MG15

MARCEL GROSSMANN AWARDS

ROME 2018

ICRANet and ICRA

MG XV

MARCEL GROSSMANN AWARDS

ROME 2018

and

TEST

ICRANet
and
ICRA

The 15th Marcel Grossmann Meeting – MG XV

2nd July 2018, Rome (Italy)

Aula Magna – University "Sapienza" of Rome

Institutional Awards

Goes to:
PLANCK SCIENTIFIC COLLABORATION (ESA)
"for obtaining important constraints on the models of inflationary stage of the Universe and level of primordial non-Gaussianity; measuring with unprecedented sensitivity gravitational lensing of Cosmic Microwave Background fluctuations by large-scale structure of the Universe and corresponding B-polarization of CMB, the imprint on the CMB of hot gas in galaxy clusters; getting unique information about the time of reionization of our Universe and distribution and properties of the dust and magnetic fields in our Galaxy"

- presented to **Jean-Loup Puget**, the Principal Investigator of the High Frequency Instrument (HFI)

HANSEN EXPERIMENTAL PHYSICS LABORATORY AT STANFORD UNIVERSITY
"to HEPL for having developed interdepartmental activities at Stanford University at the frontier of fundamental physics, astrophysics and technology"

- presented to Research Professor **Leo Hollberg**, HEPL Assistant Director

Individual Awards

Goes to
LYMAN PAGE
"for his collaboration with David Wilkinson in realizing the NASA Explorer WMAP mission and as founding director of the Atacama Cosmology Telescope"

Goes to
RASHID ALIEVICH SUNYAEV
"for the development of theoretical tools in the scrutinising, through the CMB, of the first observable electromagnetic appearance of our Universe"

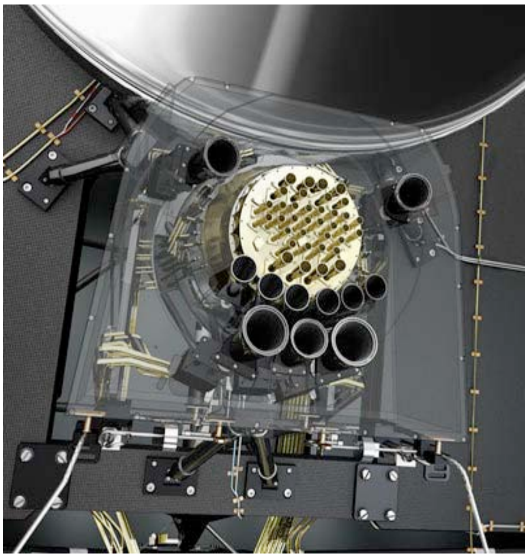
Goes to
SHING-TUNG YAU
"for the proof of the positivity of total mass in the theory of general relativity and perfecting as well the concept of quasi-local mass, for his proof of the Calabi conjecture, for his continuous inspiring role in the study of black holes physics"

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.

PLANCK SCIENTIFIC COLLABORATION (ESA)
presented to **Jean-Loup Puget**, the Principal Investigator of the High Frequency Instrument (HFI).

"for obtaining important constraints on the models of inflationary stage of the Universe and level of primordial non-Gaussianity; measuring with unprecedented sensitivity gravitational lensing of Cosmic Microwave Background fluctuations by large-scale structure of the Universe and corresponding B-polarization of CMB, the imprint on the CMB of hot gas in galaxy clusters; getting unique information about the time of reionization of our Universe and distribution and properties of the dust and magnetic fields in our Galaxy"

Photo of the Planck satellite (Courtesy of ESA).



Planck focal plane (Courtesy of ESA)

Planck ESA's mission, was designed to image the temperature and polarization anisotropies of the CMB over the whole sky, with unrivalled angular resolution and sensitivity, pushing the technology to unprecedent limits. In the framework of the highly precision experimental cosmology the legacy Planck results on testing theories of the early universe and the origin of cosmic structure, has provided a major source of information crucial to many cosmological and astrophysical issues. Planck carried out two instruments:

- the High Frequency Instrument (HFI), Principal Investigator: Jean Loup Puget;
- the Low Frequency Instrument (LFI), Principal Investigator: Nazzareno Mandolesi.

