Office for Outer Space Affairs
United Nations Office at Vienna

Einstein and Space Weather?

In 2012 SERC to ICSWSE

Recalling
Albert Einstein's Visit to Japan in 1922

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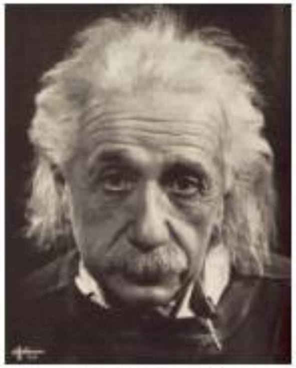
United Nations Office for Outer Space Affais
United Nations, Vienna, Austria

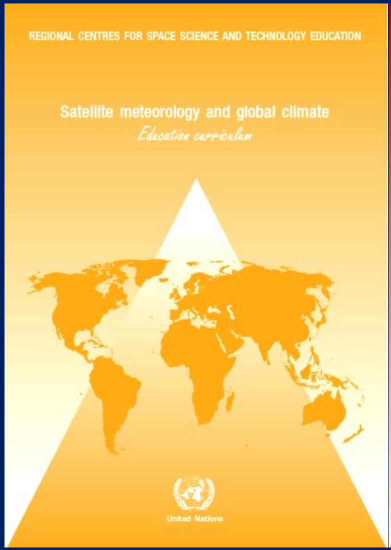
Presentation at the occasion of the inauguration of the
International Center for Space Weather Science and Education
at the 10th anniversary of SERC of
Kyushu University, Fukuoka, Japan
14 March 2012

Office for Outer Space Affairs
United Nations Office at Vienna

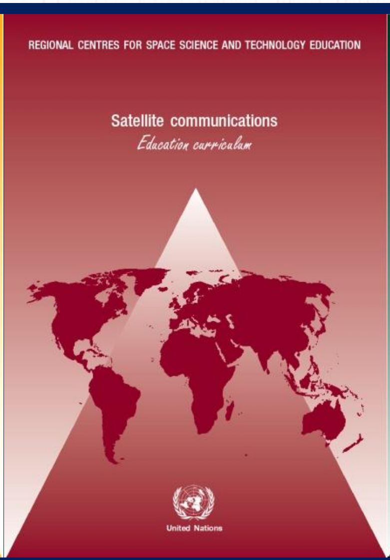
Regional Centres for Space Science and Technology Education (affiliated to the UN)

$$ds^2 = -\left(1+\frac{2\Phi}{c^2}\right)(c\ dt')^2 + \left(1-\frac{2\Phi}{c^2}\right)(dx^2+dy^2+dz^2)$$

