MG14

MARCEL GROSSMANN AWARDS

ROME 2015

ICRANet and ICRA

MG XIV

MARCEL GROSSMANN AWARDS

ROME 2015

and

TEST

ICRANet
and
ICRA

The 14th Marcel Grossmann Meeting – MG XIV

13th July 2015, Rome (Italy)

Aula Magna – University "Sapienza" of Rome

The Institutional Award

Goes to:
EUROPEAN SPACE AGENCY (ESA)
"for the tremendous success of its scientific space missions in astronomy, astrophysics, cosmology and fundamental physics which have revolutionized our knowledge of the Universe and hugely benefited science and mankind"

- presented to its Director General Johann-Dietrich Woerner

The Individual Awards

Goes to
KEN'ICHI NOMOTO
"for heralding the role of binary systems in the evolution of massive stars"

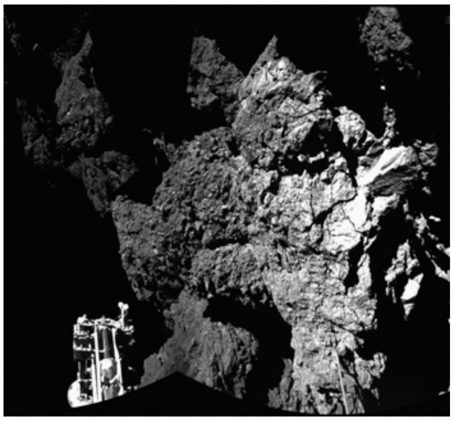
Goes to
MARTIN REES
"for fostering research in black holes, gravitational waves and cosmology"

Goes to
YAKOV G. SINAI
"for applying the mathematics of chaotic systems to physics and cosmology"

Goes to
SACHIKO TSURUTA
"for pioneering the physics of hot neutron stars and their cooling"

Each recipient is presented with a silver casting of the TEST sculpture by the artist A. Pierelli. The original casting was presented to His Holiness Pope John Paul II on the first occasion of the Marcel Grossmann Awards.

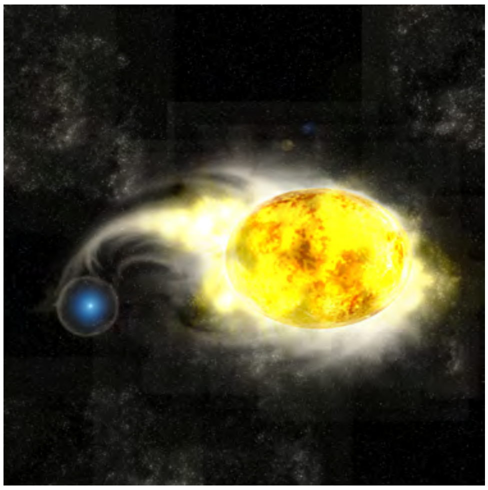
EUROPEAN SPACE AGENCY (ESA) presented to its Director General, **Johann-Dietrich Woerner**
"for the tremendous success of its scientific space missions in astronomy, astrophysics, cosmology and fundamental physics which have revolutionized our knowledge of the Universe and hugely benefited science and mankind"



The Science Program of the European Space Agency (ESA, born originally as the European Space Research Organization ESRO) has been in existence for 50 years. During that time it has worked incessantly to provide the European scientific community with the very best tools in all fields of space science -- a path of sustained excellence in discovery and innovation. Its founding fathers included figures of the caliber of Edoardo Amaldi, Pierre Auger and the cosmologist Hermann Bondi. As early as 1959, Auger pushed for a European institution in space research, the ESRO of which he became the first Director General, followed in 1967 by Bondi, who called on scientists to define the scientific guidelines for future space missions, including an historical meeting in September 1969 in Interlaken. So began the amazing European advance in space science. Fifty years ago Europe was struggling for a presence in a field dominated by the USA and USSR space programs. Today ESA science missions have achieved undisputed primacy in a number of fields. The landing on the Comet 67-P of the Philae probe released from the Rosetta spacecraft in late 2014 (see above right image of the actual landing of the comet), followed by the public worldwide, is perhaps the Agency's most visible achievement, a clear example of fascinating, inspirational science with a strong link to innovation. And Rosetta is only one of Europe's many strong successes in space science. Another mission, Planck, has provided the most precise map ever of the cosmic microwave background, the best available "baby picture" of the Universe. Or consider Herschel, observing in the far infrared; it has opened a new view of the formation of the different structures of the Universe, from stars and planets to galaxies and clusters of galaxies, showing how the shape of the Universe has evolved through time. Similar successes has been the X-ray observatory XMM-Newton, working in synergy with the ASI Beppo SAX mission, the NASA Chandra and SWIFT missions as well as with the other pillar of European Science the VLT ESO optical Observatory in Chile. These missions have been deciphering the violent behavior of the Universe, probing the physical behavior of matter under extreme conditions of gravity and temperature. This collaboration from the ground and from space has led to witnessing the onset of supernovae, to following live the gravitational collapse leading to a black hole formation, and to probing the nucleosynthesis process from the earliest stars till their final evolution, with the production of all the elements which make our life possible in the Universe. And there is more to come. The LISA Laser Interferometer Space Antenna aimed at the heroic detection of gravitational waves is a truly major fundamental physics experiment. Space has already shown what can be done in fundamental physics, with the successful launch of the NASA Gravity Probe B Mission in 2004, and the rigorous process of analysis that led to the definitive observation of the frame dragging effect of general relativity, as will be presented in this MGXIV. ESA's Science Program, by achieving space missions leading to world-leading scientific results, has been inspiring a generation of young Europeans towards science and engineering careers, thus fostering innovation, and over the longer term, growth in Europe, made all the more effective by the collaboration with national programs and resources. By pushing the boundaries of technological capabilities ESA has contributed immensely to the sustaining and enlarging of European technological and scientific skills and infrastructures, and to promoting innovation in both industry and academia. ESA has consistently aimed at inspiring people with missions that show the world-leading results Europeans can achieve by working together, joining creatively with many worldwide scientific and technological institutions. This was the vision of its founding fathers, a vision that continues to be realized 50 years on.

KEN'ICHI NOMOTO

"for heralding the role of binary systems in the evolution of massive stars"



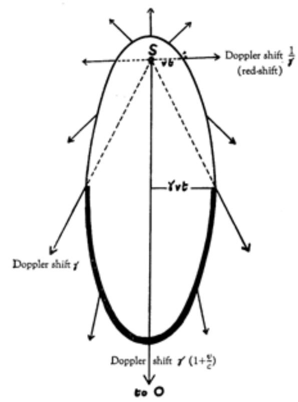
That Japan gave independent profound innovative contributions to physics is well known from the work of Hideki Yukawa. That fundamental advances have been achieved by collaborations with leading western scientists has been clearly manifested by the work of Tomonaga in close contact with Werner Heisenberg. In the field of modern cosmology the stage was set by the dialogue between Gamow, Hayashi and Enrico Fermi.

