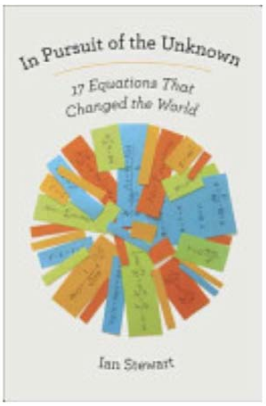
SPACE JAPAN BOOK REVIEW

From a satcom researcher point of view

Reviewer: Takashi Iida, Editorial Advisor

Ian Stewart: “In Pursuit of the Unknown: 17 Equations That Changed the World”, Basic Books, 2012.



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First of all, the reason why this book is reviewed in this column is described. This book takes up 17 equations that led the human civilization. Especially the Maxwell equation among them is the comprehensive studies of electromagnetism, and this is a basic of the basics of current radio communication, and naturally it is the basics of satellite communications. According to the reason above, it is thought that this book is eligible for the article of Space Japan Review. Now, let’s start to introduce this book with related topics.

The author of this book, Ian Stuart, is a Mathematics professor at the University of Warwick in the UK, a mathematician active at the forefront in the United Kingdom, and becomes a Fellow of the Royal Society in 2001. He is also famous as an author of popular science articles, writes actively to newspapers and magazines, and appears to science television programs as well.

In this book, for 17 equations, involving starting from the Pythagorean theorem showing the relationship $a^2 + b^2 = c^2$ of a length of three sides of a right triangle, Einstein’s theory of relativity, Schrödinger’s equation of quantum mechanics and chaos theory, the background, the process of development and the future outlook are explained. Needless to say, among the equations taken up, the most relevant to us is the Maxwell's equations. A parabolic antenna is illustrated along with the Maxwell's equations on the cover of this book of Japanese version. Therefore, in the following, it will be introduced to focus on the discussion of Maxwell's equations.

In the chapter of Maxwell's equations, first, M. Faraday is introduced as a scientist who made the major finding that triggered revolutionary technical and social evolution including electricity used as the current. It is introduced that he tied inextricably to the separate phenomena of electricity and magnetism and established the basic physics of electromagnetism. His discovery of electromagnetic induction led to prompt the study of electric power and made the development of the electric power generator instead of voltaic cell. It became the basis for electrical civilization flourish. Since Faraday was not educated in mathematics, he explained his result of the experiments on the basis of the mechanical metaphor. J. C. Maxwell, who was born in the year when Faraday announced his electromagnetic induction principle, made efforts at getting a degree in math and at establishing the mathematical basis for Faraday’s theory and experiments through reading Faraday’s experimental work. He derived the Maxwell’s equations as mathematical equations instead of Faraday’s mechanical theory. At this time, it was an issue how to present the "field", Faraday’s originality. But Maxwell succeeded in getting the formula as a flow of electrical fluid, and in representing as a system of vector. Then he realized that a coefficient of the wave equation that comes out when the behavior of electric and magnetic field is expressed in equation is equal to the speed of light in the vacuum. This has led to the astounded discovery that light is an electromagnetic wave. Thereafter, H. R. Hertz supported the existence of electromagnetic waves by experiments, and G. Marconi has evolved to the success of the wireless transmission of 1.5 km. It is pointed out that the four equations of Maxwell and a few lines of vector analysis triggered use of electromagnetic wave in all areas of human activity with the development over more than 100 years including radio, television, radar, mobile phone, X-rays and terahertz waves utilization. Marconi’s invention opened the way for wireless communication. It is famous in Japan that the war situation advantageous was triggered by conveying quickly the encryption information of "Enemy ship is observed" via wireless communication at the time of the Russo-Japanese War. I think that the wireless communication attracted major attention as a military communication in Japan, but only radar application is described as a military application in this book. This chapter concludes that Maxwell's equations not only changed the world, but also opened a new horizon of the world.

The new horizon of the world means a development of the Einstein theory. First, an interesting description is included about the ether that was considered convey electromagnetic waves

predicted by Maxwell's equations. If velocity of light is constant in the ether, experiments trying to detect the difference in the speed of light in two orthogonal directions were made in the end of the 19th century. However, any difference in the speed of light was not found in the experiment, the presence of ether was denied. Since it is found that the electromagnetic theory of Maxwell's equations is not behave relatively respect to the reference coordinate system in motion and that the light speed is invariable, the stage of emergence of Einstein was equipped well. Einstein has created the special theory of relativity that applies to all laws of physics as well as of electromagnetism, namely a theory about space, time and substance under absence of gravity. Further, Maxwell showed that light is wave and has properties as an electromagnetic wave. However, it is verified in the beginning of the 20th century that the light behaves as particles. Einstein gave an equation of $E = mc^2$ (E: energy, m: mass, c: speed of light) as a formula that relates energy change of mass due to photons emitted with the change of relativistic mass. Furthermore, Einstein did not satisfy to create only the special theory of relativity. He developed the general theory of relativity including all elements of gravity that space-time is distorted under existence of gravity.

Following Einstein, Schrödinger's equation has been described. If light as a particle is a wave, the equation was derived by assuming that electron has also the nature of the wave. Considerable space is devoted to the context including the superposition of the quantum and the semiconductor technology, but the descriptive content was felt to be a little difficult for me. The description of the book [1] is very easy for me to understand about the Schrodinger's equation. In addition, the formula of particle physics on the subsequent Schrödinger's equation are deployed to the discovery of the Higgs particle[2], but, it is a little regrettable that this book does not write about it. Furthermore, it is more desirable that the trend of physics to elucidate the birth of the universe stemmed from Einstein's general theory of relativity[3] is mentioned.

Shannon's information theory is also introduced as equations for communication. Further, the chaos theory and the Black-Scholes equation are described. In the chaos theory, it is pointed out that the event seems to be random is actually generated from the deterministic behavior according to the theory. In relation to the Black-Scholes equation, it is also mentioned with respect to Lehman-shock.

The most interest is what is the next to 17 equations that is written at the last chapter of the book. It is described to be sure that the following is not the continuous equation like the conventional one but the new natural laws on the basis of the digital structure and system simulated the world digitally to run an algorithm instead of solving equation. This book is so interesting that it makes us inspire since it gives us bird's eye view about the equations seemed to be difficult as described above and a lot of episodes related to the equations are included. However, since the content is fairly advanced though writing in the plain, there is a part beyond my comprehension. If 20 several pages long description for each equation is divided in a small section, it will be read more easily. Finally, this column is closed after introducing the helpful review about this book is reported in Reference [4].

Reference

[1] Masato Murakami: "Persuasive Quantum Physics Part I", Kaimei Publish, 2006.
[2] "NHK Special: God's Equation Part 1 What the world is made of? —100 years hard struggle by genius—", NHK TV, Sep. 21, 2013.
[3] "NHK Special: God's Equation Part 2 How the space is born? —Genius challenges the final difficult problem—", NHK TV, Sep. 22, 2013.
[4] Yoshimasa Yoshinaga: "Book Review: 17 Equations Changed the World Author: Ian Stewart, Mathematical history supported human advancement", Nikkei Shimbun Newspaper, Jun. 9, 2013.