The Department of Physics, Nagoya University

Yuko Okamoto
Department of Physics, Graduate School of Science, Nagoya University

Fig. 1: Newton's apple tree with flowers and Buildings B (right) and C (left) at the School of Science, Nagoya University (April, 2020). The lecture rooms and research groups of the Department of Physics are now housed in Buildings A, B, C, D, the Science Hall, the Science and Agricultural Building, and the Engineering and Science Building.

HISTORY

In 2011, a clone of Newton's apple tree was presented from the Koishikawa Botanical Garden of the University of Tokyo and planted in the School of Science at Nagoya University to celebrate the 2008 Nobel Physics Prize awarded to two of our former students, Professors Makoto KOBAYASHI and Toshihide MASKAWA (see Fig. 1).

Nagoya University was founded in April 1939, when Nagoya Imperial University was inaugurated as Japan's ninth Imperial University. In May 1940, the School of Science and Engineering was established and in April 1942, it was split into two schools, namely, the School of Science and the School of Engineering. The School of Science consisted of four departments: the departments of mathematics, physics, chemistry, and biology. The Department of Physics initially had three "kozas". Koza (講座) is a Japanese word literally meaning "lecture chair" and in its full scale, it consisted of a full professor (kyoju, 教授), an assistant professor (jokyoju, 助教授), and two research associates (joshu, 助手). A koza, therefore, was a research group that would be under the strong leadership of a full professor. The number of kozas in the Department of Physics was increased to four in October 1942, and to five in November 1943. The department maintained five kozas until 1957, when another koza was added. In Figure 2 we show one of the earliest photos of professors and students of the physics department, in 1942.

Fig. 2: One of the earliest photos of the professors and students of the Department of Physics, School of Science, Nagoya University (1942). Front row from left: Profs. Ryozi UYEDA, Naomi MIYABE, Goro HAYAKAWA, and Masami HAYAKAWA.

The first full professors, after the five kozas were established in 1943, were Naomi MIYABE (geophysics), Kanetaka ARIYAMA (condensed matter physics theory), Ryozi UYEDA (condensed matter physics experiment), Shoichi SAKATA (elementary particle physics theory), and Yataro SEKIDO (cosmic ray physics). The Department of Physics, with five kozas, therefore had about 20 faculty members; including the technical staff, it had about a total of 30 faculty and staff members. There were 20 undergraduate students per year, and about two to five graduate students per year. The Imperial University education typically lasted three years for undergraduate students and several additional years for graduate students. Hence, the total number of physics students at the department in a given year was about 60 to 70 altogether.

In the middle of World War II, the Japanese Government was poor. Unlike other Imperial Universities of Japan, which had some brick buildings, the buildings of Nagoya Imperial University were essentially all wooden as shown in Fig. 3 (until the 1950s, when the university started to construct concrete buildings). The Department of Physics had also to suffer from various war-time disasters. For instance, Assistant Professor (jokyoju) Goro HAYAKAWA (optics) was killed in Tokyo on March 10, 1945, when Tokyo was systematically destroyed by American air raids and bombing (carpet bombing). (Assistant Professor Goro HAYAKAWA's position was later taken by full Professor Yataro SEKIDO.) The city of Nagoya was not free from war disasters, either. On March 25, 1945, one of the students in the physics department died from a bomb, as one of thousands of citizen casualties. As a result, the Department of Physics immediately decided to evacuate into safer rural areas of Japan such as Komoro (experimental groups) and Fujimi (theoretical groups) in the Shinshu Region (mostly in present Nagano Prefecture). The entire physics department, consisting of about 100 members, moved to these safer areas. The physics department rented an elementary school, public library, Buddhist temples, and warehouses of local business, and turned them into classrooms, laboratory rooms, office rooms, etc. It also rented rooms for housing and boarding. The faculty, staff, and student members thus spent several months of "summer camp"-like endeavors together until the end of the war in August 1945 (in actuality, this evacuation lasted from April to around October 1945). Despite hunger due to lack of food and various inconveniences due to war-time shortages, everyone was very enthusiastic about research, teaching, and learning. One emeritus professor (Fumio OOSAWA) recalled the time and told us that he "enjoyed" a book-reading class of Dirac's quantum mechanics textbook with students in the warehouse classroom. He said that many were suffering from hunger and malnutrition, to the extent that if a