Out of this great tradition in astrophysics, through the intervening work of Sugimoto on computational astrophysics, comes the scientific figure of Ken'ichi Nomoto. Crucial among his many contributions on modeling the final evolution of stars has been to isolate the crucial role of the initial mass of stars above or below 8 solar masses. The role of the "electron capture supernovae" leads as a final outcome either to a white dwarf or to a neutron star, making Nomoto's work essential for the understanding of the many different kinds of supernovae, both supernovae of type Ia and core-collapse through the modeling of SN 1987A.

Possibly the most original contribution which makes Ken Nomoto outstanding in the astrophysical community has been his linking of the final evolution of stars, traditionally addressed in a single system, to the binary nature of the supernova and hypernova progenitors. Far from being just an academic exercise made possible by the advanced computational facilities achieved by the Japanese school, this link has been shown to be central to the understanding of the physics of a sequence of astrophysical events such as binary X-Ray sources, pioneered by the Uhuru satellite, of supernovae, pioneered by the Kamiokande detection of SN 1987A neutrinos, and most recently of gamma-ray bursts, made possible by the renaissance started by Beppo Sax and continued by the Swift and Fermi satellites. In the understanding of this variety of astrophysical systems which today reveal a continuous evolutionary astrophysical scenario, the work of Ken Nomoto represents a fundamental long lasting contribution.

MARTIN REES

“for fostering research in black holes, gravitational waves and cosmology”

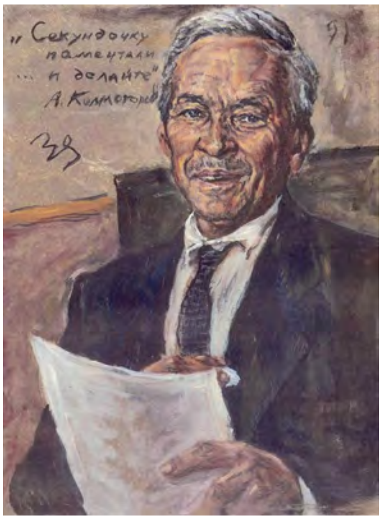


Born on June 23, 1942 in York, England, Martin Rees has received the most distinguished honors of Great Britain: Astronomer Royal since 1995, life member for life of the House of the Lords since 2005 with the title Martin John Rees, Baron Rees of Ludlow, Order of Merit recipient in 2007, Fellow of the Royal Society since 1979, Master of Trinity College, Cambridge (2004 to 2012) and President of the Royal Society (2005 to 2010). His many prizes and awards include the Gold Medal of the Royal Astronomical Society, the Isaac Newton Prize, the Heineman Prize, the Bruno Rossi Prize, the Gruber Prize and the Crafoord Prize. We are particularly happy to present him with the MGXIV Marcel Grossmann Award in 2015, the year of the centenary of the Einstein equations as well the Golden Jubilee of Relativistic Astrophysics.

Martin belongs to a small group of astrophysicists born around 1942 who have greatly influenced the birth and the development of relativistic astrophysics, including Vladimir Belinski, Brandon Carter, Steven Hawking, Remo Ruffini and Rashid Sunyaev. As early as 1966 Martin published one of the classic papers of relativistic astrophysics, pointing out that "an object moving relativistically in suitable directions may appear to a distant observer to have a transverse velocity much greater than the velocity of light". This explanation of apparent "superluminal" astronomical motion (see above figure) still remains even today an outstanding example of science exposition for its sober completeness. In the subsequent years, Martin launched a new direction of cosmological research in Cambridge, a development which is reflected in his contribution to the book “Black Holes, Gravitational Waves and Cosmology" authored by Rees, Ruffini and Wheeler, a book whose conception was initiated during a meeting in Interlaken organized by Hermann Bondi, then Director General of ESRO. In its first twelve chapters Ruffini and Wheeler reviewed the physics of black holes and gravitational waves introducing such concepts as the ergosphere, the black hole orbit of maximum binding and the astrophysical sources of gravitational waves, pointing out the limits of revealing them with ground-based experiments. In the following six chapters Martin summarized the key developments of modern cosmology: Ryle's discovery of extragalactic radio sources at high cosmological redshift, Martin Schmidt's discovery of quasars, and Penzias and Wilson's discovery of cosmological background radiation. He describes all these topics with the passion and clarity he employed in overcoming the then fashionable steady state theory to bring students and collaborators back into the mainstream of relativistic astrophysics. This same passion and effectiveness has characterized his career ever since in many other scientific accomplishments and we are very grateful to him for sharing his ideas, his teaching and his research and extending their reach through his doctoral student Roger Blandford, Craig Hogan, and Priyamvada Natarajan as well as through his dedicated direction of the Institute of Astronomy in Cambridge for many years.

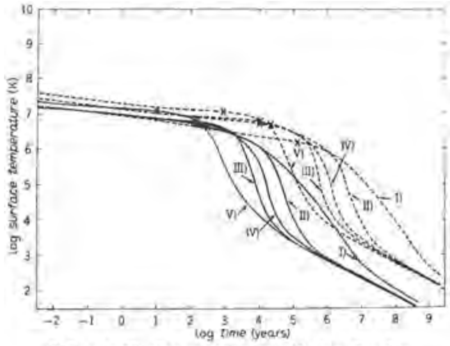
YAKOV G. SINAI

"for applying the mathematics of chaotic systems to physics and cosmology"



Andrey Nicolaevich Kolmogorov (see above portrait) and Lev Davidovich Landau have deeply influenced the development in Russia of mathematics and physics, respectively, bringing them to unprecedented levels admired by all the world. The Kolmogorov School has fostered the frontiers of mathematical knowledge in depth and breadth with such great minds as Israil Gelfand, Vladimir Arnold and Yakov Sinai.Yakov Grigorievich Sinai (see above picture) has been a Professor at Moscow State University and a Senior Researcher at the Mathematical Department of the Landau Institute of Theoretical Physics, Russian Academy of Sciences since 1971 and since 1993 he has also been simultaneously a Professor of Mathematics at Princeton University. Yakov Sinai is one of the most influential mathematicians of our time, having achieved numerous groundbreaking results in the theory of dynamical systems, in mathematical physics and in probability theory. Many mathematical ideas bear his name, including the Kolmogorov-Sinai entropy, Sinai's billiards, Sinai's random walk, Sinai-Ruelle-Bowen measures, and Pirogov-Sinai theory. He is recognized as one of the deepest contributors to the mathematical theory of stochastic dynamical systems. Sinai received the prestigious Abel Prize in mathematics in 2014 and many of his mathematical results have been applied to physics. Particularly noteworthy for the general relativity community are his fundamental results on the stochastic nature of early cosmology obtained in his pioneering 1983 paper in collaboration with E.M. Lifshitz, I.M. Khalatnikov, K.M. Khanin, and L.N. Shchur. Landau had designated the problem of the initial cosmological singularity as one of the three fundamental problems of theoretical physics and the members of his school V. Belinski, I. Khalatnikov and E. Lifshitz then found the general cosmological solution near a big bang or big crunch singularity in a series of papers from 1969 into the 1970s. This "BKL solution" gives rise to a chaotic dynamical system characterized by a positive Kolmogorov-Sinai entropy. The chaotic behavior of the higher-dimensional analogs of the BKL solution has also been deciphered by T. Damour, M. Henneaux and H. Nicolai. The results of the Kolmogorov-Sinai school have thus illuminated the stochastic nature of the BKL cosmological solution. In this very special year 2015, which marks the Year of Light, the centenary of the Einstein equations and the Golden Jubilee of Relativistic Astrophysics, this Award is a tribute to Yakov Sinai for his own achievements as well as a celebration of the fruitful interaction between the Kolmogorov school in mathematics and the Landau school in physics, in the precise spirit of the Marcel Grossmann Meetings.