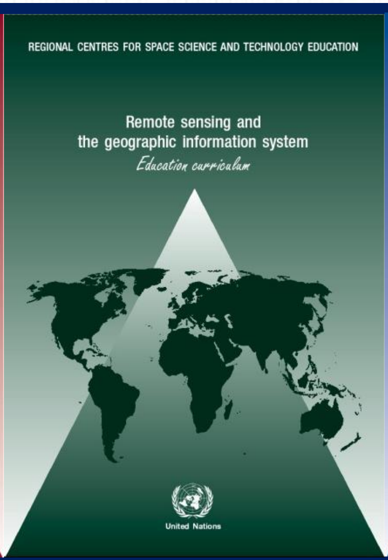




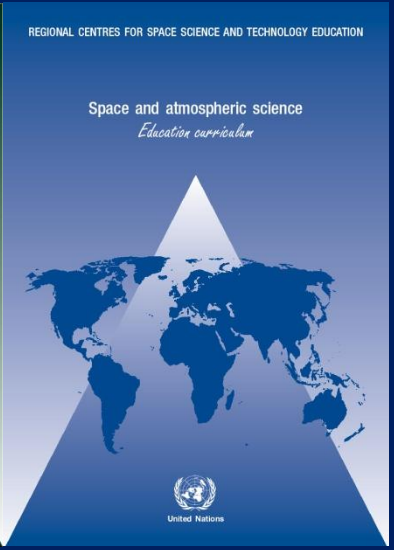
Meteorology



Communications



Remote Sensing

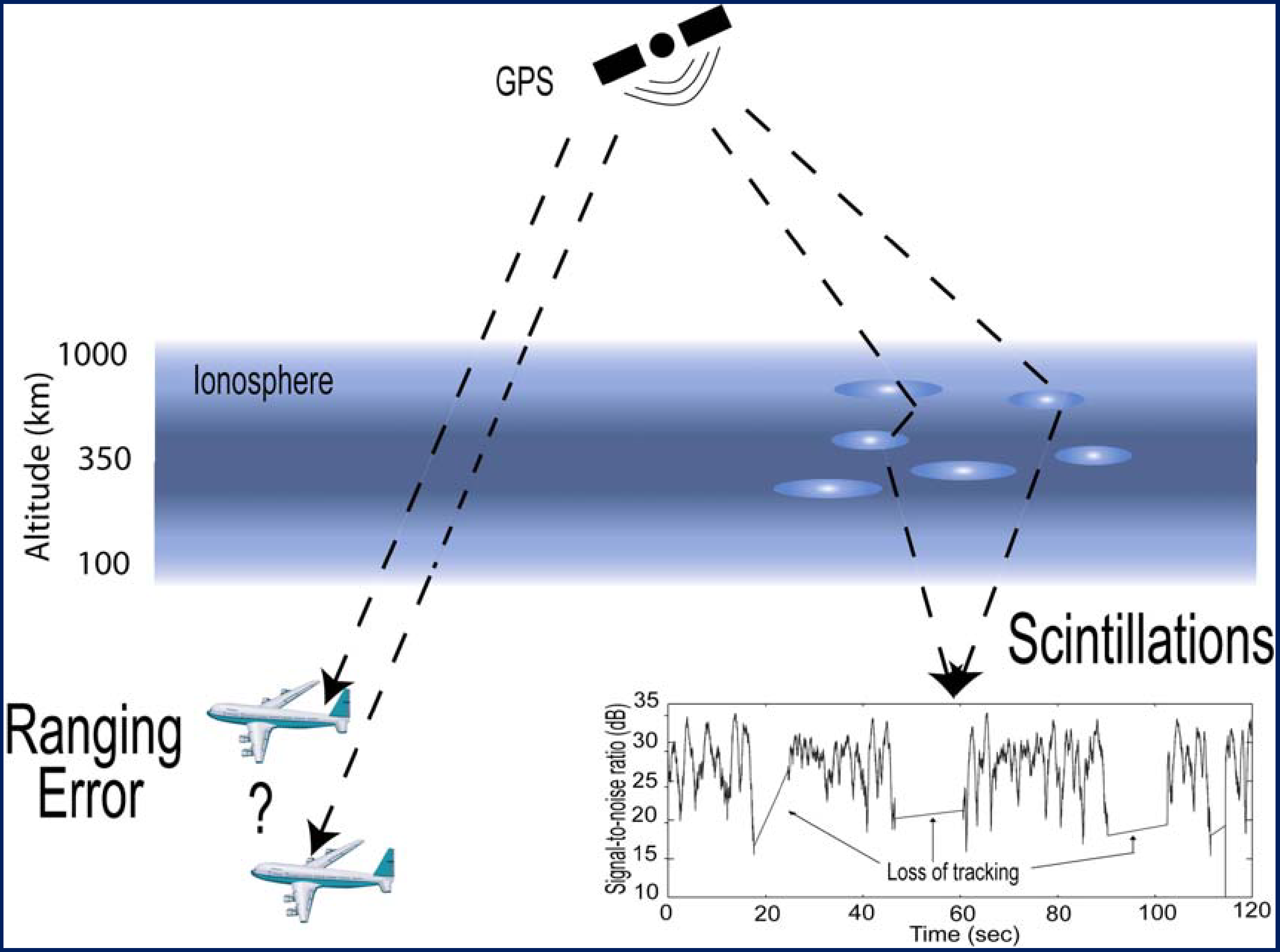


Space Science

Future: GNSS

Space Weather: Ionospheric Effects on GNSS Signals

Both code and phase ranging errors are created by signal propagation throughout the ionosphere. If ionospheric density irregularities exist, the signals are scattered, producing amplitude scintillations.
Space weather begins at the Sun (+cosmic rays): cycle of sunspots, magnetic field → solar flares, x-rays, energetic particles, coronal mass ejections, solar wind



