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# A tribute to Fritz-Albert Popp on the occasion of his 70th birthday

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On May 11, 2008 the German biophysicist Professor Fritz-Albert Popp will celebrate his 70th birthday. This is a welcome occasion to pay tribute to the scientific achievements and human qualities of a scientist whose merits as one of the founders of biophotonics and as a pioneer of quantum biophysics increasingly find appreciation internationally.

## Founder of biophotonics and pioneer of quantum biophysics

Popp is mainly known as the founder of a new field of research in biophysics: in the mid-1970s he rediscovered at the University of Marburg, at the same time but independently from the groups of Boris Tarusov (Russia), Terence Quickenden (Australia), Humio Inaba (Japan) and Janusz Slawinski (Poland), the ultraweak photon emission (UPE) from living systems. It had originally been discovered in 1922 by the Russian biologist Alexander G. Gurwitsch who called it “mitogenetic radiation”[1] and attracted world-wide attention in the 1920’s and 1930’s, but after WW II was largely forgotten and partially compromised. It is the great merit of Fritz Popp to have renewed this line of research. Popp who coined the term “biophotons” for the emission of photons from biological systems, played a significant role in establishing the new field of biophotonics as a branch of biophysics by systematic experimental corroboration of many essential aspects of UPE by modern single-photon counting technology and by laying the basis for the theoretical understanding of the observed phenomena by means of quantum optics.

The experimentally verified phenomena of light emission from living organisms prompted Popp to make fundamental considerations about the nature of life which lead already in the 1970s and 1980s to the first formulations of his “biophoton theory”[2-9]. Many of his ideas have been confirmed since then and his theory has been considerably extended and corroborated by Popp since that time[10-16]. Although today some elements of his biophoton theory still remain speculative and need further testing and confirmation, these works have made Popp one of the principal inspirers and pioneers of a new, holistic and integrative biophysics which increasingly finds interest and application with bioscientists of many countries. It is based, as one of the most fundamental aspects, on a field-oriented picture of the organism. This acts as a corrective to the massive accumulation of detail knowledge and the disconnected fragmentation of the biosciences by the dominating trend of molecular biology, and provides again a chance for developing a unifying picture of life and holistic life sciences. Together with many other recent developments in the biosciences, the results of biophoton research constitute one of the major contributions to an emerging new, holistic and comprehensive picture of life based on quantum physics[17].

His foundational work in quantum biology also made Popp one of the internationally acclaimed pioneers of the application of quantum, especially quantum optical, principles and findings in biology. In this, he resumed and renewed some work by the first pioneers of quantum biology in the 1930’s, such as Alexander Gurwitsch, Paul Weiss, Ludwig von Bertalanffy, Pascual Jordan, Erwin Schroedinger, and Herbert Froehlich who countered the emerging molecular biology with a more holistic approach[18,19]. In 1997 the existence of macroscopic quantum phenomena and their possible substantial role in biology has been acknowledged by eminent scientists in an international conference in Boston[19]; Popp was one of the speakers and his concepts already were accepted as a matter of course. His discovery that the

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hyperbolic decay of induced biophoton emission can be taken as a proof of the coherence of the emission[20] may possibly become fundamental not only for biophoton research, but for quantum optics in general. It is also not without significance that the results of biophoton research constitute one of the first experimental proofs for Nobel laureate Ilya Prigogine's theory of "dissipative structures".