SACHIKO TSURUTA
"for pioneering the physics of hot neutron stars and their cooling"



S. Tsuruta "Cooling and Heating of Neutron Stars" in "Phyics and Astrophysics of Neutron Stars and Black Holes" R.Ruffini and R. Giacconi,Ed. second edition, CSP 2009

Beginning her undergraduate studies in Japan, Sachiko Tsuruta received foreign student fellowships and obtained her Bachelor degree in physics from the University of Washington in Seattle and then earned her Ph.D. from Columbia University. It was under the guidance of Al Cameron at NASA that she initiated her pioneering work on the nature of neutron stars giving particular attention to the issue of their cooling processes.

After her Ph.D. Sachiko started an intense itinerary of major scientific institutions scattered around the Northern Hemisphere. After a five year research position at the Harvard-Smithsonian CfA, she accepted research positions at NASA, Greenbelt and then the University of Sussex. She then took a position at the Max Planck Institute for Astrophysics in Munich, during which she received a dual position as a faculty member at Montana State University in the beautiful town of Bozeman, commuting back and forth in the following years. As far back as her early days in Seattle, Sachiko had met Hideki Yukawa and Chushiro Hayashi from Kyoto University as well as Satio Hayakawa from Nagoya University and Kazuhiko Nishijima from the University of Tokyo. In the following years her presence in Japan grew through a variety of visiting positions, during which she became an active member of that restricted group of astrophysicists active in the main institutions in Japan, including Yosihide Kozai, Daichiro Sugimoto, Ken'ichi Nomoto, Yasuo Tanaka, and Minoru Oda in Tokyo (Oda received the MG VI Award), with Humitaka Sato and Katsuhiko Sato at Kyoto, with Satio Hayakawa (Hayakawa received a MG V award) and Hideyo Kunieda's group in Nagoya, with Jun Jugaku who had restructured the PASJ at Tokyo Observatory, with the nuclear physic group of Ryozo Tamagaki in Kyoto. Through their interactions and direction came to life the great development of Japanese astrophysical research in both theoretical and observational fields from the ground and from Space, that the world admires today. Yearly Sachiko has migrated from Montana to Japan, to the leading scientific institutions in Europe and around our northern Hemisphere.

Sachiko has truly been a pioneer in the study of neutron stars, including their composition, structure and thermal properties. She has extensively analyzed not only their equations of state and their cooling and heating properties but also the inner composition of their core, exploring the existence of hyperons, pions, kaons, quarks and their possible condensation in the cores and the associated URCA and other neutrino processes. Her work has also been extensively applied to the study of active galactic nuclei and supermassive black holes, both from theoretical point of view and in looking directly for its verification in observational data. She has been a splendid example of scientists working from the very beginning of relativistic astrophysics and following continuously and successfully through the latest developments. She has established a perfect example, especially for women: In her own words, "Since Japan still does not have many woman scientists, perhaps I can be a model for young Japanese women.

The 14th Marcel Grossmann Meeting – MG XIV

4th May 2015, Beijing (China)

Zhongguancun Campus, UCAS

The awards are delivered on May 4, 2015 at the MG14 satellite meeting the *International Conference on Gravitation and Cosmology*: *the Fourth Galileo-Xu Guangqi Meeting* in Beijing:

Goes to
FRANK C.N. YANG
"for deepening Einstein's geometrical approach to physics in the best tradition of Paul Dirac and Hermann Weyl"

Delivered at 9:50 am

Goes to
T.D. LEE (award received by Yu-Qing Lou on behalf of Prof. T.D. Lee)
"for his work on white dwarfs motivating Enrico Fermi's return to astrophysics and guiding the basic understanding of neutron star matter and fields"

Delivered at 7:00 pm

FRANK C.N. YANG

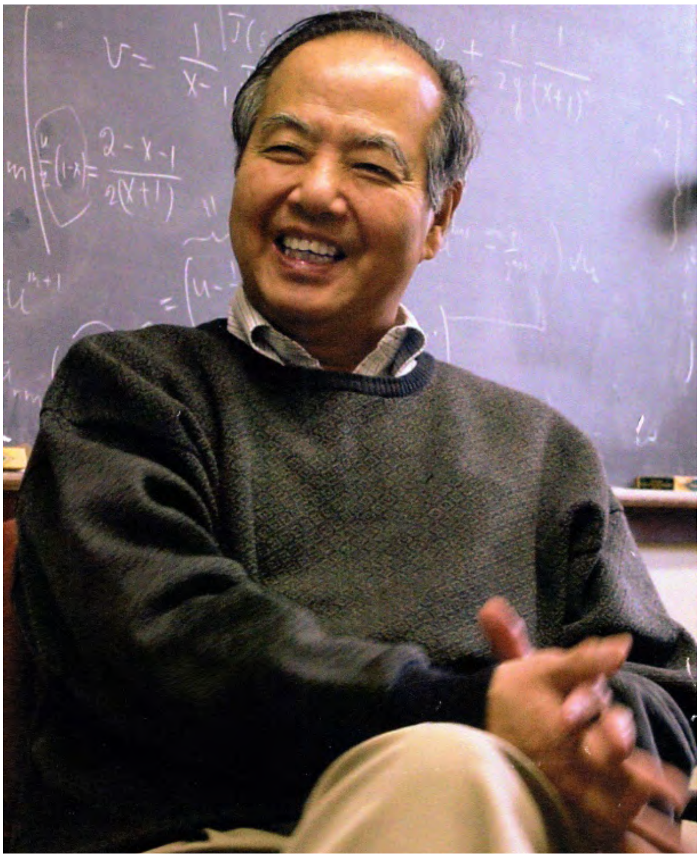
"for deepening Einstein's geometrical approach to physics in the best tradition of Paul Dirac and Hermann Weyl"