Einstein’s Special and General Theories of Relativity

- Special theory of relativity
  - Created in 1905 (H.A. Lorentz, H. Poincaré)
  - Concerns kinematics, mechanics, and electromagnetism

- General theory of relativity
  - Completed in 1916 (D. Hilbert)
  - Concerns gravitation
  - Not a separate theory: includes special relativity

- Today the general theory of relativity is not simply a subject of theoretical scientific speculation (unification with quantum field theory ?), but rather it has entered the realm of practical engineering necessity.

- Relativistic effects must be considered in the transport of atomic clocks and the propagation of electromagnetic signals (GNSS).

Three effects contribute to the net relativistic effect on a transported clock

- Velocity (time dilation)
  - Makes transported clock run slower relative to a clock on the geoid
  - Function of speed only
- Gravitational potential (red shift)
  - Makes transported clock run faster relative to a clock on the geoid
  - Function of altitude only
- Sagnac effect
  - Makes transported clock run faster or slower relative to a clock on the geoid
  - Depends on direction and path traveled: effects manifests itself in a setup called ringinterferometry

Applied to GPS of GNSS

- Gravitational redshift (blueshift)
  - Orbital altitude 20,183 km
  - Clock runs fast by 45.7 μs per day

- Time dilation
  - Satellite velocity 3.874 km/s
  - Clock runs slow by 7.1 μs per day

- Net secular effect (satellite clock runs faster)
  - Clock runs fast by 38.6 μs per day

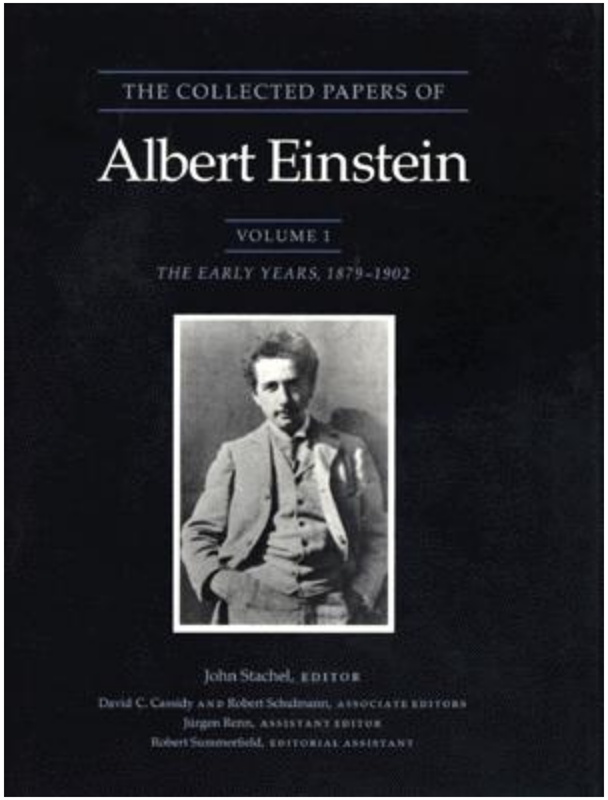
- Residual periodic effect
  - Orbital eccentricity 0.02
  - Amplitude of periodic effect 46 ns

- Sagnac effect
  - Maximum value 133 ns for a stationary receiver on the geoid

Einstein Papers Project
(Hebrew University, Princeton University Press, Boston University, California Institute of Technology)

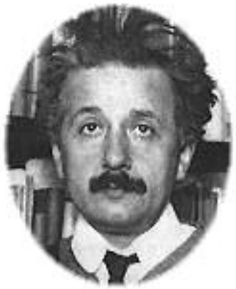
The published volumes draw upon more than 40,000 documents contained in the personal papers of Albert Einstein (1879-1955) and more than 30,000 additional Einstein and Einstein-related documents discovered by the editors since the 1980s.
The printed series will contain over 14,000 scientific and non-scientific documents, and will fill close to 30 volumes.