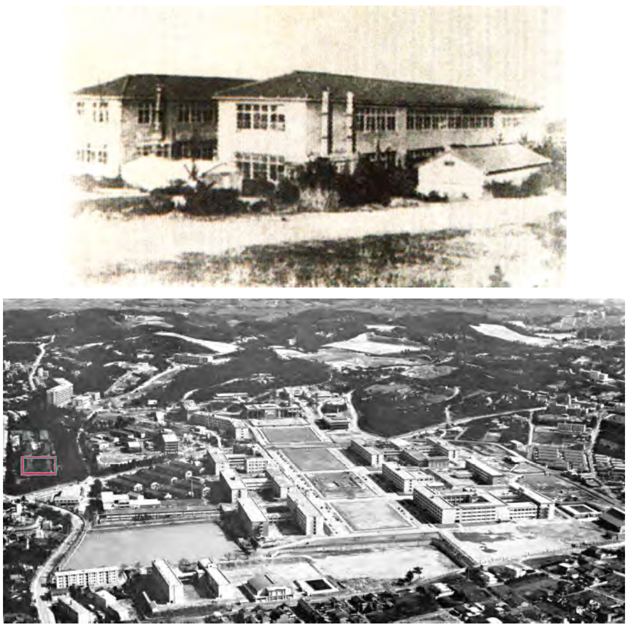
(a)
(b)


Fig. 3: (a) The first two wooden buildings of the Department of Physics, Science Buildings 1 and 2 (in fact, this is a photo of Science Buildings 3 and 4 of the Department of Chemistry, which had exactly the same structures and were located just next to Science Buildings 1 and 2). (b) A bird's eye view photo of the Higashiyama Campus of Nagoya University around 1966. Science Buildings 1 and 2 are seen at the left end around middle height (marked by a red rectangle).

finger received a small cut during physics experiments, it took a long time to heal.

After the war, the Department of Physics came back to Nagoya only to find that many parts of the city of Nagoya were destroyed. Hence, they had to restart everything from scratch despite severe shortage of everything including food, clothes, and laboratory equipment. However, everyone knew that they could finally concentrate on physics research and so they were very enthusiastic and optimistic about the new start. Led by Professor Shoichi SAKATA, the Department of Physics introduced the Charter of Physics Department on June 13, 1946, in which democracy was stated to be the guiding principle of department affairs. Before this, physics research was conducted by kozas, which were hierarchically controlled by full professors. Instead of kozas, research groups were created with members with common research interests, where research groups could be easily created or reformed, following the members' wishes. The first research groups were: D Lab (electron diffraction), E Lab (elementary particle), G Lab (geophysics), H Lab (cosmic ray), K Lab (colloid), M Lab (ferromagnetism), and S Lab (superconductivity). Note that the number of research groups was seven; there were two more groups than the number of full professors (five).

The charter states that as far as physics research is concerned, all the faculty members and students should be treated equally. This especially encouraged younger members of the department to be responsible and actively participate in discussions regarding physics research. This idealism for academic democracy and freedom was inconceivable elsewhere in Japanese universities, not to mention the Japanese Ministry of Education. It was thus installed as an unofficial charter without the approval of the Ministry of Education, and even today it remains as an internal agreement of the department. Soon after the charter was announced, several physics departments in other Japanese universities introduced similar systems, but the number of such departments remained small, considering the radicalness and the pure, idealistic nature of the charter.

In 2007 the Japanese Ministry of Education, Culture, Sports, Science and Technology finally realized that koza where the full professors controlled everything had serious drawbacks and changed the titles of assistant professor (jokyoju) and research associate (joshu) to associate professor (junkyoju, 准教授) and assistant professor (jokyo, 助教), respectively, in order to encourage their academic independence from the koza systems. Hence, the Department of Physics of Nagoya University was indeed 60 years ahead of the time. We believe that this philosophy of academic democracy and freedom indeed played an important role as a cradle for many original and innovative research results and renowned physicists that came from the Department of Physics. One clear example is the 2008 Nobel Prize in Physics that was awarded to two of Professor SAKATA's students, Professors Makoto KOBAYASHI and Toshihide MASKAWA (see Fig. 4).