The instruments were complementary and using different technology to cross check independently final results and systematic errors. They worked together to produce the overall mission results. The Planck space mission (ESA) has been a wonderful example of Team effort in a large international collaboration, involving scientific, technical and managerial aspects. The unprecedented accuracy of the Planck measurements have established new standards in the determination of fundamental cosmological parameters, as well as new insight in Galactic and extragalactic astrophysics. The Planck full-sky maps in temperature and polarization will remain a lasting legacy for at least dozen years to come. More than 100 papers signed by Planck collaboration have already 30 000 citations in scientific literature. The success of Planck HFI and LFI would not have been possible without the contribution of a large number of talented and dedicated scientists and engineers from many countries of Europe, USA and Canada. HFI was designed to produce high-sensitivity, multi-frequency measurements of the diffuse radiation permeating the sky in all directions in the frequency range of 84 GHz to 1 THz cooled at 100 mK. The instrument consisted of an array of 52 bolometric detectors placed in the focal plane of the telescope. LFI, a microwave instrument, was designed to produce high-sensitivity, multi-frequency measurements of the microwave sky in the frequency range of 27 to 77 GHz. The instrument consisted of an array of 22 tuned radio receivers located in the focal plane of the telescope, cooled at 20 K.

Jean Loup Puget - PI of the HFI.

Nazzareno Mandolesi - PI of the LFI.

HANSEN EXPERIMENTAL PHYSICS LABORATORY AT STANFORD UNIVERSITY

presented to **Leo Hollberg**, HEPL Assistant Director

"to HEPL for having developed interdepartmental activities at Stanford University at the frontier of fundamental physics, astrophysics and technology"

Brief History of Stanford's HEPL and Ginzton Laboratories

1947: WW Hansen (right) and team with the Mark I linear accelerator

In 1947, working in the Stanford Physics Department's Microwave Lab, Physics Professor, William W. Hansen and his research team, along with Assistant Professor of Physics and microwave expert, Edward L. Ginzton, completed development on the world's first traveling wave electron linear accelerator. Dubbed the Mark I (see photo) it generated a 1.5 million electron volt (MeV) beam. Hansen's entire report to the U.S. Office of Naval Research (ONR) that funded the project was just one sentence: "We have accelerated electrons."

This successful first step in linear electron acceleration spawned the birth of Stanford's High Energy Physics Lab (HEPL) and Ginzton labs. In 1990, HEPL was renamed the WW Hansen Experimental Physics Lab (also HEPL). HEPL and Ginzton were setup as Stanford's first independent labs. They were organized to facilitate cross-disciplinary research, enabling scientists, engineers, staff and students to work towards common research goals using cutting edge lab equipment and technologies on medium-scale projects. For the past 70 years, the HEPL and Ginzton Labs have spearheaded Stanford's leadership in cross-disciplinary physics and become nurturing homes to a variety of physics-based, research projects: including the following examples:

Robert Hofstadter's Nobel Prize & Later Work

In 1961, Stanford Professor Robert Hofstadter was awarded the Nobel Prize for his HEPL Mark III Linear Accelerator work on nuclear form factors (nucleons). In the 1980s, Hofstadter became interested in astrophysics and helped design the EGRET telescope in the NASA Compton Gamma Ray Observatory (CGRO).

Gravity Probe B (GP-B)

2003: Francis Everitt (left) and Brad Parkinson holding a GP-B gyro

In 1959, Physics Department Chair, Leonard Schiff, became interested in using gyroscopes in a satellite to measure the Earth's geodetic effect and the miniscule frame-dragging effect predicted by Albert Einstein's general theory of relativity. Schiff discussed this project with Stanford cryogenic physicist, William Fairbank, and gyroscope expert, Robert Cannon (Aero-Astro department).