Volume 13, to be published in 2012 by Princeton University Press,
will contain all documents on Einstein's visit to Japan 1922



Kyoto 1922: Einstein studied Lorentz's *Versuch* and then worked on Fizeau's experiment and stellar aberration before discovering special relativity.

- "…I had the chance to read Lorentz's monograph of 1895. There, Lorentz dealt with the problems of electrodynamics and was able to solve them completely in the first approximation…
- … Then I dealt with Fizeau's experiment and tried to approach it with the hypothesis that the equations for electrons given by Lorentz held just as well for the system of coordinates fixed in the moving body as for that fixed in the vacuum…
- …Why are these two things [constancy velocity of light and classical velocity addition] inconsistent with each other? I felt that I was facing an extremely difficult problem. I suspected that Lorentz's ideas had to be modified somehow, but spent almost a year on fruitless thoughts. And I felt that was puzzle not to be easily solved."
- From a lecture given in Kyoto, Dec. 14, 1922. Notes by Jun Ishiwara



"Why are these two things inconsistent with each other? I felt that I was facing an extremely difficult problem. I suspected that Lorentz's ideas had to be modified somehow, but spent almost a year on fruitless thoughts. And I felt that was puzzle not to be easily solved.

But a friend of mine living in living in Bern (Switzerland) [Michele Besso] helped me by chance. One beautiful day, I visited him and said to him: 'I presently have a problem that I have been totally unable to solve. Today I have brought this "struggle" with me.' We then had extensive discussions, and suddenly I realized the solution. The very next day, I visited him again and immediately said to him: 'Thanks to you, I have completely solved my problem."

My solution actually concerned the concept of time. Namely, time cannot be absolutely defined by itself, and there is an unbreakable connection between time and signal velocity. Using this idea, I could now resolve the great difficulty that I previously felt.

After I had this inspiration, it took only five weeks to complete what is now known as the special theory of relativity."

From a lecture given in Kyoto, Dec. 14, 1922. Notes by Jun Ishiwara; translation Akira Ukawa; revised John Stachel.

J. VAN DONGEN: On the role of the Michelson-Morley experiment: Einstein in Chicago

http://arxiv.org/ftp/arxiv/papers/0908/0908.1545.pdf

Einstein traveled to Japan in 1922, and at Kyoto University gave a lecture entitled "How I created the theory of relativity." To date, this lecture has been the most detailed source of information concerning Einstein's (non-)involvement with the Michelson-Morley experiment, but there is no universal agreement about its precise content. In a recent rendition,11 Einstein is quoted as having said that he initially did not doubt the movement of the earth relative to the ether, and that he thought up an experiment to test this assertion. In the arrangement, light from a single source was to be split into two light beams moving parallel and in opposite direction to the earth's motion; the presumed difference in the energy of the two beams was to be measured by thermocouples. Einstein added: "This idea was of the same sort as that of Michelson's experiment, but I did not know this experiment very well then." Yet, his ignorance would not last long: "While I had these ideas in mind as a student, I came to know the strange result of the Michelson experiment. Then I came to realize intuitively that, if we admit this as a fact, it must be our mistake to think of the movement of the earth against the ether. That was the first route that led me to what we now call the principle of special relativity."12

