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On the 1965 Nobel Prize in Physics to Feynman, Schwinger and Tomonaga

Already as a young man Gunnar Källén established himself as the leading expert in Sweden in the area of quantum electrodynamics. With an astonishing speed, he became a world expert in this most advanced and difficult domain of theoretical physics of that time. His distinguished four years older collaborator, Arthur Wightman, expressed it with the words:

> "At that time I was trying to puzzle out the grammar of the language of quantum field theory, and here was Källén already writing poetry in the language".

Steven Weinberg, while visiting Stockholm in connection with an "Oskar Klein Lecture"[1] said to me (CJ) that he considered himself as a student of Källén and learned his field theory from him. He said that he had come to Copenhagen taking with him the book of Heitler[2] to learn field theory. But he hardly had opened the book as Källén was nearby acting as his teacher (see Chap. 61).

Indeed, there can be no doubt that Källén understood, better than anyone else in Sweden, the significance of the contributions of various people to the development of quantum electrodynamics. Therefore, it would have been great to know his opinion about the evolution of quantum electrodynamics, his area of expertise. For example, were the theoretical discoveries monumental enough to justify a Nobel Prize? If so, who were the proper candidates to be honored? Fortunately some of these questions can be answered because Källén published a popular article (paper [1965d] on his list of publications) on the subject. Here below we give some excerpts from his article (translated from Swedish). The title is: "1965 year's Nobel Prize in Physics".

Källén considers the treatments of the energy levels of the hydrogen atom by Schrödinger and Dirac equations respectively and their great impact on

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[1] These annual lectures, in honor of the eminent Swedish theorist Oskar Klein (1894–1977) were started by Gösta Ekspong and myself (CJ). Klein's name appears in Klein-Gordon equation, Klein's paradox, Klein-Nishina formula, Kaluza-Klein, etc. Note that the compactification of the fifth dimension, in the Kaluza-Klein formalism, is due to Klein who introduced it as a possible explanation of the quantization of the electric charge.

[2] Walter Heitler (1904–1981) had written a much appreciated book "The Quantum Theory of Radiation" which from 1936 on has appeared in several editions.

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understanding of the spectrum. However, he points out, that measurements by Lamb[3] at the end of 1940's attracted a tremendous attention, as these could not be explained by the above equations.

Then he adds (translated from Swedish):

> These [Lamb's results] were vehemently discussed, among other places, at a physics congress at Shelter Island in June 1947. Several participants were of the opinion that this deviation was not due to new kinds of interaction but depended on the inadequacy of the employed method of approximations.

After this follows a two page discussion of how perturbation theory should be applied, the treatment of virtual photons, the relevant Feynman diagrams, and divergences. Then, he continues:

> An initial step toward getting out of these difficulties was taken by Kramers[4] and Bethe soon after the aforementioned Shelter Island Conference. The major idea was to interpret certain parts of these [results in perturbation theory] as the electromagnetic contribution to electron's fundamental properties such as its mass and charge.

After a rather detailed discussion of this point, Källén notes that Lamb shift is not the only effect that quantum electrodynamics, in its modern form, is able to explain. Another important application is the explanation of the measured value of the magnetic moment of the electron.

Concerning the Nobel Laureates' contributions he writes:

> The great achievement of this year's Laureates has primarily been the formulation of practically useful methods for carrying through the above calculations.
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> Tomonaga started his work already during the second world war, before Lamb's measurements. His two American colleagues came in somewhat later. Schwinger's first result was the term $\alpha/2\pi$ in the anomalous magnetic moment of the electron. … Schwinger, in his formalism, goes considerably beyond Tomonaga and his methods are much more applicable to practical calculations than Tomonaga's. Moreover, he obtained, in a much shorter time span, several valuable results.

Källén praises Schwinger's achievements, such as computation of the radiative corrections to electron-proton scattering, important for obtaining information

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[3] Willis Lamb received the 1955 Nobel Prize in Physics for these measurements.

