Laser and Particle Beams (2000), *18*, 151–152. Printed in the USA.

Book review

Title:	***How the Laser Happened: Adventures of a Scientist***
Author:	Charles Townes
Publisher:	Oxford University Press
Year:	1999
Pages:	256
ISBN:	0-19-5122268-2
Reviewer:	Heinrich Hora, University of New South Wales, Kensington, Australia

All of mankind, not only the readers of this Journal, is now fascinated by the laser. The process of many preceding physics discoveries beginning with Einstein (Zürich lecture, printed 1916, see A. Held, General Relativity and Gravitation One Hundred Years after the Birth of Einstein, Plenum, New York, 1980, Vol. 1, p. 17–21) and how this earth shattering discovery was not recognized by the giants in science is really a process of "how it happened" and the fact is: Charles Townes is its creator. Since there were some dark clouds through which this discovery of our century (next to the quantum theory and the theory of relativity) had to finally shine through, it is a revelation to now read what its creator has to say; modest, quiet, but true and fascinating.

We are most grateful to read this mature summary after so many years. It is very similar to that of Dirac (see Directions of Physics, John Wiley New York 1978, p. 2–20), not saying very much new but presenting the maestro's unique overview. In the case of the laser, indeed the trace may be even more complex and it is most important to now see the documentation through an ingenious retrospect.

Perhaps, the laser could only happen from such a very special curriculum of Townes, plus his ingenuity. Going through rather mediocre universities (Townes nevertheless discovered a new species of fish), only encouragement to perform his Ph.D. at Caltec brought him into the adequate stream of physics. His pioneering work on microwave spectroscopy at Bell Telephone Laboratories was the specifically necessary prelude he later needed. In 1947, the discussion of quadrupole moments by I.I. Rabi and Norman Ramsey brought Townes to speak about the effect of chemical bonds on variations in the energy of nonspherical nuclei (one may appreciate the far sighting argument also in view of the solution to Bagge's numerical series (1948) for the magic numbers of nuclei interpreted in this direction by Jensen and Maria Goeppert-Mayer) to which Rabi said "Charlie . . . there is absolutely no science in it". Nevertheless, Rabi hired him at Columbia University where Rabi and Polykarp Kusch's techniques on molecular beams were most important for his work on microwave spectroscopy. Another later ingredient was the (quadrupole) trap just after its discovery was reported by Wolfgang Paul at Columbia University.

The uniquely fruitful postwar climate for physics and for fundamental research was a further necessary ingredient. Just when he was going to give up ("why is it that we just haven't been able to get anywhere") his very well funded work for the Naval Research Laboratory, he received the quasidivine inspiration on 26 April 1951: to boost the energy of a microwave beam by the stimulated emission from excited ammonia molecules. Though Norman Ramsey had just discussed this as "negative temperatures", Townes envisaged the use of the resonating optical cavity as crucial in combination with molecular beam techniques including the Paul trap. This historic first laser was documented in written form on 11 May, 1951. Townes carefully acknowledges the preceding work by Einstein; Tolman, 1924; Houtermans, 1932; Fabrikant, 1939; and Ramsey (the otherwise exceptionally complete presentation of Townes does not mention A.D. Sakharov, 1948: see collected papers, p. 43 or Laser and Particle Beams 5, 163 (1987)) but what was essentially new was that the "basic experiment involved the rectangular box, evacuated but with a tube leading in to introduce the ammonia gas". It took years before Townes' Ph.D. student James Gordon, who was happy to take up the project after working before at a most specific similar technique, got the system running. The postdoc, Herbert Zeiger, cooperated for two years but left before the final success. "Kusch had berated him for wasting two years on this hair-brained project, when he could have been publishing some solid papers on more conventional research". Rabi and Kusch, both of them Nobel Laureates, "came to my office . . . 'Look', they said, 'you should stop the work you are doing. It isn't going to work. You know it's not going to work. We know it's not going to work. You're wasting money. Just stop!'" They liked to get Townes' research funds.

Three months later (early April 1954) it did work. With a second laser they could even produce a beat frequency of 100 Hertz that everyone could hear like the noise from aircraft propellers. But practically nobody else was excited. A renowned Columbia theorist "told me that the masers flatly could not, due to basic physics principles, provide a pure frequency". Niels Bohr in Copenhagen said at a walk "but that is not possible" modifying this more as a courtesy when Townes told how it did work. John von Neumann said in Princeton "that cannot be right!" but later understood it and wrote a famous proposal to Edward Teller. Even the big conferences did not give notice to Townes' presentation of his measurements. The slow phasing in of Prokhorov and Basov in Moscow, with the subsequent presenting of similar schemes where Townes argues with explanations of how any experimental success was possible only much later (mentioning that they said in 1955 "how an ammonia maser *might* work" and Townes said "well, . . . we have one of these working"), and was very helpful in showing how the background developed slowly leading to the well known land slide.

The step to the optical laser includes parallel ruby maser work by Theodore Maiman. His result on 16 May 1960 with ruby showed the narrowing of the luminescence spectrum, but "no flash had been seen". Both the Hughes group and Art Shawlow at Bell Labs independently demonstrated powerful flashes of directed light which made special spots in the wall—clear intuitive proofs that a laser is working.

A special chapter is talking about patent problems. After mentioning some very drastic general cases showing how patent courts did not at all find the truth, the case of Gordon Gould is presented from Townes' side. This is most interesting for the readers since there were some rumors before the decisions of the case, and even more publicity in the media—even in serious laser journals—after Gordon Gould was winning the case which could have induced some reservation about the work of Townes. Now the reader can judge for himself about Gordon Gould.

Townes was always very involved in watching the field he had opened when mentioning the present petawatt lasers at Livermore, its approach to nuclear fusion, laser shots to the moon, and the monstrous information density in laser glass fiber communication up to the laser peeling of potatoes, but he soon left the field and became a most influential research administrator. He belonged to those who with Wernher von Braun, after the appeal of President Kennedy, had the convincing arguments to get many people to the moon and back, while many important physicists expressed most unfavorable criticism to these developments. Later, Townes looked to laser emission in astrophysics and this was found. I think that it is because of his really modest way that he says that if he would not have succeeded that the "laser happened", others would have achieved it within ten years, or at least after they saw lasing in the universe. Most readers of the book will be convinced that this is a clear understatement.