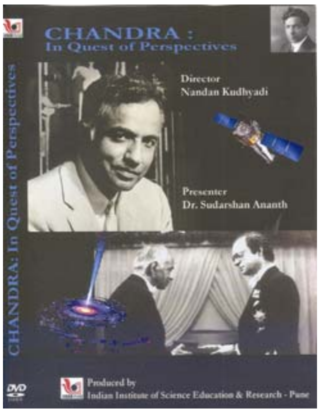
VIDEO REVIEW



Chandra – In Quest of Perspectives. A DVD by Nandan Kudhyadi.

The Indian Institute of Science Education and Research (IISER), Pune has produced a delightful 35 min documentary made by Nandan Kudhyadi on Subrahmanyan Chandrasekhar, to mark the birth centenary of this illustrious astrophysicist of the 20th century. Chandra, as he is universally referred to by his colleagues, is known to have said, 'My work has followed a certain pattern motivated primarily by the quest of perspectives. I work on my own for my personal satisfaction, generally outside the mainstream'. This provides the title of the video, *Chandra – In Quest of Perspectives.*

Indeed the forties and fifties of the 20th century, following the birth of quantum mechanics in the first three decades, marked a great ferment of excitement in the unfolding era of relativistic quantum field theory and the consequent advances in nuclear and particle physics at Cambridge, Copenhagen and Chicago, where Chandra had worked. But he worked largely on the consequences of classical physics, established during the preceding century to explain the physics behind various phenomena in astrophysics and cosmology, of course, adequately tempered by the emergent quantum principles. This is expressed by Peter Vandervoot, Chandra's younger colleague at Chicago through appropriately worded remarks that Chandra's work provides a brilliant retrospective in physics. The video adequately establishes, notwithstanding Chandra's view that his researches were outside the mainstream, the huge impact his systematic study is having on several aspects in modern astrophysics and cosmology, besides other disciplines in mathematical and physical sciences. National Aeronautics and Space Administration (NASA) named the state-of-the-art space telescope, launched in 1999 as the Chandra X-ray Observatory in his honour. Similarly, our own 2 m optical and infrared reflecting mirror telescope commissioned at Hanle, Ladakh in 2004 is proudly called Himalayan Chandra Telescope; indeed a well-deserved national honour for him.

There are many thought-provoking observations in the video, capturing the various attributes of Chandra made by a galaxy of eminent astrophysicists, such as Abhay Ashtekar, S. M. Chitre, Jayant Narlikar, Roger Penrose, Martin Rees, Kip Thorne, Vandervoot and Robert Wald. An informative narration by Sudarshan Ananth (IISER) provides the necessary background. Narlikar points out that Chandra's work that got initiated while he was still an undergraduate student, led him to observe that the end-product of a collapsing star known as white dwarfs cannot be sustained if the star is more massive than a certain value (about 1.44 times the solar mass, known now as the celebrated Chandrasekhar limit). Ananth points out that in arriving at this result Chandra combined the quantum nature of the electron, which was known to obey statistical property derived by Fermi and Dirac, with the consequences of special theory of relativity. For a more massive star the electrons approach relativistic velocities and the necessary equilibrium for the stability of white dwarfs is lost. It is surprising that Eddington, whose book Chandra received as a prize in his school days and perhaps got initiated into the field, dismissed Chandra's finding as absurd. However, this was the beginning of the study that led to the inevitability of more massive stars ending up as black holes. All stars that end up as white dwarfs (or as pulsars, another similar end state of stellar matter) confirm to have less than the limiting mass, as predicted. Chandra was right and Eddington plain wrong. Chandra had to bear this humiliation at the most crucial stage of his budding career and yet go on to make in later days more definitive advances in the theory of black holes.

Chitre declares that Chandra has been his role model. Surely, for many, Chandra will be a difficult role model to emulate. Nevertheless, it is worth aspiring. It makes me wonder as to who could be Chandra's role model, if there was one. Could it be Newton? The documentary seems to suggest so; Chandra's last book, published a few months prior to his death was indeed his tribute to the pioneer theorist, and the video includes a delightful brief on Newton's legacy, perhaps thus sharing with us Chandra's great admiration for Newton's originality and breath-taking economy in steps to arrive at a precise conclusion that characterizes his methods. There is a great similarity in the styles, both emphasizing a quest for depth in understanding combined with a sense of methodical completeness.

Chandra had a philosophy of working on a problem in an area that he picked up for about a decade, and usually follow it up with detailed papers that represent such a study. He felt that one should be in a position to summarize all of them in a monograph on the subject. After that, I was privileged to hear him say, one must move away and study a different area. Chandra, true to his declared dictum, produced authoritative monographs on a wide range of topics, one almost every decade of his active life. The narrator alludes to this, displaying Chandra's first monograph on '*Brownian Motion*', followed by one on '*Radiative Transfer*' and progressed to the last one on '*Newton's Principia for the Common Reader*' with indeed '*Magnetic Hydrodynamics*' and '*Mathematics of Black Holes*' en route. Each of them is known in the community to be an authoritative, complete masterpiece.

There is a minor error of fact in the narrative, when it is said that Chandra moved to the University of Chicago campus in 1966 and started to teach in the Laboratory of Space Research from then. In fact, even when Chandra was staying at the Yerkes Observatory at Williams Bay, Wisconsin, he travelled to teach at the University of Chicago campus nearly every week for several years prior to his moving to the campus neighbourhood in 1966. He would drive nearly 100 miles every Wednesday morning, give two 90 min lectures on consecutive days for the courses he gave, usually scheduled on Wednesdays and Thursdays, and participate in the Departmental Wednesday colloquium before returning back on Thursday afternoon. At one stage he did this even when his class size was just two; Chandra seems to have quipped that his travel was well worth it, since the whole class (consisting of T. D. Lee and C. N. Yang) got the coveted Nobel honour!