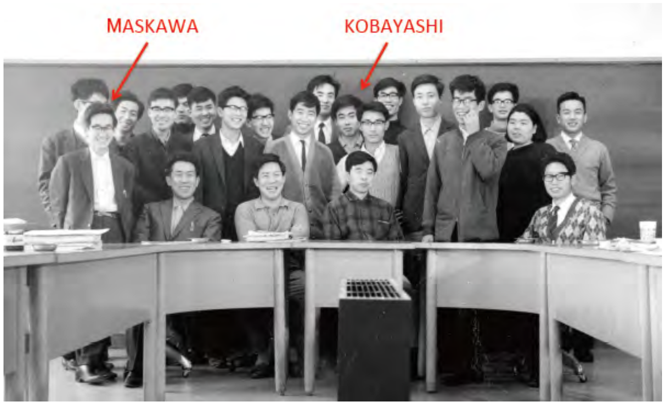


Fig. 4: Members of the Theoretical Elementary Particle Physics Laboratory (E Lab) in 1969.

Through many decades since its creation, the Department of Physics has grown to have about 70 regular faculty members (full professors, associate professors, lecturers, and assistant professors), 15 technical and administrative staff members, and about 600 undergraduate and graduate students. The present curriculum consists of four years of undergraduate education, two years of graduate education for Master of Science degrees, and three more years of graduate education for PhD degrees. The department currently has about 25 research groups that are actively engaged in all four major fields of physics, namely, astrophysics, elementary particle physics, condensed matter physics, and biophysics. The department has very active research groups in the elementary particle physics and condensed matter physics fields, which are two major fields of physics found in most universities in Japan. The department also has one of the largest and strongest research groups in astrophysics and in biophysics, while many other physics departments in Japanese universities have only a small number (or none) of researchers in these two emerging fields.

There are many famous and influential physicists who have passed through the Department of Physics as professors and students. In the following section, we list such notable figures.

TITANS OF THE DEPARTMENT OF PHYSICS

We summarize below the works of the influential physicists who were professors and/or students of the Department of Physics, School of Science, Nagoya University at some period of their respective physics careers. I remark that the works presented are their greatest ones and do not necessarily mean that they were done at Nagoya University, although many of them were indeed performed at Nagoya University.

• Shoichi SAKATA
proposed the “Two-Meson Theory” [1], a conclusive clue to establishing Yukawa’s Meson Theory; proposed the “C-Meson Theory” [2], a forerunner of the renormalization theory; discovered the criterion for renormalizability [3]; proposed the “Sakata Model” [4], a forerunner of the quark model; discovered the “Maki-Nakagawa-Sakata Matrix” [5], which predicted neutrino oscillations, and more, thereby leading Japan’s theoretical elementary particle physics research together with two other key outstanding figures in the field, namely, Hideki YUKAWA and Sin-itiro TOMONAGA.

• Makoto KOBAYASHI
discovered the “Kobayashi-Maskawa Matrix”, which predicted the existence of a third generation of quarks and explained the mechanism for CP violation [6]. [2008 Nobel Prize in Physics]

• Toshihide MASKAWA
discovered the “Kobayashi-Maskawa Matrix”, which predicted the existence of a third generation of quarks and explained the mechanism for CP violation [6]. [2008 Nobel Prize in Physics]

• Mituo TAKETANI
was one of Japan's pioneers in the field of philosophy of science and proposed the Theory of Three Stages in Scientific Research, which stated that scientific research advances in three stages, namely, the phenomenological stage, substantialistic stage, and essentialistic stage [7].

• Yoshio OHNUKI
discovered the U(3) symmetry in the Sakata Model, a composite model of elementary particles, and from this work, clarified the mathematical structures of the Sakata Model, which showed the usefulness of group theory (symmetry) in classification of elementary particles [8]. This classification based on U(3) symmetry led to the quark model by Gell-Mann et al. He also gave a precise formulation method of fermion fields based on the method of coherent states, using path integrals [9].

