that takes account of interactions in a nanometric space is pointed out.

21 Progress in off-shell science in analyzing light–matter interactions for creating dressed photons

M. Ohtsu

Research Origin for Dressed Photon,
3-13-19 Moriya-cho, Kanagawa-ku, Yokohama, Kanagawa 221-0022 Japan

Abstract

This article reviews the recent progress in theoretical studies on mechanisms of creating dressed photons (DPs) by focusing on the light–matter interactions in a nanometer-sized space. First, the intrinsic nature of the DP is reviewed, and fifteen experimentally observed phenomena are described. Second, it is pointed out that the conventional on-shell scientific method has intrinsic problems in describing these interactions. Finally, the off-shell scientific method, which can overcome these problems, is reviewed, and it is demonstrated that this method, relying on the Clebsch dual (CD) field, has succeeded in identifying the mechanism of creation of the DP, specifically: the spacelike CD field (Majorana fermion (MF) field) interacts with the timelike components of the 4-momenta field, and the MF field subsequently creates a timelike particle and antiparticle forming a pair. This pair is annihilated promptly because of its non-propagating nature. However, a non-propagating electromagnetic field remains in the interacting system, which is the very field of the DP.

22 Nutation in energy transfer of dressed photons between nano-particles

M. Ohtsu[1] and T. Kawazoe[2]

[1]Research Origin for Dressed Photon,
3-13-19 Moriya-cho, Kanagawa-ku, Yokohama, Kanagawa 221-0022 Japan

[2]Tokyo Denki University,
5 Senju-Asahi-cho, Adachi-ku, Tokyo 120-8551, Japan
(Present affiliation: Nichia Corp. 13-19, 3, Moriya-Cho, Kanagawa-Ku, Yokohama-Shi, Kanagawa 221-0022 Japan)

Abstract

Experimental results on the temporal behavior of dressed photon (DP) energy transfer are presented. Nanometer-sized particles (NPs) of cubic CuCl crystals grown in a NaCl crystal were used as the sample for the experiments. By measuring the temporal variations of the photoluminescence (PL) intensities emitted from these NPs, unique characteristics of DP energy transfer were found. Namely, the PL intensities exhibited nutation that originated from the bidirectional DP energy transfer between the small and large NPs. The period of the nutation was 50 ps. The periodic variation of the PL intensity emitted from the small NP had a phase lag of $\pi / 3$ behind that from the large NP. The duration of the forward DP energy transfer was longer than that of the backward transfer. The difference between these times resulted in temporal modulation of the PL intensities. The temporal variations exhibited additional pulsatory variations whose period was one-*fourth* the nutation period.

23 Route to Off-Shell Science

M. Ohtsu

Research Origin for Dressed Photon,
3-13-19 Moriya-cho, Kanagawa-ku, Yokohama, Kanagawa 221-0022 Japan

Abstract

This article reviews the experimental and theoretical studies under development and shows the route that should be taken to establish off-shell science in the future. Section 1 reviews the past and present of the science and technology of the DP. It presents the reasons why the off-shell scientific theory is required. As the bases of these reasons, fifteen experimentally observed unique phenomena that originate from the DP are presented (their details will be reviewed in Sections 2–6). Section 2 reviews the nature of the DP by presenting experimental results. Theoretical results describing them are also presented. However, it should be pointed out that these theories are no more than urgent theoretical solutions based on on-shell scientific methods. Sections 3–5 review a variety of disruptive innovations realized by using DPs: nano-optical devices (Section 3), nano-fabrication technology (Section 4), and optical energy conversion technology (Section 5). Section 6 reviews light-emitting diodes, lasers, and polarization rotators whose operating principles are based on the nature of the DP. Finally, Section 7 reviews the theoretical approaches to off-shell science. They are theories based on spatio-temporal vortex hydrodynamics, quantum probability, quantum walk, quantum measurement, and micro-macro duality. Appendix A reviews the results of numerical simulations for the experimental results in Sections 5 and 6. They rely on statistical mechanics and complex-systems science to derive urgent solutions. The problems with these on-shell science-based simulations are presented. Appendix B provides a supplementary explanation of the theory based on spatio-temporal vortex hydrodynamics reviewed in Section 7.

24 Errata: Route to Off-Shell Science

M. Ohtsu

Research Origin for Dressed Photon,

3-13-19 Moriya-cho, Kanagawa-ku, Yokohama, Kanagawa 221-0022 Japan

Abstract

Refer to the Abstract of *Off-shell Archive* (June, 2020), OffShell: 2006R.001.v1.

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25 Past, present, and future studies on the longitudinal electric field components of light

M. Ohtsu

Research Origin for Dressed Photon,
3-13-19 Moriya-cho, Kanagawa-ku, Yokohama, Kanagawa 221-0022 Japan

Abstract

Unlike a planar lightwave, a tightly focused light beam has longitudinal components of the electric field (LCEF) that are polarized along the propagation direction. This article reviews the past and present status of theoretical and experimental studies on the LCEF. By pointing out that the LCEF is an essential constituent element of the dressed photon (DP), the future outlook of these studies for advancing DP science and its applications is discussed.

26 The dressed photon as a member of the off-shell photon family

M. Ohtsu

Research Origin for Dressed Photon,
3-13-19 Moriya-cho, Kanagawa-ku, Yokohama, Kanagawa 221-0022 Japan

Abstract

This article reviews recent progress in theoretical studies in off-shell science that has been recently established for correctly describing light–matter interactions. These studies produced the Clebsch-dual (CD) field theory to deal with the spacelike momentum field that is indispensable in such interactions. This theory describes that the spacelike momentum field is converted to a timelike field at a singular point in a host material, resulting in the creation of a timelike Majorana field of a particle–antiparticle pair. Annihilation of this pair creates a dressed photon (DP). Furthermore, based on the correlation between theoretical models of the CD field and dark energy, the maximum size of the DP is derived and is expressed by using basic physical constants. The derived value (40 nm) agrees with the experimental value. Finally, by noting the mechanism of creation of the DP, it is concluded that the DP should be described on the basis of the off-shell photon model, not the virtual photon model.