One omission in this rather complete overview on Chandra, I believe, is the stellar role he played as the editor of *The Astrophysical Journal* (*APJ*), a position he held continuously for 19 years, and how single-handedly he turned the *APJ* into a world-class, high-impact publication in the field. And those days with no internet and computers, journal editing must have been both intellectually demanding as well as physically exhausting. In this task of great quality and distinction, Chandra was aided by just one efficient secretary for the entire editorial task. Once again, this illustrates the level of seriousness Chandra always brought to bear on any task he undertook.

The documentary is a fine tribute, with a well-edited, visually pleasing photography and professional quality of production. We can feel proud about the timely project and are indebted to IISER Pune and its Director K. N. Ganesh, for this initiative.

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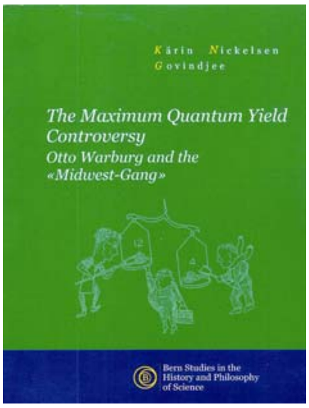

The Maximum Quantum Yield Controversy: Otto Warburg and the «Midwest-Gang». Kärin Nickelsen and Govindjee. Bern Studies in the History and Philosophy of Science, Institute für Philosophie, University of Bern, Switzerland. 2011. ii + 138 pp. Price: 10 Euros.

About five years ago, I had the opportunity of reviewing the great work *Discoveries in Photosynthesis* published by Springer (*Curr. Sci.*, 2007, **92**, 246–248). This is a work in which the principal editor was Govindjee (http://www.life.illinois.edu/govindjee). He is also an author of the book under review. Govindjee, who has now been in the area of photosynthesis for more than half a century, has earned our deep admiration and respect for his dedication to research and teaching, the magnitude of his efforts and ceaseless productivity. Within the covers of that earlier book, I found a great treasure trove of the history of great many discoveries and the work of hundreds of investigators.

I had thought that the publication of that monumental work running into more than 1300 pages would have exhausted the possibility of other books on the history of photosynthesis, at least for some time to come. I was thus pleasantly surprised to learn about yet another book relating to the history of research in photosynthesis. The first author of the book under review is Kärin Nickelsen. Though not a specialist in the field of photosynthesis herself, she has nevertheless had earlier research experience in plant physiology that led her to the broader study of the history of science in general. After teaching and doing research as a 'Assistenzprofessorin' in History and Philosophy of Biology at the University of Bern, Switzerland, she is currently Professor of History of Science at the University of Munich in Germany. With impressive earlier publications in this area, which include application to technology (one of her books is on Theodore von Karman, the great Hungary-born German scientist, who later emigrated to USA to lead the Aeronautical Engineering Group at Caltech and then establish the present Jet Propulsion Lab in Pasadena), she has teamed up with Govindjee to make this extraordinarily valuable contribution to the history of photosynthesis research.

This book deals exclusively with just one aspect of photosynthesis research. But it is welcome, since the determination of the minimum quantum requirement (inversely the maximum quantum yield) of oxygen yield has been so central to the formulation of the 'Z scheme' and development of current concepts of photosynthesis. To explain to the general readers of this review, quantum requirement is simply the number of quanta required to split water molecules and form a single molecule of oxygen. The emphasis on oxygen evolution, rather than on the capture of a photon and excitation of a chlorophyll molecule, simply derives from the fact that in photosynthesis this is what one can measure most easily, and it is one of the products of oxygenic photosynthesis. Although chlorophylls, rather than water molecules, absorb quanta, and to be precise a manganese–calcium–water complex holds a crucial intermediary position, one can take an overall view. And in essence, there has to be a simple one-to-one numerical relationship between every excitation event and the resulting 'extraction' of an electron held between hydrogen and oxygen in the water molecule. Quantum requirement can be determined with respect to any photochemical reaction. Precise determination of quantum requirement of a reaction allows one to decipher the mechanism of that reaction (whether, for example, a photochemical process comprises one, two or more steps), and such work became popular after Albert Einstein published his law of photochemical equivalence with respect to photoionization or photooxidation reactions.

Following the work of Sam Ruben and Martin Kamen published in 1941, it became clear that the photosynthetic equation was $2H_2O + CO_2 + \text{light} \rightarrow \{CH_2O\} + H_2O + O_2$. (Multiply all reactants and products by six to formulate the more common equation for synthesis of one glucose molecule.) Thus, there was renewed emphasis to determine how many quanta are required to split the molecules of water. As would be evident to the readers, theoretically, four quanta are minimally required to split the two molecules of water and release of a single oxygen molecule, since four electrons are removed from two molecules of water to get one molecule of oxygen. However, in reality the process has turned out to be less efficient, since transfer of one electron from water to CO_2 requires two photons.

The above conclusion has come basically from the quantum yield determinations as most investigators, particularly Robert Emerson, found a minimal requirement of 8–10 quanta for the evolution of one oxygen molecule. Already during the 1940s, Nobel laureate James Franck and later Eugene Rabinowitch (the grand master of photosynthesis) suggested a two-light reaction scheme to explain the quantum requirement of 8–10. In 1960, Robin Hill and Fay Bendall