Freeman Dyson
Talk at the 110th Statistical Mechanics Meeting, Rutgers, 15 December, 2013
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Four score and ten years ago an event of considerable importance for our intellectual life occurred. It is being widely celebrated this year (in Singapore and the Institute for Advanced Study for example) and I am deeply honored and very pleased to be asked to add a few words.

The title of my talk as it appears in the program, "Freeman Dyson", is enigmatic because it was hard to decide which of the many facets of Freeman, and my interaction with him, to address. Indeed, I already said a good deal about his accomplishments in our field and his influence on our work in this room earlier at the four score mark, and it is good to avoid repetition.

Much has happened in the past decade. It is fair to say that Freeman has attracted widest public attention for his political, social and literary offerings in this period, but the science is still very much there. He is a great literary stylist, whether writing about quantum fields or religion, and he is arguably the most elegant writer in today’s mathematics and physics communities. His articles and book reviews in the New York Review of Books are carefully read by thousands and are often the topic of lunchtime and dinnertime conversations, at least at my house.

On the science side of the last decade we see that Freeman continues to be productive. A recent paper with Bill Press on the 'prisoner's dilemma' in the Proceedings of the National Academy of Sciences astounded many for its discovery that there are strategies for repeated playing of this two-person game that can, for example, permit one player to control the score of the other player. It is amazing what linear algebra can accomplish. In this paper one can clearly discern the mark of Freeman’s straight to the jugular thinking coupled with his economy of presentation. But this paper with Press is not the whole story about the last decade. With Larry Glasser and Norm Frankel his love of classical mathematics resurfaced with a paper on a power series of Lehmer and its relation to $\pi$.

Freeman has an amazing ability to acquire and organize facts. Another paper within the last decade is one with Thibault Damour on the stability of the Fine-Structure constant – a subject that engaged his attention since at least 1972. How many among us here would know enough nuclear and other physics to be able to analyze critically the data relevant to Shlyakhter’s observation that one can discern the variation of $\alpha$ from the Samarium isotopic distribution in nature’s very own nuclear reactor that was active in an African mine two billion years ago? Such excursions into
basic physics occurred frequently in Freeman’s earlier work, and I strongly suggest to the young – and even the old – in the audience to take a look at his Selected Papers published by the American Mathematical Society. The reader will find another good example in the article Can we control the carbon dioxide in the atmosphere? Who among us would know about, and put together, the relevant information on the growth rate of the American sycamore tree and the CO2 production rate of swamp plants? This kind of information came from participation in an Oak Ridge study group, but few people other than Freeman would be able to use this knowledge to suggest a solution to the CO2 problem.

Further, in this vein, how many of us would be able to use the solar energy production, the mass of the earth, and other parameters, regarded as typical for planetary systems, to calculate the possible radiative output of advanced civilizations, and, therefrom, our chances of receiving greetings from outer space. Look at his article The search for extra-terrestrial sources. In short, arguing with Freeman is like arguing with your smartphone or with the Oxford English dictionary. You can’t win and you can only accept graceful defeat. But even if you don’t agree with him on global warming research, or the role of theology in public life, the main thing is that Freeman, like Nelson Mandela, has an exemplary ability to enter sensitive areas without igniting conflagrations around him.

Having cited these aspects of Freeman’s contributions, we must come back to the epicenter of his dynamic life. Freeman describes himself as an expert in mathematical physics, which he characterized as ”a discipline of people who try to reach a deep understanding of physical phenomena by following the rigorous style and method of mathematics. It is a discipline that lies at the border between physics and mathematics. The purpose of mathematical physicists is not to calculate phenomena quantitatively but to understand them qualitatively. They work with theorems and proofs not with numbers and computers. Their aim is to qualify with mathematical precision the concepts upon which physical theories are built.” This quote, which I learned from Joel Lebowitz’s lecture at the Institute for Advanced Study, is a beautifully concise characterization of mathematical physics, as far as it goes, and Freeman has certainly earned more than his spurs in this endeavor. That is why we are celebrating his birthday at this particular meeting. But I hope he will not mind if I add a couple of remarks to this assessment.

One is that mathematical physics sometimes can go beyond a conceptual understanding of what is already there, for it can create new physics concepts on its own by exploiting mathematics beyond that which is normally used in physics. In other words it is capable of inventing a few new
directions for physics all by itself without waiting for physicists to give the marching orders. In short, it can be regarded as part of physics – contrary to the opinion of some physicists.

A superb example of this is the creation by Freeman and Madhan Lal Mehta, and also earlier work by Eugene Wigner, Michel Gaudin Charles Porter and others of the modern theory of the random matrix theory. Although one may say that it was originally conceived as important to physics, the mathematics that ensued was, indeed, found useful for many problems in real world situations. Random matrix theory is now a big field; the Institute for Advanced Study is now devoting a year to its study.