## Life and work

Fritz-Albert Popp was born on May 11, 1938 in Frankfurt am Main and grew up near the town of Coburg (Upper Franconia). In 1957 he began to study physics at the University of Göttingen and in 1966 he obtained his diploma in Experimental Physics at the University of Würzburg. In 1969 he obtained his Ph.D. in Theoretical Physics from the University of Mainz. In 1970 Popp took his first academic job as an assistant at the Radiology Center of the University Clinic of Marburg, where he obtained his habilitation in Theoretical Radiology and Biophysics in 1972. From 1973 to 1980 he was a lecturer (docent) for Radiology at the University of Marburg. During his time at Marburg University Popp also started his work in biophotonics. As radiology officer of the clinic he was technically responsible for the irradiation treatments of cancer patients. Therefore he was naturally interested in the cancer problem, and together with his diploma and Ph.D. candidates he set out to study the actual state of cancer research. Based on quantum theoretical considerations and calculations he investigated the question why one of the two substances, benzo(a)pyrene and benzo(e)pyrene with identical chemical structure, is strongly cancerogenic, while the other is completely harmless[2-4]. He found that benzo(a)pyrene which occurs in tobacco smoke, car exhausts, etc. and in which merely one of the five benzene rings is configured differently, only differs by its fluorescence in the blue-violet range from the sister substance. Now it was well known that light in the blue-violet spectral range can repair chromosome damage within seconds in the process known as "photo-repair". This finding prompted Popp to develop concepts on the possible role of light in cancinogenesis and generally in the process of life[3-5]. In 1973 Popp was first informed about the researches of Russian scientists in the wake of Alexander Gurwitsch about the possible role of light in biological communication. In 1975 Popp's Ph.D. student Bernhard Ruth built a highly sensitive emission photometer, which made it possible to provide a water-tight proof of the existence of "ultraweak photo-emission" in biological systems and to systematically investigate its properties for the first time[7,21]. These developments determined the further course of Popp's scientific career, and from now on he devoted all his efforts to the systematic study of cellular light and its implications[22,23]. Already in these ten years at Marburg University (1970-1980), in a clear-sighted and innovative vision Popp developed most of the basic ideas of his biophoton theory many of which have been confirmed through the later researches of his own or other groups since that time.

However, also what kind of consequences Popp would have to endure time and again in his career for advancing the bold hypothesis that light existed in the cell and there fulfilled communication and regulation functions, became already clear in his time at Marburg. The growing number of publications in scientific journals and the increasing experimental confirmation also by other research groups resulted in the theoretical support by fellow scientists, among them the eminent physicist Herbert Froehlich (in 1976) and the physical chemist and Nobel laureate Ilya Prigogine (in 1985).

During 1980-1982 Popp was director of a small private research laboratory in Flörsheim near Worms, until he followed an invitation by the renowned cell biologist Walter Nagl in 1982, to establish a research group at the chair of cell biology of the University of Kaiserslautern. In 1986 he founded the company Strahlungsanalysen (later Biophotonik) for the development of commercial applications of the research findings at the newly established Technology Park of Kaiserslautern. In 1992 the International Institute of Biophysics (IIB) was founded as an international network of research groups in biophoton research. At the Moscow State University and at the Chinese Universities of Hangzhou and Harbin "Open Laboratories" were founded by members of the IIB as common initiatives of the IIB and these universities. Since 1995 the IIB is based in Neuss where it is located, as the scientific part of a "Creativity Lab" together with artist's studios and lecture halls, on the site of a former NATO missile launching installation linked with the "Museumsinsel Hombroich", well-known in international arts circles. The membership of the IIB has steadily increased in the course of time and today comprises 19 research groups from 13 countries. More recently, a number of conferences devoted to the work of Herbert Froehlich have led to a rapprochement between the Popp group and a number of scientists investigating biophysical aspects of life on the basis of Froehlich's concepts; some of them have become members of the IIB. The yearly summer schools held in Neuss since 2001 are very successful and show steadily increasing numbers of participants from all over the planet who appreciate the unusual combination of scientific rigor with openness, a stimulating atmosphere and richly varied interdisciplinary presentations and discussions. A number of conference proceedings and other edited works by members of the IIB have been published by renowned scientific publishers like World Scientific, Kluwer, and Springer[12-16,24-26]. Popp himself is the author of more than hundred papers in scientific journals, about fifty contributions to edited works and eight monographs of which one has been translated into French, Polish, and Italian. He is also the editor of ten collective works. An extensive list of publications by Popp and other researchers on biophoton research, integrative biophysics and related questions can be found on the IIB website at: http://www.lifescientists.de/publication/bibliography1-1.htm. Popp has repeatedly been invited to lecture at a number of universities worldwide and has been appointed visiting or honorary professor of several universities in China, India, Germany and the USA. He is also an invited member of the New York Academy of Sciences, a member of the Executive Board of Directors of the Center for Frontier Sciences at Temple University, Philadelphia, USA, and a member of the International Consciousness Research Laboratory (ICRL) at Princeton University, USA.