• Shuzo OGAWA
pointed out the role of symmetry in the Sakata Model, and has discovered U(3) symmetry with Y. Onuki et al. [8] He also gave a theoretical interpretation that the event in the cosmic ray that was observed by Niu et al. involved a new particle (now known as the charm quark) [10].

• Susumu KAMEFUCHI
discovered the criterion for renormalizability [3] and proposed the spectral representation of elementary particles, which is closely related to the Nakano-Kubo formula [11].

• Hiroomi UMEZAWA
discovered the criterion for renormalizability [3], proposed the spectral representation of elementary particles, which is also closely related to the Nakano-Kubo formula [11], and proposed a formalism for quantum field theory at finite temperatures [12].

• Ziro MAKI
discovered the “Maki-Nakagawa-Sakata Matrix”, which predicted neutrino oscillations [5] and proposed a quartet model of elementary particles [13].

• Masami NAKAGAWA
discovered the “Maki-Nakagawa-Sakata Matrix”, which predicted neutrino oscillations [5].

• Yasushi TAKAHASHI
proposed a formalism for quantum field theory at finite temperatures [12] and discovered the “Ward-Takahashi identity” [14].

• Anthony Ichiro SANDA
proposed a renormalizable gauge fixing method in broken gauge symmetric theory and developed the theory of CP violations in B meson decays that would prove the Kobayashi-Maskawa Theory, and gave strong motivation

for the experiments in Belle at KEK, Japan and BaBar at SLAC, USA, in addition to fixing the necessary parameters of the accelerators to perform the experiments [15].

• **Takehiko TAKABAYASHI**
was one of Japan's pioneers in the field of history of physics and science; was also a theoretical physicist, a poet, and a critic [16].

• **Yataro SEKIDO**
studied anisotropy and the origin of cosmic rays by muon telescopes and founded cosmic ray research in Japan [17].

• **Kiyoshi NIU**
discovered a new elementary particle that includes the charm quark in cosmic ray data recorded in a nuclear emulsion plate [18].

• **Kimio NIWA**
developed a full-automatic nuclear emulsion read-out system and discovered the tau neutrino [19].

• **Shuji FUKUI**
developed a discharge (spark) chamber [20].

• **Akira TOMIMATSU**
discovered the "Tomimatsu-Sato Solution", which is one of the exact solutions to the Einstein Equation in the General Theory of Relativity [21].

• **Satio HAYAKAWA**
started space astronomy research in Japan with X-ray and infrared observations, including the first rocket observation of cosmic X-rays [22]; was respected by many members of Nagoya University for his leadership and became the first (and still now the only) President of Nagoya University elected from the School of Science.

• **Yasuo TANAKA**
led Japanese X-ray astronomy research with many X-ray missions [23].

• **Yasuo FUKUI**
developed a small high sensitivity radio telescope and created a citizen's club, Nagoya University Star Club, to raise private funds to set up a radio telescope "NANTEN" and its successor "NANTEN2" in Chile, South America. With the telescopes he led an extensive study of the molecular clouds and star formation in the Magellanic Clouds and discovered that the supersonic gas collision is the mechanism of the massive star/stellar cluster formation [24].

• **Shuji SATO**
developed infrastructures of Japanese infrared astronomy, Subaru in Hawaii, USA [25], IRSF (InfraRed Survey Facility) in Sutherland, South Africa [26], and moderate-size instruments in the East Asia. Combination of the instrument [25] and the moderate-size telescope, KANATA, has provided unique and crucial data of temporal phenomena [27].

• **Ryozi UYEDA**
was a pioneer in the world in the development of a reflection high-energy electron diffraction device featuring a vacuum evaporator and was a pioneer in Japan's nanoscience research with his works on superfine particles [28].

• **Norio KATO**
developed X-ray diffraction topography, established a dynamical diffraction theory based on spherical waves, served as president of the International Union of Crystallography and contributed to the establishment of the Japanese Association for Crystal Growth [29].