A second comment about mathematical physics is that things have changed a bit in the two decades since his definition of mathematical physics was written. To many people (including higher ups in funding agencies) mathematical physics now largely connotes string theory or speculative cosmology such as the so-called ‘information paradox’ or something close to these. Such a definition differs from Freeman’s and my definition in two ways: One is that it is not necessary to prove theorems (referred to by some as working in ‘non-rigorous mathematics’), although the theory surely is exciting for some mathematicians. Number two, it need not refer now, or in the future, to real world physics as understood by our forefathers. But languages evolve and this would not be the first time that night and day change places or that some words, like the word ‘sanction’, become their own antonyms.

Let me end by allowing me to indulge in a few personal reminiscences about my own indebtedness to Freeman. My first interaction was as a graduate student in the fifties. There was essentially no book available to learn the modern quantum field theory from, except for Freeman’s book *Advanced Quantum Mechanics*. These course notes have been recently republished and are available online. He wrote it in 1951 when he was 28 years old. How many people can write a leading edge book at that age? I tried to understand it and didn’t really do so until I was 38 years old, but that didn’t stop me from writing a Ph.D. thesis on the topic!

One has to remember that by 1949, at the age of 26, Freeman had established himself as a major theoretical physicist with his papers on *The Radiation Theories of Tomonaga, Schwinger and Feynman* and *The S-matrix in Quantum Electrodynamics*. With these and other papers Freeman established the equivalence of the Feynman, Schwinger and Tomonaga formalisms and showed how pertubative quantum electrodynamics could really be understood. It is a pity that these basic insights into the path integral formulation of field theory did not make it into his *Advanced Quantum Mechanics* book because the path integral formalism, while almost meaningless mathematically,
gives us the easiest way to formulate perturbation theory. Perhaps Freeman can be persuaded to update his wonderful old book with path integrals, which I know he could explain with unparalleled clarity.

My next interaction was Freeman’s 1967 review in Physics Today of my book with Dan Mattis on one-dimensional physics. His positive evaluation helped us a lot, but the point for the moment is that it showed, once again, his interest in the crazy ideas and his willingness to go to bat for them. He said, and I quote “A man grows stale if he works all the time on insoluble problems, and a trip to the beautiful world of one dimension will refresh his imagination better than a dose of LSD”. He predicted, jokingly, that one-dimensional physics would become a popular field, which it did, although this couldn’t have been foreseen then. He also predicted, jokingly, that a journal of one-dimensional physics would emerge, but that didn’t happen, thankfully. In this context we can recall that he wrote at least two important one-dimensional papers: The Dynamics of a Disordered Linear Chain, which made it into our book, and Existence of a Phase-Transition in a One-Dimensional Ising Ferromagnet which came later and had greater impact, although both papers are gems.

My next brush with Freeman was through his fabulous 1967 work with Andrew Lenard on the stability of matter, which motivated Walter Thirring, Joel and me and many others to continue working on the subject. It engaged me in a major research effort for 35 years until the last question raised by Freeman, the ground state of the two-component charged bose gas, was finally settled.

The work of Freeman and Andrew included the stability of matter with fermions (such as electrons) as well as the instability of charged bosons. Closely related to this was the paper on the ground state of bosons with short-range interactions, which attempted to provide a reasonable mathematical foundation for the heuristic calculations of Bogolubov, Foldy, Yang and others. In particular, Freeman realized for the first time that if these papers are correct then charged bosons of finite mass would have an energy proportional to $-N^{7/5}$, thereby providing one of the few realistic examples – maybe the only one – of a system with a finite energy but without a proper thermodynamic limit. I mention this in detail here because it is a topic close to the hearts of statistical mechanicians.

Lastly there was the work with him and Barry Simon on extending the Fröhlich-Simon-Spencer proof of phase transitions in classical systems with continuous symmetry into the quantum regime. As many people here know, aspects of that problem are still open, however. It is hard to understand why this is taking so long and I wish Freeman would hurry up and solve it — before the youngsters
get to it.

There is more to be said but I should stop now. In my remarks ten years ago I compared Freeman to one of the giant trees in the rain forest on which the lives of many flora and fauna depend, but since then he has changed species. He famously wrote: ‘Some mathematicians are birds, others are frogs. Birds fly high in the air and survey broad vistas of mathematics out to the far horizon. They delight in concepts that unify our thinking and bring together diverse problems from different parts of the landscape. Frogs live in the mud below and see only the flowers that grow nearby. They delight in the details of particular objects, and they solve problems one at a time. I happen to be a frog.”

If this is so, he is a frog with wings – the new species whose Latin name must be *Rana Volucris*

We all look forward to meeting here again a decade from now and marvelling at the new flights of this impressive intellect. In the meantime, let us begin the banquet festivities, and more celebration of Freeman’s accomplishments.

Happy 90th Freeman!