Reminiscences on Optical Soliton Research with Akira Hasegawa

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After receiving my Ph.D. in plasma physics from Princeton University in 1967, I went to Bell Labs in Whippany, N.J., where I applied this knowledge to national defense problems. Remember that in 1967 in the U.S. young scientists were being drafted to fight in Vietnam, and that is one reason that I chose to go to Whippany. Akira Hasegawa was already an established researcher in plasma physics who worked at Bell Labs in Murray Hill, N.J., about 30 miles away. Naturally we soon began communicating by internal mail and telephone (and occasionally by exchanging visits) concerning plasma physics problems of mutual interest, such as the influence of magnetic fields on collisionless shock waves, and ion acoustic waves and solitons. I recall many discussions with Akira Hasegawa about the then recent work of Tosiya Taniuti[1] (Nagoya University) who was developing the "reductive perturbation method" that strongly influenced my thinking about nonlinear wave motion. Encouraged by Hasegawa, I also communicated directly with Taniuti and his students (Sugihara and Kodama) in the years 1969-1971. By nature I am a "packrat," and I still have this correspondence.

About 1970 I began to develop an interest in numerical simulations, at first of plasmas and unmagnetized fluids, and then of wave propagation. I

[1] deceased

developed a code to solve the KdV equation that uses a novel algorithm that I called the Split-Step Fourier (SSF) algorithm in 1971. I also became interested in the theory of wave propagation in random media (WPRM), and together with Ron Hardin (Bell Labs, Whippany) developed a code based on the SSF algorithm to solve the linear parabolic wave equation (Schroedinger equation) for radar propagation through randomly fluctuating high-altitude plasma clouds.

In 1972 my applied research at Bell Labs turned from plasma physics and radar to ocean acoustics, a field that continues even now to be the main focus of my research. Ron Hardin and I converted the radar SSF code to a sonar SSF code, and this work immediately turned out to be a major breakthrough in the field of ocean acoustics when model predictions were found to compare closely with experimental data. Today a descendant of this code (called the "PE model") is widely used by the U.S. Navy, and indeed throughout the world.

Toward the end of 1972 Akira Hasegawa approached me with his ideas about solitons in optical fibers. At that time research in optical fiber communications was a "hot" topic throughout Bell Labs, due mainly to the then recent development of low-loss optical fibers. However, dispersive spreading of pulses limited the data transmission rate to relatively low values. Hasegawa's ideas about deliberately introducing nonlinearity in order to balance dispersion (and thereby to greatly increase the data transmission rates) was seen by Bell Labs managers to be a radical concept because all of communication theory and engineering is based on linear concepts. Since I was then a rebellious young man, I enthusiastically embraced the optical soliton concept of Hasegawa. Besides, most of my research before then was concerned with linear and nonlinear wave propagation theory and modeling, so this was a natural subject for me to investigate. For about a year a significant portion of my time was devoted to helping Hasegawa develop his optical soliton concept.

First I quickly converted my parabolic wave equation SSF code into a nonlinear optical soliton SSF code that solved the so-called nonlinear Schroedinger (NLS) equation. I made run after run with this code to study stability under the influences of losses, randomness, mismatching, and so forth, both for "bright" and "dark" solitons. Akira Hasegawa and I also made several visits to Bell Labs in Holmdel, N.J., where frontier experimental research on nonlinear effects in optical fibers was being done by Erich Ippen, Roger Stolen, and others. In retrospect, this year (1973) was the most exciting and productive time in my career, since I was also deeply immersed in learning more about ocean acoustics and underwater surveillance systems. The main results of this theoretical and numerical research on optical solitons by Akira Hasegawa and me was published in two papers in Applied Physics Letters in August 1973 [1, 2]. I still have the original handwritten drafts of these two papers. Within a few years researchers at Bell Labs experimentally confirmed the theoretical prediction of optical solitons and their stability, and as the saying goes, "the rest is history."

Meanwhile in 1973 my bosses at Bell Labs, Whippany, found out about my unauthorized research on optical solitons, and severely chastised me for not devoting all of my time to work in ocean acoustics, for which I was being paid, they said. My computer accounts were eliminated one by one due to accusations that my numerical work was "illicit." In disgust, I gave notice of my resignation from Bell Labs in January 1974, and I left at the end of April 1974. [Akira Hasegawa tried to intervene on my behalf by obtaining my transfer to Murray Hill, but without success.] Unfortunately, I never returned to research on optical solitons, but the field seemed to move ahead just as well without my involvement. Although I have been quite happy and successful working in ocean acoustics, I will always wonder whether I could have made a greater impact by continuing research on optical solitons with Akira Hasegawa.

References

[1] A. Hasegawa and F. Tappert, "Transmission of stationary nonlinear optical pulses in dispersive dielectric fibers. I. Anomalous dispersion," Appl. Phys. Lett. **23**, 142–144 (1973).

[2] A. Hasegawa and F. Tappert, "Transmission of stationary nonlinear optical pulses in dispersive dielectric fibers. II. Normal dispersion," Appl. Phys. Lett. **23**, 171–172 (1973).