In 1962, Fairbank invited post-doc, Francis Everitt, to join the research effort. The team sent a proposal to NASA's Office of Space Sciences requesting funding to develop gyroscopes and a satellite to carry out this unprecedented test. It took 40 years of R&D at Stanford and other places to create and ready the cryogenic satellite and all of its cutting-edge technologies for launch. In 1975, Leonard Schiff moved the GP-B program to HEPL, breathing new life into the lab. In 1981, Francis Everitt became Principal Investigator, a position he still holds. In 1984, Brad Parkinson became Project Manager and a Co-PI, along with Co-PI's John Turneaure and Daniel DeBra.

On 20 April 2004, GP-B launched from Vandenberg AFB into a polar orbit. Data collection began on 28 August 2004 and lasted 50 weeks. Data analysis took five years in order to remove confounding factors in the data. The final results, published in PRL on 31 May 2011, yielded highly accurate geodetic and frame dragging measurements, with 0.28% and 19% margins of error, respectively.

GPS Spinoffs from GP-B

In the 1990s, Brad Parkinson's research on GPS solutions for positioning the GP-B satellite led to two revolutionary spin-off projects: 1) Wide Area Augmentation System (WAAS) provides highly precise positioning accuracy and itegrity for navigation and the automatic landing of airplanes and 2) Precision Farming adding GPS technology to tractors has enabled the automation of many aspects of farming and has spawned a $1 billion/year industry.

Fermi Gamma Ray Space Telescope (GLAST)

Peter Michelson, Fermi LAT Principal Investigator

Stanford Physics Professor, Peter Michelson, is a former HEPL Director and the Principal Investigator for the Large Area Telescope (LAT) on board NASA's Fermi Gamma Ray Space Telescope, the successor to CGRO/EGRET. Launched on 11 June 2008, Fermi has been highly successful mapping the gamma-ray sky. Under Michelson's guidance, HEPL's collaborations with Italy are noteworthy. The development of cryogenic bar detectors of gravitational waves, in collaboration with Edoardo Amaldi and his colleagues, established new stringent upper limits to the gravitational waves incident on the Earth. Likewise, the Fermi LAT was developed by a collaboration between Italian INFN and ASI, NASA, and international partners in France, Japan, and Sweden, and used tracking detectors developed, integrated, tested, and qualified for the mission by Italy. GP-B provided the first evidence of frame-dragging on a spinning, superconducting gyroscope. The Fermi detector offers the potential of seeing, through the GeV emission in the Binary Driven Hypernova subclass of long GRBs, the emission from a newly born Black Hole, originating in the induced gravitational collapse of a supernova hypercritically accreting on a binary neutron star companion.

Robert Byer's LIGO and ACHIP Projects

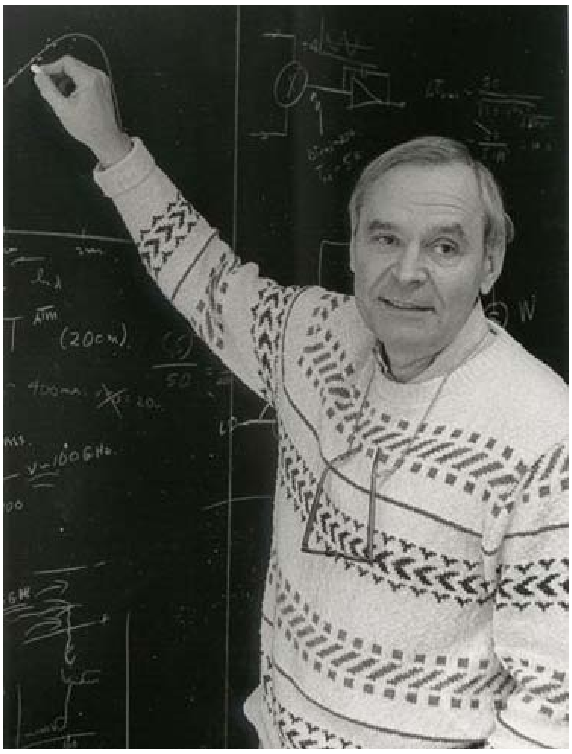
Professor Robert Byer

Robert Byer, former Stanford Dean of Research and former HEPL Director, nurtured the GP-B, GPS and Fermi programs to success during his tenure. He is currently an Applied Physics Professor specializing in lasers and optics. His LIGO Group provided seismic isolation, coatings and materials for the LIGO observatories. His ACHIP project is developing a particle accelerator on a microchip—bringing the HEPL/Ginzton Labs full circle to Hansen's 1947 research.