This passage suggests that the Michelson-Morley experiment did, after all, influence Einstein in a direct way, and was relevant in the construction of the theory. Nevertheless, considerable debate has persisted, focusing on the translation of the Kyoto address. Notes of the lecture were taken in Japanese by Einstein's interpreter, Jun Ishiwara; two English translations appeared in 1979 and 1982.13 These translations indeed implied a direct role for the Michelson-Morley experiment, but they have been criticized by Seiya Abiko and Ryoichi Itagaki. Regrettably, these critics are however not agreed on what a proper translation should be. According to Itagaki, the above passage, taken from Abiko (p. 13), should read: "But when, still as a student, I had these thoughts in my mind, if I had known the strange result of this Michelson's experiment and I had acknowledged it as a fact, I probably would have come to realize it intuitively as our mistake to think of the motion of the Earth against the ether."14

For scholars who do not master the Japanese language, and given that Einstein actually delivered his lectures in German, it is thus difficult now to know Einstein's precise words in Kyoto on the Michelson-Morley experiment.15 Fortunately, recently uncovered documents show that, a year earlier, Einstein addressed the issue on a similar occasion in Chicago.

Abiko, Seiya (2000) "Einstein's Kyoto address: 'How I created the theory of relativity'", *Historical Studies in the Physical and Biological Sciences*, *31*, pp. 1-35.

[11] See (Abiko 2000); a translation of Einstein's lecture is on its pages 13-17.
[12] Einstein, as in Abiko, *ibid*. on p. 13.
[13] Jun Ishiwara, pp. 131-133 in *Ainsutain Koenroku* (Tokyo: Kaizo-sha, 1923); (Ogawa 1979), (Einstein 1922/1982).
[14] (Itagaki 1999).
[15] The future Volume 13 of the Collected Papers of Albert Einstein is to provide another, authoritative translation of the Kyoto lecture.

Prof. Dr. Eiichi Yasui

1960–1987 Teaching and research at Humboldt University, Berlin, Germany.
He focused on didactics of Japanese language as well as translation of scientific and technical texts from German into Japanese

Jun Ishiwara's Notes on Einstein's Lecture 1922: Translation 1987 into German by E. Yasui
(B.L. van der Waerden, The Netherlands)

Archive for History of Exact Sciences 36(1986) 271 - 279

Jun Ishiwaras Text über Albert Einsteins Gastvortrag an der Universität zu Kyoto am 14. Dezember 1922

(Eine Übersetzung aus dem Japanischen)

HANS JOACHIM HAUBOLD & EIICHI YASUI

Vorgelegt von B. L. VAN DER WAERDEN

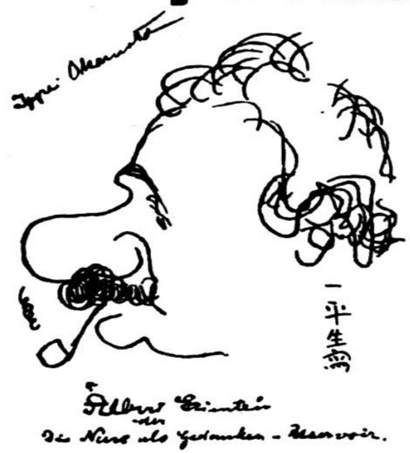
Gedrängt das Volk, gespitzt die Ohren,
Sie sitzen alle wie verloren,
In Sinnen tief, verzückt der Blick,
Ergeben in ein hart' Geschick.
Der EINSTEIN an der Tafel steht,
Die Predigt rasch vom Stapel geht,
Und ISHIWARA flink und fein,
Schreibt alles in sein Büchlein ein.
A. EINSTEIN