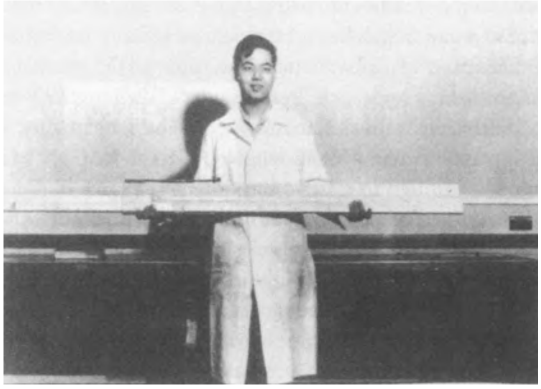
"… I would like to discuss some influence Fermi had in China: this is the case in which two of Fermi's Chinese students and collaborators had an unprecedented impact on science at the international level and triggered the scientific development of the largest nation in the world: China. During my second visit to China in 1979 I went to Kun Ming: it was quite an experience to see this beautiful location on the border of a lake so vividly described by Marco Polo. There was a train line constructed by the French reaching this town from Hanoi. There was also a beautiful university where two young students studied physics during World War II, there the professors from the Bei DA and Qing Hua university of Beijing and their families having escaped from the east of China ahead of the Japanese invasion. Their names were Chen Ning Yang and Tsung Dao Lee. At the end of the war they transferred to the USA: Frank C.N. Yang became Fermi's assistant and T.D. Lee was followed in his Ph.D. thesis by Fermi. The remarkable scientific career of these two young Chinese scientists is well recorded in the history of science. After Nixon's visit to China in 1972, Yang and Lee frequently went back to China to deliver lectures based on the Fermi tradition and today they are spending the greater part of their time in China organizing scientific centers and activities. In 1979 Yang gave a lecture at the second MG meeting in Trieste (see figure on the right: C.N. Yang speaking with a thoughtful Pam Dirac listening). During the Third Galileo-Xu Guangqi Meeting in 2011 I had another pleasant meeting with C.N. Yang. This also gave me the opportunity to see Beijing University again, having originally seen it in 1978 after the cultural revolution with all its libraries burned, now renewed and reaching a new splendor. Next to the Zhou Pei-Yuan Institute are the offices of the C.N. Yang Center. We talked about our common friend Isidor Rabi and his role in collaborating with Eisenhower as President of Columbia University prior to the latter's election as President of the USA. We also talked about Fermi's role in formulating his theory of beta decay, of the adventures of the A-bomb and H-bomb projects and many other topics. This also gave me the chance to introduce him to our ongoing projects with ICRANet in Brazil."

From "Einstein, Fermi, Heisenberg and Relativistic Astrophysics: Personal Reflections by Remo Ruffini" World Scientific Singapore 2015

T.D. LEE

"for his work on white dwarfs motivating Enrico Fermi's return to astrophysics and guiding the basic understanding of neutron star matter and fields"





"… Returning to the main topic of Fermi and astrophysics, it is interesting that according to T.D. Lee Fermi's original critical attitude expressed in his Trento lecture on the interior of stars was evolving towards the end of his life. As recalled by T.D. Lee in a talk held at a joint meeting of the APS and AAPT in February, 2010 "Remembering Enrico Fermi," Fermi was beginning to warm up towards astrophysics in his final years: Fermi asked Lee during his Ph.D. thesis the approximate temperature of the Sun at its center. Lee replied, "Ten million degrees." Fermi asked: "How do you know?" Lee told him he had looked it up. Fermi asked if he'd verified the number and Lee replied, "It's really complicated. It's not so easy to integrate these equations." Fermi suggested that Lee build a huge specialized slide rule that would enable the solution of two radiative transfer equations, one that involved the 18th power of the temperature, and the other that involved the reciprocal of temperature to the 6.5th power. Over the next few weeks Lee built a slide rule that was 6.7 feet long and carried out the necessary integration. 'It was great fun'…

In the imperial Chinese tradition of the past, in each town in China there was a palace in which every year the best young astronomers were examined and selected and brought to the imperial palace to perform their study and research. Great credit goes to T.D. Lee for having reactivated this selection process on a large scale and having sent the most qualified young students not to the imperial palace in Beijing but to the leading universities in the USA for many years a similar program has been activated in Tokyo.

These experiences, as well as our more limited effort with ICRA and ICRANet, have been significant components in guaranteeing that most impressive scientific, technological and industrial development that the entire world admires today in China. In some sense this authentic scientific and cultural evolution of modern China was triggered directly and indirectly by the influence of Fermi."

From "Einstein, Fermi, Heisenberg and Relativistic Astrophysics: Personal Reflections by Remo Ruffini" World Scientific Singapore 2015

13th Marcel Grossmann Meeting
July 2012, Stockholm, Sweden

Institutional Award
ALBANOVA
for its innovative status as a joint institute established by Stockholm University and the Royal Institute of Technology and for fostering contributions to cosmology and astrophysics in the profound scientific tradition established by Oskar Klein.

- presented to the Rector of Stockholm University, Prof. Kåre Bremer.

Individual Awards
DAVID ARNETT
for exploring the nuclear physics and yet unsolved problems of the endpoint of thermonuclear evolution of stars, leading to new avenues of research in physics and astrophysics.

VLADIMIR BELINSKI and I.M. KHALATNIKOV
for the discovery of a general solution of the Einstein equations with a cosmological singularity of an oscillatory chaotic character known as the BKL singularity.

FILIPPO FRONTERA
for guiding the Gamma-ray Burst Monitor Project on board the BeppoSAX satellite, which led to the discovery of GRB X-ray afterglows, and to their optical identification.

12th Marcel Grossmann Meeting
July 2009, Paris, France

Institutional Award
INSTITUT DES HAUTES ÉSTUDES SCIENTIFIQUE (IHÉS)
for its outstanding contributions to mathematics and theoretical physics, and notably for having renewed basic geometrical concepts, and having developed new mathematical and physical aspects of spacetime.
- presented to Prof. Jean-Pierre Bourguignon

Individual Awards
JAAN EINASTO
for pioneering contributions in the discovery of dark matter and cosmic web and fostering research in the historical Tartu Observatory.

CHRISTINE JONES
for her fundamental contributions to the X-ray studies of galaxies and clusters tracing their formation and evolution and for her role in collaborations using clusters to study dark matter and in analyzing the effects of outbursts from supermassive black holes on the intracluster gas.

MICHAEL KRAMER
for his fundamental contributions to pulsar astrophysics, and notably for having first confirmed the existence of spin-orbit precession in binary pulsars.

11th Marcel Grossmann Meeting
July 2006, Berlin, Germany

Institutional Award
FREIE UNIVERSITÄT BERLIN
for the successful endeavor of re-establishing — in the spirit of the Humboldt tradition — freedom of thinking and teaching within a democratic society in a rapidly evolving cosmos
—presented to Dr. Dieter Lenzen, President of FUB

Individual Awards
ROY KERR
for his fundamental contribution to Einstein's theory of general relativity: "The gravitational field of a spinning mass as an example of algebraically special metrics."

GEORGE COYNE
for his committed support for the international development of relativistic astrophysics and for his dedication to fostering an enlightened relationship between science and religion.

JOACHIM TRUMPER
for his outstanding scientific contributions to the physics of compact astrophysical objects and for leading the highly successful ROSAT mission which discovered more then 200,000 galactic and extragalactic X-ray sources: a major step in the observational capabilities of X-ray astronomy and in the knowledge of our universe.