## Scientific achievements

Popp can look back to a number of important achievements. In the 1970s and beginning of 1980s he made essential contributions to the firm establishment of the existence of ultraweak photon emission (biophotons) and to providing evidence for its universal occurrence in almost all biological species. As it also was the case later, here Popp did not perform experiments himself, but acted as a head of research groups, supervisor of students and postgraduates, and stimulator of research partners. Also, in the next phase of systematic investigation of the biophoton phenomenon his laboratory played a key role. Here the task was to demonstrate that the changes in the intensity of biophoton emission were an expression of physiological processes and reactions to external influences, but could not be reduced to the effects of factors such as temperature changes or the influence of oxygen. This is of a double significance: On one hand, it shows that biophoton emission can not only be interpreted as pure "spontaneous chemiluminescence" from oxidation or other chemical processes, but can also be understood as an expression of a living whole and is biologically significant. On the other, the light emission reflects all the states and changes of and influences on the organism, such that its measurement can provide information about these parameters.

In 1981 Popp performed an experiment together with his student Martin Rattemeyer which showed that the helical molecules of DNA are the main source of biophoton emission in the cell[22,27]. This conclusion has been supported by the later experiments by Wei Ping Mei, Hugo Niggli and Roeland van Wijk *et al*.

The next step in corroboration of Popp's hypothesis that the light stored in DNA together with a coherent biophoton field that permeates at least the cell, if not the whole organism, could be the central regulating instance in the organism, was to answer the question if the DNA molecule was at all able to absorb, store and emit light in a differentiated way. This was attempted with the so-called "exciplex model of DNA" developed by Popp together with the laser theoretician Keh-Hsueh Li of the Chinese Academy of Sciences—he had collaborated with Popp since the time in the Flörsheim Laboratory—and the cell biologist Walter Nagel of Kaiserslautern University[10].

Another important achievement of Fritz Popp is the introduction of photon count statistics into biophoton research. This made it possible to place the observed phenomena into the context of quantum optics – a field which has made rapid progress in the last 20 years and in which a number of completely new disciplines, such as Cavity Electrodynamics and Non-Classical Light, have emerged that treat exactly those phenomena in the area of ultraweak radiation with which biophoton research is concerned. Therefore biophotonics has become the first area of biology in which these quantum optical phenomena, up to now only theoretically predicted and technically generated, have been observed in nature. By applying photon count statistics in addition to the measurement of the pure spontaneous eigen-radiation of the organisms ("spontaneous luminescence"), the even more productive investigative method of measuring the induced or stimulated biophoton emission ("delayed luminescence") was made accessible. Here the organisms are subjected to a short excitation with light before the measurement, such that the particular nature of the interaction of living matter with light is manifested particularly well. The method reveals that living systems re-emit the absorbed light with a great delay, similar to some recently discovered solid-state systems. More than 10 years of investigations by Popp's group showed that the characteristic of the "hyperbolic decay" of the re-emitted radiation observed in these measurements is a reliable indicator for the coherence of biophoton emission, an additional property of cell radiation besides intensity that meanwhile has become one of the most fundamental criteria in biophoton research. Coherence – the order and interference ability of light – is the principal property of laser light and the prerequisite for the informative and regulative ability of biophotons which is postulated by Popp's biophoton theory.