[4] In this book we have included a special chapter about Kramers because not only Källén but also Møller and Weinberg in their articles refer to him as a pioneer in connection with renormalization in field theory. We feel fortunate to have obtained a first-hand information on this matter from a student of Kramers. See Chap. 67.

about the electromagnetic structure of the proton which had been honored by the 1961 Nobel Prize to Robert Hofstadter. Källén notes that:

> … even Schwinger's methods are rather complicated and time-consuming. One of Feynman's most important contributions to the theory of quantized fields is his graphic approach which leads to substantial simplifications and makes it possible to go further and do more complicated calculations. Many current computations, would have been impossible without the help of the new methods.

He concludes:

> It is, therefore, exceedingly gratifying that the Academy of Sciences, with the 1965 Nobel Prize in Physics, has crowned the greatest and most crucial achievement of the past two decades, in theoretical physics.

In a nutshell, Källén thinks Schwinger is GREAT, indeed the greatest of the three in this area. The attentive readers perhaps already have the premonition of what was to come afterwards. Källén loved to knock down great scientists from their pedestals. The greater the better. See further the next chapter.

Källén on Popular Presentation of Science

Before discussing the Källén-Schwinger relationship, this is perhaps the right place to insert an aside about an interesting consequence of Källén's above article as it tells us about his opinion on the popular presentation of theoretical physics.

In 1966, Källén received a letter, dated 19 October, from Jesse W. M. DuMond (1892–1976) at Cal. Inst. Tech., who informed him about a recent article that he had written, with the title "Our Knowledge of Fundamental Constants of Physics and Chemistry in 1965" (see Rev. Mod. Phys. 37 (1965) 537). He referred to Schwinger's calculation of the anomalous magnetic moment of the electron (the famous $\frac{\alpha}{2\pi}$-term) and stated:

> "This famous triumph of the theory of quantum electrodynamics plays an important role in our most recent evaluation of the fundamental physical constants. …"

DuMond had been informed by Kai Siegbahn[5] about Källén's article on the 1965 Nobel Prize. In his letter he expressed the opinion that Källén had *not* gone far enough in his Kosmos 65 article to satisfy his curiosity [about where Schwinger's factor $\frac{\alpha}{2\pi}$ comes from]:

> "… I feel rather hopeless about trying to get help from Professor Schwinger or Professor Feynman, I am wondering if you would consent to try to write, in suitably simple semi-popular language, a more satisfactory explanation of this matter. It seems to me that the physical ideas sufficient to explain how Schwinger arrived at just the term $\frac{\alpha}{2\pi}$, should suffice, at least to satisfy the reader's craving for understanding a little better."

DuMond was asking Källén to write a new more detailed article for the Swedish journal Kosmos. Källén replied that he would certainly be unable to do so:

> "One has to realize in this connection that the Kosmos is mainly intended for readers with a very scanty, if any, knowledge of advanced theoretical physics. It certainly is possible to write about new experimental discoveries for such an audience but, to the best of my judgement, it would need a pedagogical genius to give an account of the development of modern theory on this level, supposing that one does not limit oneself to very general and vague statements as I did in my paper about the 1965 Nobel prize. I hope you realize that I should very much like to write the account that you want if I thought I had even a fraction of the pedagogical ability which would be necessary to do such a thing. Actually, about a year ago when I wrote about the 1965 Nobel prize, I was thinking very hard about how much of the technical side of the matter I could present. I finally decided that it was a hopeless task to even try to give an adequate description of the situation and that I had to be content with a very superficial account which is certainly not very satisfactory to the curious mind. I am myself very much aware of my own limitations and I know it is hopeless for me to try to derive $\frac{\alpha}{2\pi}$ for the readers of the Kosmos and I hope you will forgive me for this."

Nonetheless, Källén wrote a couple more popular science articles (papers [1956a] and [1964a] on his list of publications in Part 5 of this book) but without going into subtle details.

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[5] Kai Siegbahn (1918–2007), Nobel Laureate in Physics 1981, took active interest in the determination of the fundamental constants. See, for example, E. B. Karlsson and H. Siegbahn, Nuclear Instruments and Methods in Physics Research A 601 (2009) 1.