

Scatterings continued from page 11

In the course of the year 2000, OPN is publishing a series of articles identifying individuals who have made key contributions to our field over the past century.

J.C. Ward: Elegant Physics and a Practical Perspective

by F.J. Duarte

In 1949, Freeman Dyson published two papers in *Physical Review* that demonstrated the equivalence of the quantum electrodynamics theories of Feynman, Schwinger, and Tomonaga. In the second paper Dyson considered the divergence of the S matrix in quantum electrodynamics and showed that the divergences could be consistently removed by a mass and charge renormalization. Dyson wrote expressions for several operators as well as for the renormalized electronic charge. In the process, Dyson “conjectured” that two of the infinite constants involved (Z_1 and Z_2) were identical.

Soon afterwards, early in 1950, a very succinct and elegant letter was published in *Physical Review* that proved in seven steps that indeed $Z_1 = Z_2$. The author of that letter was a 25-year-old Oxford physicist named John Clive Ward. In a second publication in 1951, he extended the initial result to a set of identities. Today, the *Ward Identities*, considered to have greatly simplified calculations in quantum field theory, are standard teaching in theoretical physics.

This was not the first important and elegant contribution that John Ward made to physics, and it wouldn't be the last. In the 1960s he collaborated with Abdus Salam and co-authored some of the papers that became central to what is now known as the *Standard Model*. Yet despite these enormous contributions to modern physics, the name John Ward remains relatively unknown to general audiences and even to many in the physics profession. Who was this brilliant physicist? The focus of this brief tribute is to shed some light on the life and physics of this quiet achiever.

John Ward was born in London on August 1, 1924, and was educated at Oxford. He spent a brief season in Australia in the late 1940s, and returned in 1967, via Princeton and Johns Hopkins, to play a major role in the creation of the physics program at Macquarie University. There he designed a physics curriculum, with the help of R.E.B. Makinson, based on the now famous *Feynman Lectures on Physics*, and encouraged the formation of a superb undergraduate experimental physics program led by Elmer Laisk. Under his influence, the foundations of a Macquarie physics education became a combination of courses in electromagnetism, quantum

physics, solid state physics, and experimental physics, in addition to courses in applied mathematics. A program in advanced electronics, under the leadership of R.E. Aitchison, was also created.

At Macquarie John became known for his forceful defense of science, high academic standards, and uncompromising honesty. In this regard, in the late 1970s he openly supported the student movement that permanently changed the degree structure of the university.

Ultimately, this innovation significantly strengthened the sciences at Macquarie. Indeed, John was very pleased with the results and proud of his participation in this reform movement.

Although a gifted theoretician, John Ward always maintained a profound respect for experimental physics and engineering. His well-balanced and utilitarian philosophy was reflected in the nature of the Macquarie physics degree and in some respects influenced his decision not to create a formal program in theoretical physics—despite the fact that he taught a course on theory, for honours students, entitled Topics in Physics. As a teacher he was not always easy to understand, although he

demonstrated to his students the physicist's talent for solving problems in a simple and straightforward manner which he favored over other more formal or mathematical approaches.

Most of his physics was created prior to the Macquarie years. Although he did not publish extensively, several of his contributions constituted significant developments in theoretical physics. In addition to the Ward Identities and his papers with Salam on the Standard Model, John made major contributions to solid-state physics (with J. Wilks), statistical mechanics (M. Kac, E.W. Montroll and R.B. Potts), and to quantum statistics (J.M. Luttinger) in papers published in the 1950s and early 1960s. He is also credited with the design, in the mid 1950s, of a hydrogen thermonuclear device for the British. Recently, this work has attracted the interest of historians.

John's contributions to optics were at a fundamental level. In 1947, for instance, while at the Clarendon Laboratory, he co-authored, with M.H.L. Pryce, a paper published in *Nature*¹ that introduced the theory for the emission of correlated quanta, from a single source, in opposite directions. This brief paper gives a formula to calculate the expected coincidence rate as a function of azimuths. This quantum result was essential to the development of experiments designed to deal with the Einstein-Podolsky-Rosen paradox and subsequently to test Bell's inequalities. In the field of quantum electrodynamics, the relevance to the photon of his work on renormalization is described in two papers published in *Physical Review*. The first paper, published in 1950, dealt



John Clive Ward.

with the scattering of light by light; the second, published in 1951, was on the interaction of nucleons, mesons, and photons.