As a central element of this theory, Popp developed in 1983, together with his colleagues Li and Nagel, a physical model of the possible mechanism of the regulation of biological and biochemical processes by the biophoton field[20,23]. This electromagnetic model of cell differentiation and growth has been repeatedly submitted to successful experimental tests, among others by the Polish scientist couple Barbara and Stanislaw Chwirot on larch spores[29-31] and by the Dutch cell biologist Roeland van Wijk on human cells[32]

Last but not least with his work Popp has laid the foundations for a number of possible applications, some of which are already being tested in practice, while others still necessitate further fundamental research. Among them is the possibility to differentiate cancer cells from healthy cells of the same type by their biophoton emission[33], as well as the evaluation of food quality by biophoton measurement[34-36]. The promising results of systematic investigations of human biophoton emission by a specially developed whole body measurement equipment initiated by Popp[37-40] and continued by Roeland and Eduard van Wijk[41-43] constitute the first steps to a possible application in medical and psychological diagnostics.

**Evaluation**

In summary, the most important of Popp's scientific achievements probably consist, besides the experimental securing of the basic phenomena and the foundation of the methodology of biophoton research, in the demonstration of the coherence of ultraweak bioluminescence, in the establishment of its investigation as a division of quantum biology, in the renewal of the work of the 1930 pioneers, in the development of his highly stimulating theoretical ideas, and in his never-tiring stimulation, mentoring, advice and support of the research of students, collaborators and colleagues. Even if some of his theoretical work may remain speculative or may not stand to the tests to come, Popp certainly has established himself as one of the most important pioneers and inspirers of biophotonics and of a new biophysics, and as the doyen of the biophysical school of cell radiation research. He belongs to the pioneers in the realization of the paradigm change initiated by scientists like Alexander Gurwitsch, Paul Weiss, Ervin Bauer, Ludwig von Bertalanffy, Erwin Schrödinger, Ilya Prigogine, Herbert Fröhlich etc. that leads our concept of life slowly but securely away from Newtonian-Cartesian mechanical and equilibrium notions[17]. But in this tribute to Fritz Popp's achievements let us not forget his human qualities and mention that without his visionary imagination that complements his professional competence, without his enormous dedication to the envisioned goal, without the stamina and perseverance, and without the ability to motivate others he would not have been able to get the new field of research accepted.

Certainly Fritz Popp could have had a more comfortable life if he had taken a more conventional route. More than three decades of untiring devotion to the noble cause of biophotonics, lots of labor and struggles for economic survival have taken their toll on Fritz Popp's health. We thank him for his highly valuable engagement for a new science and wish him for the beginning of his eighth decade that he now may be finally able, like others of his age, to reap the fruits of his life-long labours. It is his own wish to be able to continue to promote the application of biophoton research in fields like food quality, health and environmental research and obtain further insights into life processes. In the last few decades his interest particularly was devoted also to the connections between cell radiation and consciousness and evolution[44]. We wish him (and ourselves) that, in spite of all adversities, he may be granted many more years of unbroken creative power, enjoyment and stamina to make further contributions to these fields.