10th Marcel Grossmann Meeting
July 2003, Rio di Janiero, Brazil

Institutional Award
CBPF (Brazilian Center for Research in Physics)
for its role as a teaching and research institution and as a place originating fundamental physics ideas in the exploration of the universe.
—presented to its founders Cesar Lattes, Josè Leite Lopez and Jayme Tiomno

Individual Awards
YVONNE CHOQUET-BRUHAT AND JAMES W. YORK, JR.
for separate as well as joint work in establishing the mathematical framework for proving the existence and uniqueness of solutions to Einstein's gravitational field equations.

YUVAL NE'EMAN
for his contributions to science, epistimology, mathematics and physics from subnuclear to space sciences.

9th Marcel Grossmann Meeting
July 2000, Rome, Italy

Institutional Award
SOLVAY INSTITUTES
for identifying and recording in discussions by the protagonists the crucial developments of physics and astrophysics in the twentieth century.
—presented to Jacques Solvay

Individual Awards
CECILLE AND BRYCE DEWITT
for promoting General Relativity and Mathematics research and inventing the "summer school" concept.

RICCARDO GIACCONI
for opening, five successive times, new highways for exploring the Universe.

ROGER PENROSE
for extending the mathematical and geometrical foundations of General Relativity.

8th Marcel Grossmann Meeting
June 1997, Jerusalem

Institutional Award
HEBREW UNIVERSITY
for its role as a cradle of Science and Humanities and for hosting the manuscripts of Albert Einstein.
— presented to M. Magidor, President of the Hebrew University of Jerusalem

Individual Awards
TULLIO REGGE
for his contributions to the interface between mathematics and physics leading to new fields of research of paramount importance in relativisic astrophysics and particle physics.

FRANCIS EVERITT
for leading the development of extremely precise space experiments utilizing superconducting technology to test General Relativity and the Equivalence Principle.

7th Marcel Grossmann Meeting
June 1994, Stanford, USA

Institutional Award
SPACE TELESCOPE SCIENCE INSTITUTE
for its critical role in the direction and operation of the Hubble Space Telescope, a truly unique international laboratory for the investigation and testing of general relativity in the context of modern astrophysics and cosmology.
— presented to Peter Stockman

Individual Awards
SUBRAHMANYAN CHANDRASEKHAR
for his contributions to the analysis of gravitational phenomena from Newton to Einstein and especially for leading the way to relativistic astrophysics with the concept of critical mass for gravitational collapse.

JIM WILSON
for having built on his experience in nuclear physics, thermonuclear reactions, and extensive numerical simulation to create a new testing ground for the novel concepts of relativistic astrophysics.

6th Marcel Grossmann Meeting
June 1991, Kyoto, Japan

Institutional Award
RITP
for keeping alive first in Hiroshima and them in Kyoto research in relativity, cosmology, and relativistic field theory and the development of a school of international acclaim.
— presented to Professor K. Tomita

Individual Awards
MINORU ODA
for participating in the pioneering work of the early sixties in X-ray astronomy and for his subsequent molding of an agile and diversified Japanese scientific space program investigating the deepest aspects of relativistic astrophysics.

STEPHEN HAWKING
for his contributions to the understanding of spacetime singularities and of the large scale structure of the Universe and of its quantum origins.

5th Marcel Grossmann Meeting
August 1988, Perth, Australia

Institutional Award
THE UNIVERSITY OF WESTERN AUSTRALIA
for its contributions to relativistic astrophysics.
— presented to the Vice Chancellor, Professor Robert Smith

Individual Awards
SATIO HAYAKAWA
for his contributions to research in gamma, X-ray and infrared radiation as well as cosmic rays.

JOHN ARCHIBALD WHEELER
for his contributions to geometrodynamics and Einstein's visions.

4th Marcel Grossmann Meeting
July 1985, Rome, Italy

Institutional Award
THE VATICAN OBSERVATORY
for its contributions to the origin and development of astrophysics.
— presented to His Holiness Pope John Paul II

Individual Awards
WILLIAM FAIRBANK
for his work in gravitation and low temperature physics.

ABDUS SALAM
for his work in unifying fundamental interactions.

TEST: **T**raction of **E**vents in **S**pace-**T**ime

Anna Imponente
National Gallery of Modern Art, Rome

The TEST sculpture provides an innovative example of interaction between science and art, not abstractly interpreted as a result of a subsequent critical analysis but indeed an active and creative collaboration between an astrophysicist and a sculptor.

In order to comprehend the meaning of collaboration between scientists and artists and to retrace its historical origin, we must go back to the Renaissance. There we find the so-called *Weltanschaung* and the idea of unitary art as a continuous and inseparable process of recognition of the structure of reality. This underlies the experience of Leonardo Da Vinci's talent, expressed in his drawings, of not separating scientific enquiry from artistic research.

In the seventeenth century, the "climb to the stars" of the stage machinery in baroque scenography, nourished by imagination, had loosened this link. It had coincided, on the one hand, with experimental Galilean sciences pursuing exact research towards a rational comprehension of the universe, and on the other hand, with the flourishing of the poetics of subjectivity, taste and feeling, the *beaux arts*, and a stratification of painting into specialistic genres.

In the nineteenth century, however, a new reversal of this trend can be observed: the scientific achievements of H.L. Helmholtz in the field of optics and of E. Chevreul in that of chemistry helps *pointillistes* painters in the separation of color. Furthermore, at the beginning of the twentieth century (1907) the Cubist revolution, which changes the concepts of space and time towards a simultaneity of vision, is synchronized with Einstein's theory of special relativity (1905).

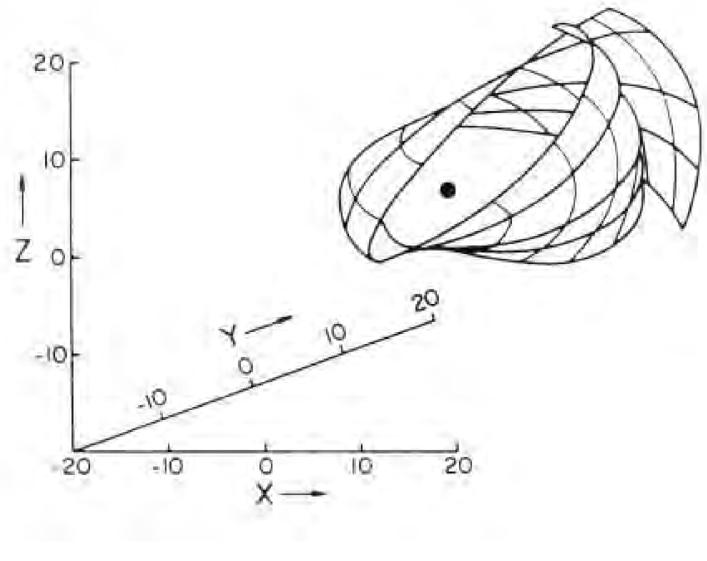
$$\dot{r} = \rho^{-2}\{[E(r^2 + a^2) - a\Phi]^2 - \Delta(\mu^2 r^2 + K)\}^{1/2}$$

$$\dot{\theta} = \rho^{-2}\{K - (\Phi - aE)^2 - \cos^2\theta[a^2(\mu^2 - E^2) + \Phi^2 \sin^{-2}\theta]\}^{1/2}$$

$$\dot{t} = -a\rho^{-2}(aE\sin^2\theta - \Phi) + \rho^{-2}(r^2 + a^2)\Delta^{-1}P$$

$$\dot{\phi} = -\rho^{-2}(aE - \Phi\sin^{-2}\theta) + a\rho^{-2}\Delta^{-1}P$$

$$E = .968\ ,\ \Phi = 2\ ,\ Q = 10\ ,\ a = e = 1/\sqrt{2}$$



Equations for a family of geodesics in a Kerr black hole and their graphical representation (*M. Johnston and R. Ruffini, 1974*).