At Macquarie, after the arrival of J.A. Piper, John often demonstrated an interest in optics and laser physics, suggesting experiments in areas such as selective multiple-step laser excitation and high-resolution laser spectroscopy. Most of these discussions were informal and took place in the traditional tea room.

The papers written by John are distinctly brief and extremely elegant. For instance, "An identity in quantum electrodynamics"² is less than one-half page long and includes seven mathematical steps. "Scattering of light by light"³ is even shorter and includes only one integral equation. But in terms of elegance perhaps the most striking paper is "A convergent non-linear field theory."⁴ This is a work of art less than one-half page long that opens with a Lagrangian followed by the appropriate Schrodinger equation and concludes with a Feynman diagram depicting "the simplest possible self-energy graph." His ability to express meaningful physics in such a succinct and elegant manner was faithful to the axiom of beauty in physics articulated by Paul Dirac.

For his contributions to theoretical physics, he was elected Fellow of The Royal Society and received several prestigious awards including the Heineman Prize, the Hughes Medal, and the Guthrie Medal. Many respected physicists believe, however, that his work on the Standard Model was not sufficiently recognized. In retrospect, what matters is that his ideas and equations contributed to the advancement of physics and did so in a way that inspired admiration among his most illustrious peers. For his work in quantum electrodynamics, for instance, Sakharov classified him as one of the titans of modern physics, alongside Feynman, Schwinger, Tomonaga, and Dyson. These sentiments are felt beyond the borders of the world of theoretical physics, and have found echo in the optics community, for example in the opinion of Willis Lamb, who has explicitly expressed his admiration for John and his work.

John is often described as eccentric, strange, and unusual. He certainly was an unusual man, with rare talents and a subtle sense of humor. In addition to being an accomplished piano and French horn player, he was also a maker of wine. On the personal side he was fairly modest, extremely honest, and always expressed his opinion in a direct and straightforward fashion. This quality was not always appreciated by university administrators. The truth is that John cared deeply about the future of the students, the university, and society as a whole. The Macquarie physics program was testimony to this commitment since it

offered a set of basic and fundamental courses designed to maximize the practical value for students.

I had the privilege of sharing the last couple of days of 1999 and the first day of 2000 with John, in Santiago de Chile... at the foot of the Andes Mountains. We discussed a plethora of topics including physics, astronomy, entropy, and geopolitics. We laughed, tasted some wine, and celebrated our achievement in the science reforms at Macquarie. He was looking forward to getting back to work on his physics and he suggested teaching jointly a refresher physics course for high school teachers in Santiago, similar to a course he had taught at Macquarie.

But this was not God's will. Following a trip to the South Pacific, John passed away May 6, surrounded by his immediate family... an enormous loss to physics and those who had the fortune to know him.

References

1. Pryce, M.H.L., and Ward, J.C., *Nature*, **160**, 435 (1947).
2. Ward, J.C., *Physical Review*, **78**, 182 (1950).
3. Ward, J.C., *Physical Review*, **77**, 293 (1950).
4. Ward, J.C., *Physical Review*, **79**, 406 (1950).

F.J. Duarte is based in Rochester, New York.

Exciting New Membership Benefit!

Stay in touch with colleagues... Never change your e-mail address again!

OSA now offers a personal e-mail alias service—available exclusively to OSA members.

Just register with OSA and enjoy the benefits of:

- ✓ An e-mail address that stays with you for life
- ✓ An easy-to-remember, easy-to-use mail location that automatically affiliates you with OSA
- ✓ A one-stop shop for information changes and updates.

Have you changed your Internet Service Provider, your e-mail address or your employer? Just notify OSA and your e-mail alias will be updated—automatically!

Now, the only e-mail address you'll ever need is as easy as `yourname@osa.org`.

Register today for this **free** service at www.osa.org or call Aimee Gibbons at 202/416-1431 for more details.