I. Einführung

Die Ergebnisse der beiden britischen Expeditionen zur Beobachtung der totalen Sonnenfinsternis am 29. Mai 1919 bestätigten die von EINSTEINS Allgemeiner Relativitätstheorie vorhergesagte Lichtablenkung im Gravitationsfeld der Sonne. In einer gemeinsamen Sitzung der 'Royal Society' und der 'Royal Astronomical Society' am 06. November 1919 in London wurde der wissenschaftlichen Welt diese experimentelle Bestätigung der EINSTEINschen Theorie bekanntgegeben und als bedeutendste Entdeckung der Gravitationstheorie nach NEWTONS Aufstellung seiner Grundgesetze gefeiert (FRANK 1979). Das damit begründete weltweite Interesse an den Forschungsergebnissen ALBERT EINSTEINS führte ihn in den Jahren 1921 bis 1932 zu ausgedehnten Vortragsreisen an international bekannte Forschungseinrichtungen. So weilte EINSTEIN im Dezember 1922 auf Einladung des japanischen Physikers Y. NISHIDA an der Universität zu Kyoto. Auf die Bitte von NISHIDA hin erklärte sich EINSTEIN bereit, vor Studenten der genannten Universität den hier in Rede stehenden von seinem Charakter her didaktischen Vortrag über seinen Weg zur Schaffung der Relativitätstheorie zu halten. Auf der Vortragsreise durch Japan begleitete ihn der japanische Physiker J. ISHIWARA, der selbst Arbeiten zu Problemen der Relativitätstheorie unternommen und veröffentlicht hatte und der EINSTEIN bereits im Jahre 1912 persönlich kennenlernte

Jun Ishiwara's Notes on Einstein's Lecture 1922 : Translation 1982 into English by Y.A. Ono
(J. Stachel, USA)

How I created the theory of relativity



"The nose as a reservoir for thoughts" cartoon by Ippei Okamoto. (Courtesy AIP Niels Bohr Library.)

This translation of a lecture given in Kyoto on 14 December 1922 sheds light on Einstein's path to the theory of relativity and offers insights into many other aspects of his work on relativity.

Albert Einstein
Translated by Yoshimasa A. Ono

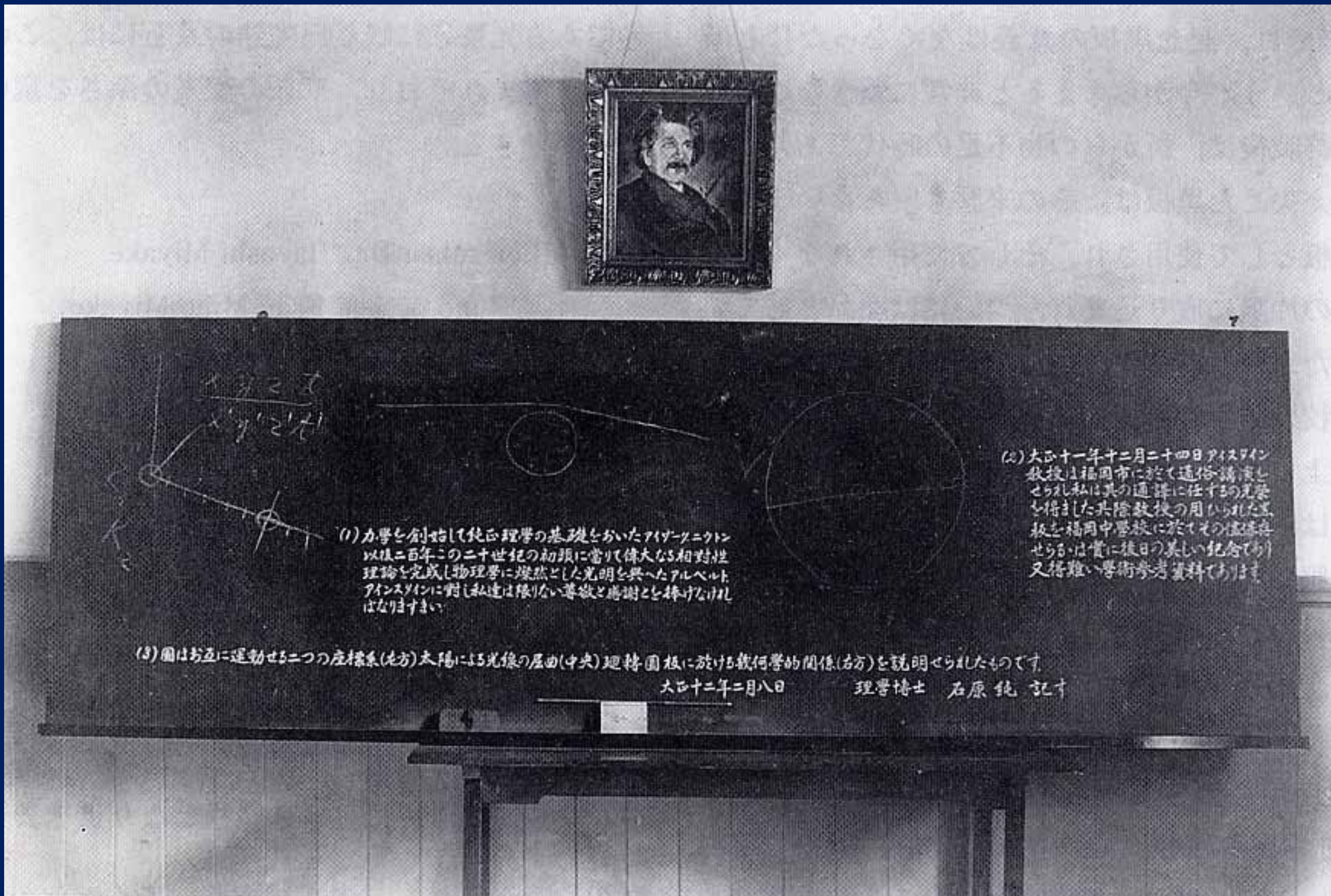
It is known that when Albert Einstein was awarded the Nobel Prize for Physics in 1922, he was unable to attend the ceremonies in Stockholm in December of that year because of an earlier commitment to visit Japan at the same time. In Japan, Einstein gave a speech entitled "How I Created the Theory of Relativity" at Kyoto University on 14 December 1922. This was an impromptu speech to students and faculty members, made in response to a request by K. Nishida, professor of philosophy at Kyoto University. Einstein himself made no written notes. The talk was delivered in German and a running translation was given to the audience on the spot by J. Ishiwara, who had studied under Arnold Sommerfeld and Einstein from 1912 to 1914 and was a professor of physics at Tohoku University. Ishiwara kept careful notes of the lecture, and published[1] his detailed notes (in Japanese) in the monthly Japanese periodical *Kaizo* in 1923; Ishiwara's notes are the only existing notes of Einstein's talk. More recently T. Ogawa published[2] a partial translation to English from the Japanese notes in *Japanese Studies in the History of Science*.