• **Tadao KASUYA**
discovered the "Ruderman-Kittel-Kasuya-Yosida (RKKY) Interaction", which is a long-distance interaction between localized spins existing in different sites of metal [30].

• **Kei YOSIDA**
discovered the "Ruderman-Kittel-Kasuya-Yosida (RKKY) Interaction", which is a long-distance interaction between localized spins existing in different sites of metal [31] and also showed that the ground state in Kondo effects is a spin singlet [32].

• **Sadao NAKAJIMA**
developed the theory of the many body problem deriving the attractive force between electrons in superconductivity from phonons and Coulomb repulsive interactions [33].

• **Huzio NAKANO**
discovered the "Nakano-Kubo Formula" for electric conductivity, which is one of the bases for non-equilibrium statistical mechanics [34].

• **Akio YOSHIMORI**
discovered the screw-type structure in rutile-type crystals due to the competition of anti-ferromagnetic interaction between spins on the body-centered cubic lattice and explained the spin structure observed in the experiment of MnO_2 [35].

• **Yousuke NAGAOKA**
discovered "Nagaoka ferromagnetism", which shows the maximum total spin due to a hole moving in the conduction electron system with strong on-site repulsive interaction, and also developed a theory in the early study of the Kondo effect [36].

• **Fumio OOSAWA**
discovered the "Asakura-Oosawa Theory" on depletion forces [37]; obtained analytical solutions to the Poisson-Boltzmann equation for a salt-added system with cylindrical geometry [38], which led them to propose the counterion condensation of polyelectrolytes [39]; started biophysics research in physics departments of Japanese universities, using biomolecules (actin from rabbit's muscle) and studied the phase transitions between G-actin and F-action [40]; proposed a theoretical model of helical and linear aggregation of macromolecules and showed that the muscle protein F-actin is a helical aggregate of G-actin [41]; sent out his students to many universities nationwide as professors to start biophysics groups there; played a major role in the inauguration of the Biophysical Society of Japan.

• **Sho ASAKURA**
discovered the "Asakura-Oosawa Theory" on depletion forces [37]; started biophysics research in physics departments of Japanese universities, using biomolecules (actin from rabbit's muscle) and studied the phase transitions between G-actin and F-action [40]; succeeded in in-vitro reconstruction of bacterial flagella, elucidating the mechanism of flagella formation [42].

• **Ken HOTTA**
started biophysics research in physics departments of Japanese universities, using biomolecules (actin from rabbit's muscle) and studied the phase transitions between G-actin and F-action [40].

• **Nobuhisa IMAI**
obtained analytical solutions to the Poisson-Boltzmann equation for a salt-added system with cylindrical geometry [38], which led them to propose the counterion condensation of polyelectrolytes [39]; started biophysics research in physics departments of Japanese universities, using biomolecules (actin from rabbit's muscle) and studied the phase transitions between G-actin and F-action [40].

• **Tatsuo OOI**
started biophysics research in physics departments of Japanese universities, using biomolecules (actin from rabbit's muscle) and studied the phase transitions between G-actin and F-action [40]; invented a two-dimensional distance map of amino-acid pairs [43]; and developed a method for representing solvation free energy of proteins in terms of solvent-accessible surface areas [44].

• **Michiki KASAI**
proposed a theoretical model of helical and linear aggregation of macromolecules and showed that the muscle protein F-actin is a helical aggregate of G-actin [41].

• **Satoru FUJIME**
showed that bio-macromolecules are soft by the quasi-elastic light scattering method that uses laser light as a probe [45].

• **Mitiko GO**
discovered the correspondence relation between the modules of protein structures and the exons in DNA [46].

• **Sugie HIGASHI-FUJIME**
succeeded in real-time optical microscope imaging of the process of muscle contraction that was reconstructed in vitro using isolated skeletal muscle proteins, actin and myosin [47].