The relationship between Remo Ruffini and Attilio Pierelli was not one of director/implementer nor could it exactly be defined as a four-handed performance. It has instead been a line of work suggested to the artist by a graphic design which had already been scientifically tested and computerized by M. Johnston and Ruffini at Princeton University in 1974.

This scientific investigation concerned the calculation of the geometric motion of five particles moving in space-time according to the application of a solution of Einstein's equations; the *in vitro* materialization and the visible replica of the discovery of a phenomenon existing in our own galaxy, namely the *black hole*, consisting of a stellar mass which is sucked into itself by gravitational collapse under the effect of its own self-gravity.

The encounter between Ruffini and Pierelli was not just a coincidence. On the one hand, there is the scientist, who in investigating astrophysical laws has always matched the exactness of results with the acknowledgement of a natural elegance of formulas, approaching an aesthetic outline of the detailed calculations. On the other hand, there is the sculptor, who appeases his eagerness for geometry by the contemplation of intricate reflecting symmetries and by perspective-illusive visions based on proportionate sizes, with the intention of proving the poetry of pure science before it becomes a technological adventure. In the theoretical formulation of his research on space, Pierelli has surveyed the history of mathematical thought and non-Euclidean geometries, deriving his hyperspatial shapes from the investigations of Gerolamo Saccheri, a Jesuit philosopher and mathematician of the seventeenth century.

The intuition of the aesthetic potential of this new form derived from the integration of Einstein's equations and describing the geodesics or trajectories of bodies around a black hole is compared by Ruffini to the "Greeks' discovery of π and the circle, which led to Hellenic architecture and the column" (interview with R. Ruffini by F. Bellonzi, Rome, 1985). Initially in 1981 the structural novelty of this form was understood by the architect Maurizio Sacripanti when he considered it as a space one can enter with one's own body and perceive directly with one's senses (M. Sacripanti in *Catalogo Roma*, Palazzo delle Esposizioni, 1981).

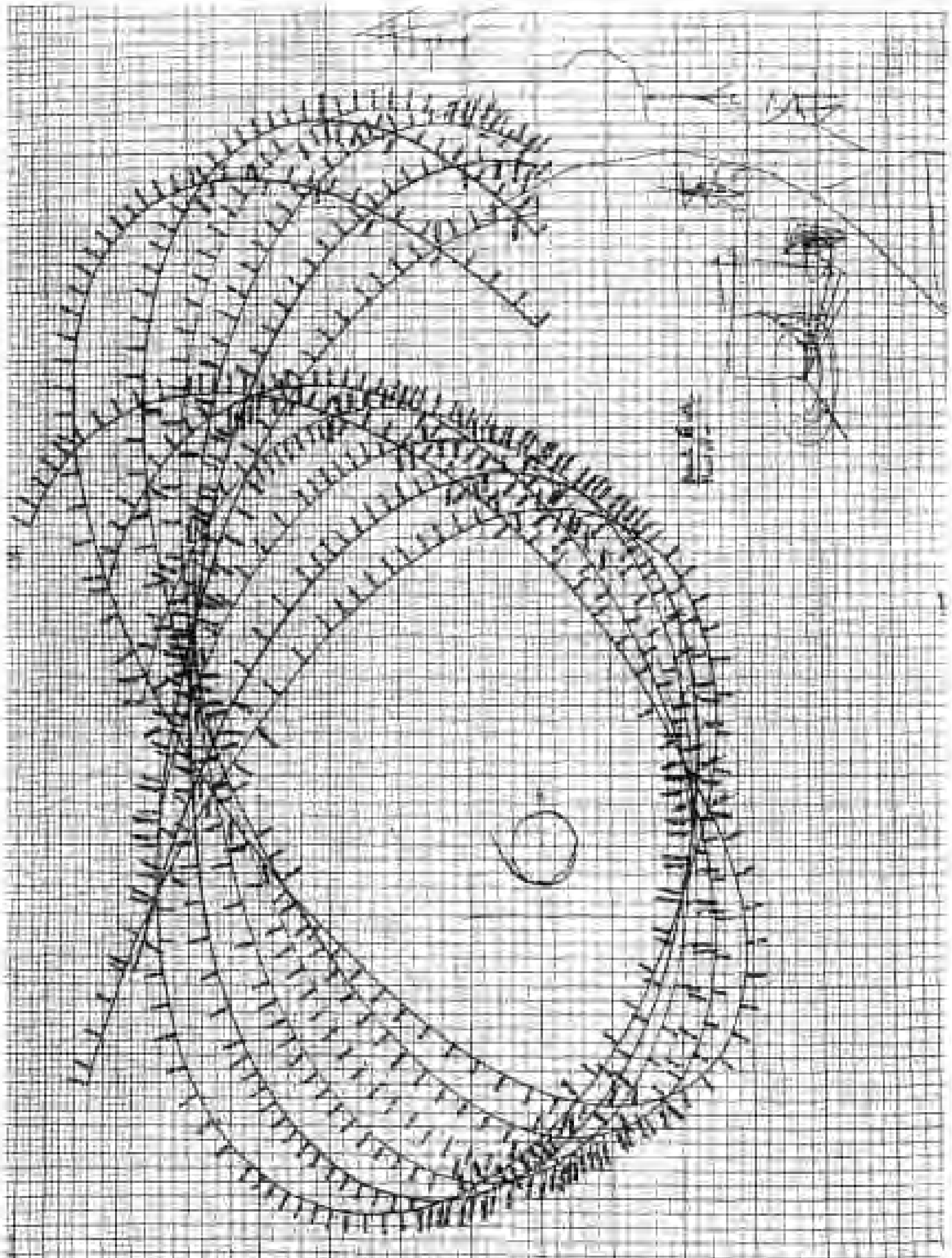
The initiation of this new work has the flavor of a challenge that the sculptor makes to himself, namely to represent the trajectories in a plastic form given their spatial co-ordinates—height, width and length—and to reinterpret them as an aesthetic object, using his own judgement to verify its artistic coherence.

TEST, sculpture by A. Pierelli, photo by S. Takahashi.