Professor **LYMAN PAGE**

"for his collaboration with David Wilkinson in realizing the NASA Explorer WMAP mission and as founding director of the Atacama Cosmology Telescope"

Lyman Page



David Wilkinson

This award is given in recognition of Lyman Page's pivotal role in transforming cosmic microwave background observations into a high-precision experimental science over the past two decades. In particular Page provided major contributions to the success of the Wilkinson Microwave Anisotropy Probe (WMAP) space mission, which delivered outstanding measurements of the CMB anisotropy and polarization pattern. He is now continuing his effort by promoting a new generation of experiments like the Atacama Cosmology Telescope to study CMB polarization to greater precision.

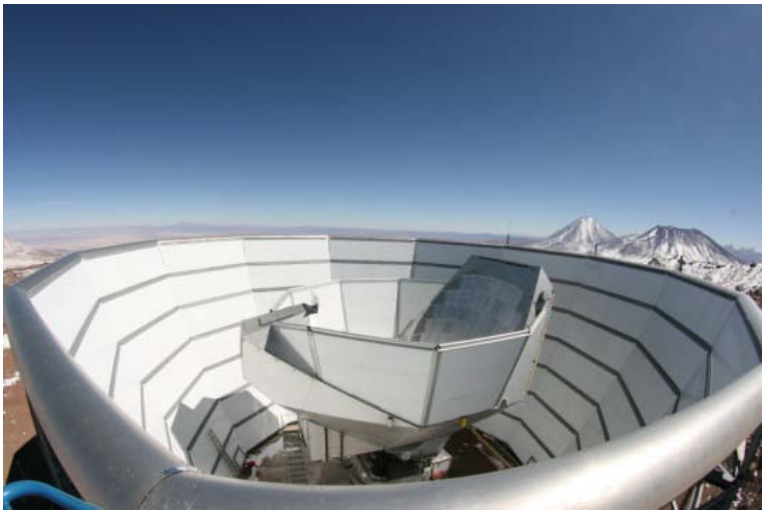


Photo of the Atacama Cosmology Telescope

The CMB, the faint afterglow of the Big Bang, is the most powerful probe of the early universe. From its study, we have learned the age of the universe, its major constituents, and have characterized the fundamental fluctuations in gravity that gave rise to cosmic structure. The desire to measure the CMB ever more precisely has driven the development of extraordinary detectors and techniques which will be reviewed in the Lectio Magistralis by Lyman Page. He will describe what we might hope to learn from the CMB in the next decade, including detecting gravitational waves from the birth of the universe if they exist at sufficient amplitude.

Professor **RASHID ALIEVICH SUNYAEV**

"for the development of theoretical tools in the scrutinising, through the CMB, of the first observable electromagnetic appearance of our Universe"

Rashid Sunyaev

Rashid Sunyaev and
Yakov Borisovich Zeldovich

Rashid Sunyaev gave extraordinary contributions to the understanding of physical processes in the universe which identified new and uniquely informative targets for observational cosmology. In particular, the Sunyaev-Zeldovich effect, now observed in thousands of clusters of galaxies over the entire sky, has become a cornerstone of cosmology and extragalactic astrophysics, so much so that it is now considered a research field in its own right. Furthermore, Sunyaev's studies of processes in the early universe responsible for angular anisotropy and frequency distortions of the cosmic microwave background have left a profound and lasting legacy for cosmology. In particular, Sunyaev and Zeldovich predicted the presence of acoustic peaks in the CMB angular fluctuation power spectrum and the existence of baryonic acoustic oscillations.

He is currently the project scientist leading the scientific team of the international high-energy astrophysics observatory Spektr-RG being built under the direction of the Russian Space Research Institute.