But Ogawa's translation, as well as the earlier notes by Ishiwara, are not easily accessible to the international physics community. However, the early account by Einstein himself of the origins of his ideas is clearly of great historical interest at the present time. And for this reason, I have prepared a translation of Einstein's entire speech from the Japanese notes by Ishiwara. It is clear that this account of Einstein's throws some light on the current controversy[3] as to whether or not he was aware of the Michelson–Morley experiment when he proposed the special theory of relativity in 1905; the account also offers insight into many other aspects of Einstein's work on relativity.

—*Y. A. Ono*

Albert Einstein's Arrival at Hakata Railway Station on 24 December 1922
(from Prof. S. Abiko)

Albert Einstein’s Drawings on the Blackboard After Lecturing on 25 December 1922
(from Prof. S. Abiko)



Mrs. Elsa Einstein and Albert Einstein in Fukuoka on 26 December 1922
(from Prof. K. Yumoto)

日本旅館で最初の夢
學聖が親しむ福岡の風物
五彩の花籠を受て喜ぶ快濶な夫人
日本の旅行は淡い夢客室は詩の國
博多織と人形とを贈る

九大招待會で 總長の熱烈の辭
金屏風で日本式に飾る
宮入貝や犀の化石や金魚陳列
ア博士熱心に觀察す

◇ア博士歡迎會□□(廿四日夜のバクリスタ)□□

Thank you, Japan!

… we continue studying Albert Einstein’s writings as a source of wisdom and pleasure for the benefit of science and society.

In this regard we also recall Albert Einstein’s Letter to the General Assembly of the United Nations in 1947