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**References**

1 Beloussov L V, Life of Alexander G. Gurwitsch and his relevant contribution to the theory of morphogenetic fields. With additional commentary by John M.Opitz and Scott F.Gilbert, *Int J Dev Biol*, 41 (1997) 771.
2 Popp F A, MO-Rechnungen an 3,4-Benzpyren und 1,2-Benzpyren legen ein Modell zur Deutung der chemischen Karzinogenese nahe, *Zeitschr f Naturf*, 27b (1972) 731.
3 Popp F A, Zur Resonanzhypothese der Kanzerogenese. *Strahlentherap*, 146 (1973) 582.
4 Popp F A, Einige Möglichkeiten für Biosignale zur Steuerung des Zellwachstums, *Arch Geschwulstf*, 44 (1974) 295.
5 Popp F A, Schaumlöffel E, Böhm P, Herrmann K & Kramer J, Biosignale zur Steuerung des Zellstoffwechsels. Eine Resonanzhypothese der Karzinogenese (Vorläufige Mitteilung). *Münch Med Wochenschr*, 116 (1974) 381.
6 Popp F A, So könnte Krebs entstehen. *Bild der Wissensch*, 13, (1976) 58.
7 Popp F A, Becker G, König H L, Peschka, W, *Electromagnetic Bio-Information, Proceedings of the Symposium, Marburg, September 5, 1977* (Urban & Schwarzenberg, Munich-Vienna-Baltimore) 1979.
8 Popp F A, Electromagnetic control of cell processes, in *Proceedings of the International Symposium on Wave Therapeutics - Interaction of Non-Ionizing Electromagnetic Radiation with Living Systems, Versailles, May 19-20, 1979*, edited by ZW Wolkowski (Université de Paris-Val de Marne, Créteil) 1983, 60
9 Popp F A, Photons and their importance to biology, in *Proceedings of the International Symposium on Wave Therapeutics - Interaction of Non-Ionizing Electromagnetic Radiation with Living Systems, Versailles, May 19-20, 1979*, edited by ZW Wolkowski (Université de Paris-Val de Marne, Créteil) 1983, 43.
10 Popp F A, Biologie des Lichts, Grundlagen der ultraschwachen Zellstrahlung (Paul Parey Verlag, Berlin and Hamburg) 1984.
11 Popp FA, Gurwitsch A A, Inaba, H, Slawinski, J, Cilento, G, van Wijk R, Chwirot, W B & Nagl W, Biophoton emission (Multi-Author Review), *Experientia*, 44 (1988) 543.
12 Popp F A & Li K H, Gu Q, *Recent advances in biophoton research and its applications (*World Scientific Publishing, Singapore) 1992.
13 Ho M W, Popp F A & Warnke U, *Bioelectrodynamics and Biocommunication* (World Scientific Publishing, Singapore) 1994.
14 Beloussov L V & Popp F A, *Biophotonics - Non-Equilibrium and coherent systems in biology, biophysics and biotechnology, Proceedings of the International Conference Dedicated to the 120th Birthday of Alexander Gavrilovich Gurwitsch (1874-1954), September 28 - October 2, 1994, Moscow, Russia* (Bioinform Services, Moscow) 1995.
15 Chang J J, Fisch J & Popp FA , *Biophotons* (Kluwer Academic Publishers, Dordrecht) 1998.
16 Shen X & Wijk R van, *Biophotonics – Optical science and engineering for the 21st century*, (Springer, New York) 2005.
17 Bischof M, Introduction to integrative biophysics, in *Integrative biophysics*, edited by F A Popp & L V Beloussov, (Kluwer Academic Publishers, Dordrecht) 2003, 1.
18 Introduction, *Biophotonics – Optical science and engineering for the 21st century*, edited by X Shen & R van Wijk R (Springer, New York) 2005, VI.
19 Sassaroli E, Srivastava Y, Swain J & Widom, A, *Macroscopic quantum coherence, Proceedings of the International Conference, Northeastern University, Boston, USA, 11-13 July, 1997* (World Scientific Publishing, Singapore) 1998.
20 Popp F A & Li K H, Hyperbolic relaxation as a sufficient condition of a fully coherent ergodic field, *Int J Theor Phys*, 32 (1993) 1573.
21 Popp F A, Ruth B, Bahr W, Böhm J, Grass P, Grolig G, Rattemeyer M, Schmidt HG & Wulle P, Emission of visible and ultraviolet radiation by active biological systems, *Collective Phenomena*, 3 (1981), 187.
22 Rattemeyer M, Popp F A & Nagl W, Evidence of photon emission from DNA in living systems, *Naturwiss*, 68 (1981) 572.
23 Nagl W & Popp F A, A physical (electromagnetic) model of differentiation, I. Basic considerations, *Cytobios*, 37 (1983) 45.
24 Popp F A & Beloussov L V , *Integrative biophysics* (Kluwer Academic Publishers, Dordrecht) 2003.
25 Popp F A, Gu Q & Li K H, Biophoton emission: Experimental background and theoretical approaches, *Mod Phys Lett B*, 8, 21 & 22 (1994) 1269.
26 Bajpai R P, Biophoton: A symposium in print, *Indian J Exp Biol*, 41(2003), 383.
27 Popp F A & Nagl W, Biophoton emission: New evidence for coherence and DNA as source, *Cell Biophys*, 6 (1984) 33.
28 Popp F A & Nagl W, A physical (electromagnetic) model of differentiation. II. Applications and examples, *Cytobios*, 37 (1983) 71.
29 Chwirot W B, Dygdala R S & Chwirot S, Quasi-monochromatic-light-induced photon emission from microsporocytes of larch showing oscillation decay behaviour predicted by an electromagnetic model of differentiation, *Cytobios*, 47 (1986) 137.
30 Chwirot W B, Ultraweak photon emission and anther meiotic cycle in larix europea (experimental investigation of Nagl and Popp's electromagnetic model of differentiation), *Experientia*, 44 (1988) 594.
31 Chwirot W B & Dygdala R S, Ethidium-bromide-induced changes in intensity of ultraweak photon-emission from microsporocytes of larch in selected stages of development, *J Plant Physiol*, 134 (1989) 762.
32 Wijk, R van, Aken, H van, Mei W & Popp F A, Light-induced photon emission by mammalian cells, *J Photochem Photobiol B*, 18 (1993) 75.