Yakov Zeldovich and Remo Ruffini at the audience with Pope John Paul II

Professor **SHING-TUNG YAU**

“for the proof of the positivity of total mass in the theory of general relativity and perfecting as well the concept of quasi-local mass, for his proof of the Calabi conjecture, for his continuous inspiring role in the study of black holes physics”

Shing-Tung Yau

Shing-Tung Yau has made fundamental contributions to differential geometry which have influenced a wide range of scientific disciplines, including astronomy and theoretical physics. With Richard Schoen, Yau solved a longstanding question in general relativity by proving that the combined total energy of matter and gravitational field in an asymptotically flat universe is positive. In 1982 Yau was awarded the Fields Medal, the highest award in mathematics, and in 1994 he shared with Simon Donaldson the Crafoord Prize of the Royal Swedish Society in recognition of his development of nonlinear techniques in differential geometry leading to the solution of several outstanding problems.

Another outstanding achievement of Yau is his proof of the Calabi conjecture which allowed physicists to show that string theory is a viable candidate for a unified theory of nature. Furthermore in 2008 Yau (with M.T. Wang) introduced the concept of "quasi-local mass" in general relativity which can be of help to get around the old conundrum — the non-locality of the energy density in relativistic gravity.

During his scientific carrier Yau had more than 50 successful PhD students. At present he is a professor of mathematics at Harvard University where along with research he continues many pedagogical activities. For example, he has created the "Black Hole Initiative", an interdisciplinary center at Harvard University involving a collaboration between principal investigators from the fields of astronomy (Sheperd Doeleman, Avi Loeb and Ramesh Narayan), physics (Andrew Strominger), mathematics (Shing-Tung Yau) and philosophy (Peter Galison). This "Black Hole Initiative" is the first center worldwide to focus on the study of the many facets of black holes.

MG16 in 2021 will mark the 50th anniversary of the mass-energy formula for black holes based on the Kerr metric. This timing is an omen that Yau and his school will soon further enlarge our knowledge of this formula with their powerful mathematical analysis.

14th Marcel Grossmann Meeting
July 2015, Rome, Italy

Institutional Award
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

Individual Awards
KEN’ICHI NOMOTO
“for heralding the role of binary systems in the evolution of massive stars”

MARTIN REES
“for fostering Research in black holes, gravitational waves and cosmology”

YAKOV G. SINAI
“for applying the mathematics of chaotic systems to physics and cosmology”

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

FRANK C.N. YANG
“for deepening Einstein’s geometrical approach to physics in the best tradition of Paul Dirac and Hermann Weyl”

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”

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).

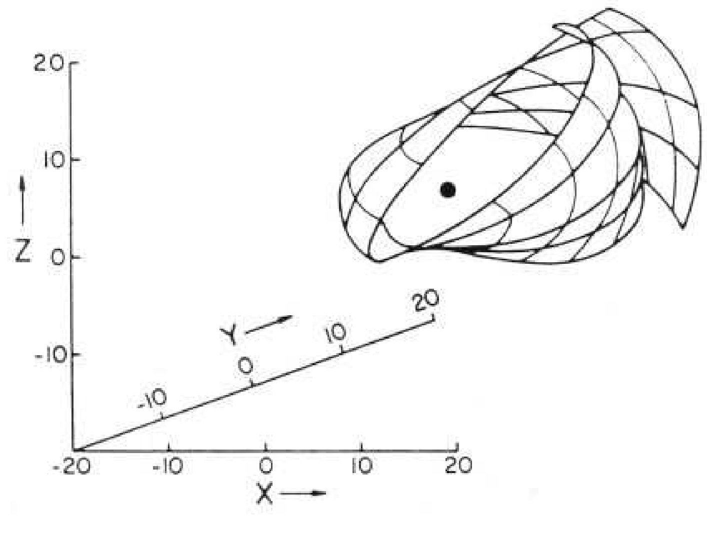
$$\dot{r} = \rho^{-2}\{[E(r^2 + a^2) - a\Phi]^2 - \Delta(\mu^2 r^2 + K)\}^{1/2}$$

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

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

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

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



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).