The realization of this project seems to be conceptually complex and revolutionary. It is meant to describe a motion, but not a terrestrial one, as the futurists and Boccioni had already done in 1913 with the famous sculpture *Unique forms in space continuity.* Nor should it be the motion of a body set free in the earth's gravitational field, which would fall either vertically or with elliptical or hyperbolic motions. Instead it should resemble a Möbius strip without being so simple, since it would be differentially dragged by the rotational field of the black hole in the geometry of space-time. Hence the acronym TEST which stands for "Traction of Events in Space-Time." Thus the sculpture has no priviledged interpretational directions and no supporting pedestal which might associate it with a central perspective view: no "top" or "bottom," no "right-side" or "left-side." Any orientation gives a complete and faithful realization.

Rather one should imagine it in rotation, with its surface being independent of any relation with the source of natural light ("ambientation" is the fundamental issue of sculpture), ignoring any possible atmospheric effect; in other words, the opposite of a "Mobile" of Calder which awaits a gust of wind to reanimate itself and come alive. Here, the metal light alone outlines and designs the vision of the rotating black hole. The transformation of this sequence of events into a solid form is portrayed by abstracting their properties and reducing everything to a direct perception of its essence, a *Wesenschau.* This representation does not lend itself to psychological or science-fictional interpretation and suggestion; the collective imagination can perceive and attain an emotional projection and exemplification of the universe, of egoism, since it involves a prehensile shape which absorbs and sucks in matter. Moreover, the title TEST, only by pure chance, includes the monogram "ET" which recalls the mythical encounter of a human being with the extraterrestrial of Steven Spielberg's fairy-tale film. There the emblematic image of the finger contact between the two had been borrowed from Michelangelo's *Creation of Man* in the Sistine Chapel while the return to space resembled a mythical ascension on the trail of the Christmas comet.

From a scientific point of view, the clear and lucid form of this sculpture might remind one of the application of mathematical logic to ideographic instantaneity that Giuseppe Peano carried out towards the end of the last century (G.C. Argan, 1985). And from a properly artistic perspective, it can be related to the philosophy of Russian Constructivism around 1920, and to the first clear perception, by Naum Gabo, of the unity of all visible forms and of the existence of aesthetic ones only in accordance with physical and



Three-dimensional trajectories of particles near a Kerr black hole
(*Calculations by V. Bellezza and V. Ferrari, drawing by M. Sacripanti*).

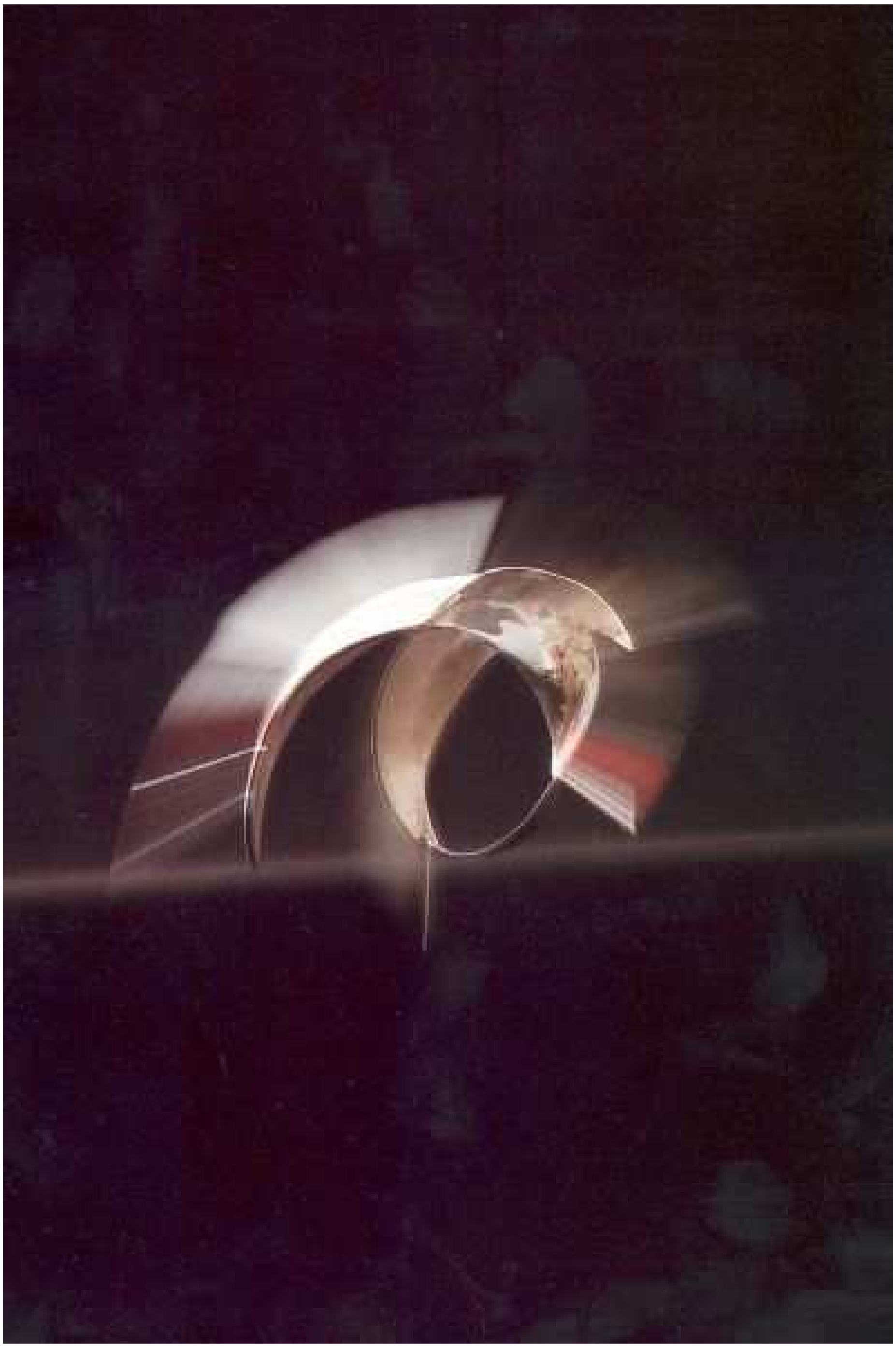
mathematical laws.

In the more recent context, characterized towards the late seventies by strong neo-expressionist and subjectivistic artistic movements, or neo-manner-ist re-evaluation of art from the past, interaction with science has meant above all the adoption and use of advanced technologies, the so-called "computer art." However, the use of media totally different from the traditional ones can change only the visual perception of the image and produce only a technical updating of the communication without necessarily yielding a new artistic message. On the other hand a "snapshot" which is new in concept and ichonography can also be expressed through the use of traditional and experimented techniques. Its very novelty may be expressed through the use of modules of different sizes and composition: namely in the form of a 20cm silver object, as in 1985, or in that of a 50cm bronze one, or in steel tubes, like the $340 \times 470 \times 260 \mathrm{cm}^3$ structure which was shown at the Venice Biennial Exhibition of 1986.