FUTURE PERSPECTIVES

We have presented our past titans in physics from the Department of Physics, School of Science, Nagoya University. We would like to emphasize that the present members of the Department of Physics are also doing very well. In particular, our members have contributed to the discovery of the Higgs particle [48], the measurement of gravitational waves [49], the discovery that modified gravity can unify inflation in the early universe and cosmic acceleration in the present universe as a model of dark energy [50], the elucidation of the mechanism of Fe-based superconductors [51], the discovery of superconductivity in quasicrystals [52], the development of high-speed atomic-force microscopy [53], the elucidation of the mechanism of photosynthesis [54], etc. Finally, we want to mention that the very techniques that led to the discovery of tau neutrino [19], namely, the nuclear emulsion read-out system, was recently used to discover a void in a pyramid [55]. We hope to continue to produce influential scientific works in the future.

Acknowledgements: I would like to thank Dr. Shinichiro HOTTA of Nagoya University Archives for providing me with some of the photos that are shown in this article. I am grateful to Dr. Masaharu TANABASHI for reading the manuscript and correcting some errors. I am greatly indebted to many of my former and present colleagues at the Department of Physics, Graduate School of Science, Nagoya University for teaching me the history of the Department.

References

[1] S. Sakata and T. Inoue, Prog. Theor. Phys. 1. 143 (1946).
[2] (a) S. Sakata and O. Hara, Prog. Theor. Phys. 2, 30 (1947). (b) S. Sakata and H. Umezawa, Prog. Theor. Phys. 5, 682 (1950).
[3] S. Sakata, H. Umezawa, and S. Kamefuchi, Phys. Rev. 84, 154 (1951).
[4] S. Sakata, Prog. Theor. Phys. 16, 686 (1956).
[5] Z. Maki, M. Nakagawa, and S. Sakata, Prog. Theor. Phys. 28, 870 (1962).
[6] M. Kobayashi and T. Maskawa, Prog. Theor. Phys. 49, 652 (1973).
[7] (a) M. Taketani, Kagaku 12, 307 (1942) (in Japanese); (b) M. Taketani, Prog. Theor. Phys. Suppl. 50, 53 (1971).
[8] (a) M. Ikeda, S. Ogawa, and Y. Ohnuki, Prog. Theor. Phys. 22, 715 (1959). (b) Y. Ohnuki, Proc. Rochester Conf., pp. 843-850 (1960).
[9] Y. Ohnuki and T. Kashiwa, Prog. Theor. Phys. 60, 548 (1978).
[10] T. Hayashi, E. Kawai, M. Matsuda, S. Ogawa, and S. Shige-eda, Prog. Theor. Phys. 47, 280 (1972).
[11] H. Umezawa and S. Kamefuchi, Prog. Theor. Phys. 6, 543 (1951).
[12] Y. Takahashi and H. Umezawa, Collect. Phen. 2, 55 (1975).
[13] Z. Maki, Prog. Theor. Phys. 31, 331 (1964).
[14] Y. Takahashi, IL NUOVO CIMENTO 6, 371 (1957).
[15] I. I. Bigi and A. I. Sanda, Nucl. Phys. B 193, 85 (1981).
[16] T. Takabayashi, "Thoughts of a physicist: academism, poems, and critical essays" (Nihon Hyoronsha, 2000) (in Japanese).
[17] Y. Sekido and H. Elliot (eds.), Early History of Cosmic Ray Studies: Personal Reminiscences with Old Photographs (Springer, 1985).
[18] K. Niu, E. Mikumo, and Y. Maeda, Prog. Theor. Phys. 46, 1644 (1971).
[19] N. Agafonova et al., Phys. Lett. B 691, 138 (2010).
[20] S. Fukui and S. Miyamoto, IL NUOVO CIMENTO 11, 113 (1959).
[21] A. Tomimatsu and H. Sato, Phys. Rev. Lett. 29, 1344 (1972).
[22] S. Hayakawa, Cosmic Ray Physics. Nuclear and Astrophysics Aspects (Wiley-Interscience, 1969).