33 Nagl W & Popp FA, Opposite long-range interactions between normal and malignant cells, in *Energy transfer dynamics*, edited by TW Barrett & HA Pohl (Springer Verlag, Berlin-New York) 1987, 248.
34 Köhler B, Lambing K, Neurohr R, Nagl W, Popp F A & Wahler J, Photonenemission - Eine neue Methode zur Erfassung der "Qualität" von Lebensmitteln, *Dt Lebensm Rundsch*, 87 (1991) 78.
*35* Köhler B, Fölsch D W, Strube J & Lange K, The influence of housing systems on the egg quality under particular consideration of the elements fresh grass and lighting conditions, *13th International Conference of the IFOAM (Int. Federation of Agricultural Movements), Basel, Switzerland, 28-31 August 2000.*
36 Popp F A, *Die Botschaft der Nahrung, Unsere Lebensmittel in neuer Sicht* (The Message of Food. Our Foodstuffs in a New Perspective), Fischer alternativ (Fischer Taschenbuch Verlag, Frankfurt am Main) 1993. 2nd expanded edition (Verlag Zweitausendeins, Frankfurt am Main) 1999, 3rd ed. 2000, 4th ed. 2001.
37 Cohen S & Popp F A, Low-level luminescence of the human skin, *Skin Res Technol*, 3 (1997) 177.
38 Cohen S & Popp F A, Biophoton emission of the human body, *J Photochem Photobiol B: Biology*, 40 (1997) 187.
39 Cohen S & Popp F A, Whole-body counting of biophotons and its relation to biological rhythms, in *Biophotons*, edited by J J Chang, J Fisch & F A Popp, (Kluwer Academic Publishers, Dordrecht) 1998.
40 Cohen S & Popp F A, Biophoton emission of human body, *Indian J Exp Biol*, 41 (2003), 440.
41 Wijk R & Wijk, E, Human biophoton emission (review article), *Recent Res Devel Photochem Photobiol*, 7 (2004) 139.
42 Wijk R & Wijk E P A, An introduction to human biophoton emission (review article), *Forsch Komplementärmed - Klass Naturheilk*, 12 (2005) 77.
43 Wijk R, Kobayashi M & Wijk EPA, Anatomic characterization of human ultra-weak photon emission with a moveable photomultiplier and CCD imaging, *J Photochem Photobiol B: Biology*, 83 (2006) 69.
44 Popp F A, Evolution as expansion of coherent states, in *The Interrelationship between mind and matter*, edited by B Rubik (Center for Frontier Sciences at Temple University, Philadelphia) 1992.