In the silence of his studio the artist finds his knowing craftsmanship, in making the moulds to be forged into metal and in his attempts to achieve the right shape of the torsions which express the intuition of their artistic value, with the light and opacity of the metal. With his mind, he tries not to betray the accuracy promised to the measurements of the curvatures and strives to make them coincide with his own geometric dream.

The discovery of a form which is not an invention, but bears the simple beauty and the perfection of an archetype existing in nature, leads one to re-experience aesthetically the same emotion that must have been felt by whoever discovered it first.

—English translation by Susanna Hirsch



TEST, sculpture by A. Pierelli, photo by S. Takahashi.

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Typeset with LaTeX by Bob Jantzen.

Acceptance speech of C.N.Yang

On Receiving the Marcel Grossmann Award from ICRANet, Pescara, Italy

I remember that it was at the Second Marcel Grossman Meeting in Trieste in 1979, that I formulated the phrase “Symmetry Dictates Interactions” , which describes the principle that governs the structure of interactions.

I am happy to receive this award from an organization based in Italy, the country I feel closest to, after China and the USA.

Enrico Fermi (1901-1954)

Enrico Fermi was one of the Great Sons of Italy in Her Long History.
Prometheus in Greek Mythology, 燧人氏 in Chinese Mythology, taught Mankind How to use *Chemical Energy*

Enrico Fermi in reality, taught Mankind
How to use *Nuclear Energy.*

Enrico Fermi was, of all the great physicists of the 20th century, among the most respected and admired. He was respected and admired because of his contributions to both theoretical and experimental physics, because of his leadership in discovering for mankind a powerful new source of energy, and above all, because of his personal character. He was always reliable and trustworthy. He had both of his feet on the ground all the time. He had great strength, but never threw his weight around. He did not play to the gallery. He did not practise one-up-manship. He exemplified, I always believe, the perfect Confucian gentleman.

Fermi from 1950 to 1951 was a Member of the General Advisory Committee (GAC) of the Atomic Energy Committee (AEC) chaired by Oppenheimer. He then resigned with a quote:
“You know, I don’t always trust my opinions about these political matters".

Shakespeare’s Sonnets No. 94
They that have power to hurt and will do none,
That do not do the thing they most do show,
Who, moving others, are themselves as stone,
Unmoved, cold, and to temptation slow;
They rightly do inherit heaven’s graces,
And husband nature’s riches from expense;
They are the lords and owners of their faces,
Others but stewards of their excellence.

In my years in Chicago, Fermi was personally very kind to me. I remember in June 1948, I had problems with the US Immigration Office. Fermi and Professor Allison, the Director of Chicago’s Institute, went with me to the Immigration Office in Chicago. The Head of the office was so overwhelmed by the presence of Fermi that all my Immigration problem were resolved immediately.
Fermi made many first rate contributions to physics. His contemporaries, including himself, considered his beta decay theory the most important. To bring out the great impact that paper had on physicists in the early 1930s, allow to me to tell you a story.

Fermi made many first rate contributions to physics. His contemporaries, including himself, considered his beta decay theory the most important. To bring out the great impact that paper had on physicists in the early 1930s, allow to me to tell you a story.

Y: *What do you think was Fermi's most important contribution to theoretical physics?*
W: *β-decay theory.*

Y: *How could that be? It is being replaced by more fundamental ideas. Of course it was a very important contribution which had sustained the whole field for some forty years: Fermi had characteristically swept what was unknowable at that time under the rug, and focused on what can be calculated. It was beautiful and agreed with experiment. But it was not permanent. In contrast the Fermi distribution is permanent.*
W: *No, no, you do not understand the impact it produced at the time. Von Neumann and I had been thinking about β-decay for a long time, as did everybody else. We simply did not know how to create an electron in a nucleus.*

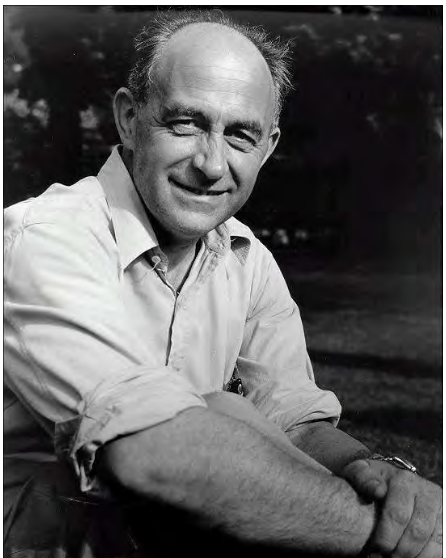
Y: *Fermi knew how to do that by using a second quantized ψ?*
W: *Yes.*

Y: *But it was you and Jordan who had first invented the second quantized ψ.*
W: *Yes, yes. But we never dreamed that it could be used in real physics.*

In the fall of 1954 Fermi was critically ill. Murray Gell-Mann and I went to the Billwigs Hospital to see him for a last time. He was thin, but not sad. He was reading a book full of stories about men who had succeeded, through shear willpower, to overcome fantastic obstacles and misfortunes.

As we bade goodbye and walked towards the door of his room, he said:

"*Now I have to leave physics to your generation.*"



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Founded by: Republic of Armenia, ICRA, Republic of Italy, University of Arizona, Stanford University, Vatican City State

Date of foundation: February 10, 2005 (Adhesion of Brazil: August 12, 2011)

ICRANET promotes international scientific cooperation and undertakes research in the field of Relativistic Astrophysics. Its activities are:

- development of scientific research
- teaching at doctorate and post-doctorate level
- long-term and short-term scientific training
- organization of workshops and scientific meetings
- arrangement of exchange programs for scientists and associates
- development of new standards of electronic communication among the Research Centers
- establishment of integrated data banks for all celestial bodies in all observable wave bands
- cooperation and affiliation with international scientific organizations and technology transfer with industry.

Scientific areas covered include cosmology, high-energy astrophysics, theoretical and mathematical physics. ICRANET coordinates the research activities of Member Universities and Research Centers operating in different geographical areas. A series of new seats for the activities are being developed in order to achieve these goals. The first has been completed and is fully operative in Pescara. The second, third and fourth are being established in Nice, Rio de Janeiro and Yerevan. Projects for additional Centers in Stanford (USA), Central Asia, China and Australasia are considered. ICRANET encourages the mobility of scientists among the Centers and offers fellowships to young students at graduate, post-graduate and post-doctoral levels within the framework of special training programs. ICRANET also sponsors the IRAP-PhD Joint Doctorate Program sponsored by Erasmus Mundus, CAPES, and ICRANet and recognized by the following Universities and Institutions: Albert Einstein Institut, Institut des Hautes etudes scientifiques (IHES), University of Bremen, University of Cologne, University of Ferrara, University of Nice "Sophia Antipolis", University of Oldenburg, University of Rome "Sapienza", University of Savoie.

ICRANET is at the service of the scientific institutions and the Member States that wish to cooperate in the field of Relativistic Astrophysics.