[23] Y. Tanaka, Ann. Rev. Astron. Astrophys. 34, 607 (1996).
[24] Y. Fukui et al., Publications of the Astronomical Society of Japan 51, 745 (1999); ibid. 69, L5 (2017).
[25] M. Watanabe et al., Publications of the Astronomical Society of the Pacific 117, 870 (2005).
[26] T. Nagayama et al., Proc. SPIE 4841, 459 (2003).
[27] A. A. Abdo et al., Nature 463, 919 (2010).
[28] R. Uyeda, Prog. Materials Sci. 35, 1 (1991).
[29] N. Kato, J. Phys. Soc. Jpn. 18, 1785 (1963).
[30] T. Kasuya, Prog. Theor. Phys. 16, 45 (1956).
[31] K. Yosida, Phys. Rev. 106, 893 (1957).
[32] K. Yosida, Prog. Theor. Phys. 36, 875 (1966).
[33] S. Nakajima, Prog. Theor. Phys. 20, 948 (1958).
[34] H. Nakano, Busseiron Kenkyu 84, 25 (1955) (in Japanese); Prog. Theor. Phys. 15, 77 (1956).
[35] A. Yoshimori, J. Phys. Soc. Jpn. 14, 807 (1959).
[36] Y. Nagaoka, Phys. Rev. B 147, 392 (1966).
[37] S. Asakura and F. Oosawa, J. Chem. Phys. 22, 1255 (1954).
[38] N. Imai and F. Oosawa, Busseiron Kenkyu 47, 49 (1952) (in Japanese); N. Imai and T. Onishi, J. Chem. Phys. 30, 1115 (1959).
[39] T. Ohnishi, N. Imai, and F. Oosawa, J. Phys. Soc. Jpn. 15, 896 (1960); N. Imai, J. Phys. Soc. Jpn. 16, 746 (1961).
[40] F. Oosawa, S. Asakura, K. Hotta, N. Imai, and T. Ooi, J. Poly. Sci. 37, 323 (1959).
[41] F. Oosawa and M. Kasai, J. Mol. Biol. 4, 10 (1962).
[42] S. Asakura, G. Eguchi, and T. Iino, J. Mol. Biol. 10, 42 (1964).
[43] K. Nishikawa, T. Ooi, Y. Isogai, and N. Saito, J. Phys. Soc. Jpn. 32, 1331 (1972).
[44] T. Ooi, M. Oobatake, G. Nemethy, and H. A. Scheraga, Proc. Natl. Acad. Sci. USA 84, 3086 (1987).
[45] S. Fujime, Adv. Biophys. 3, 1 (1972).
[46] M. Go, Nature 291, 90 (1981).
[47] S. Higashi-Fujime, J. Cell Biol. 101, 2335 (1985).
[48] ATLAS Collaboration, Phys. Lett. B 716, 1 (2012).
[49] B. P. Abbott et al., Living Reviews in Relativity 21, 3 (2018).
[50] S. Nojiri and S. D. Odintsov, Phys. Rev. D 68, 123512 (2003).
[51] H. Kontani and S. Onari, Phys. Rev. Lett. 104, 157001 (2010).
[52] K. Kamiya et al., Nature Commun. 9, 1 (2018).
[53] T. Ando, T. Uchihashi, and T. Fukuma, Prog. Surf. Sci. 83, 337 (2008).
[54] H. Sakamoto, T. Shimizu, R. Nagao, and T. Noguchi, J. Am. Chem. Soc. 139, 2022 (2017).
[55] K. Morishima, M. Kuno, and M. Tayoubi, Nature 552, 386 (2017).

Yuko Okamoto is a professor of biophysics in the Department of Physics, Graduate School of Science, Nagoya University, Japan. He received his BS and MS in physics from Brown University, USA, in 1979 (Grew Foundation Scholar) and his PhD in physics from Cornell University, USA, in 1984. After his postdoctoral work at Virginia Polytechnic Institute and State University, USA, he worked as an assistant professor (and from 1993, as an associate professor) at Nara Women's University, Japan, from 1986 to 1995. He moved to the Institute for Molecular Science, Japan, in 1995 as an associate professor and held a joint appointment at The Graduate University for Advanced Studies, Japan as an associate professor. He has held his current position as a professor at Nagoya University since 2005. His research has focused on the development of enhanced sampling methods in molecular simulations and their applications to computational physics/chemistry/biology problems such as protein folding, ligand binding, and prediction of three-dimensional structures of molecules.