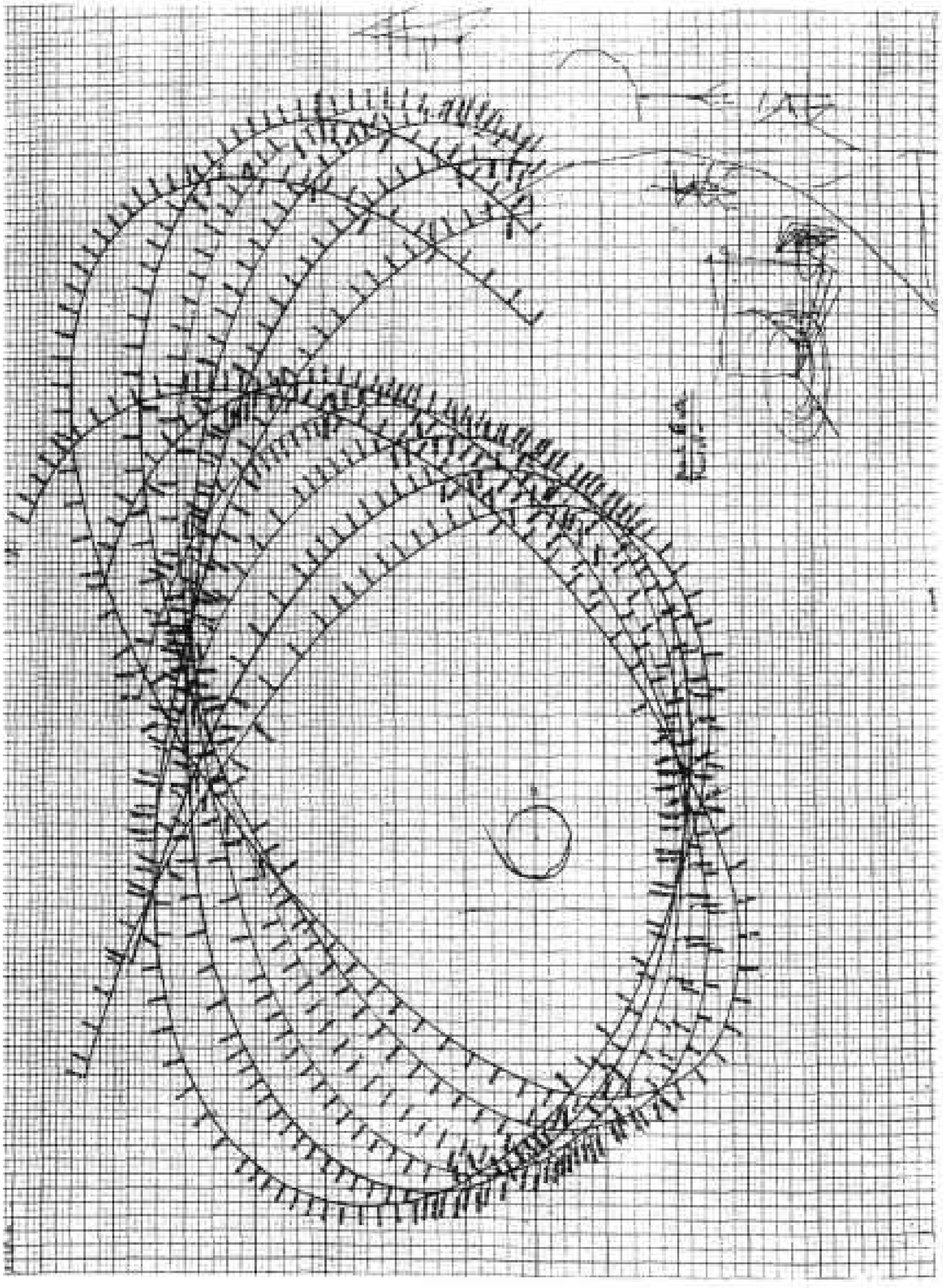
The initiation of this new work has the flavor of a challenge that the sculptor makes to himself, namely to represent the trajectories in a plastic form given their spatial co-ordinates—height, width and length—and to reinterpret them as an aesthetic object, using his own judgement to verify its artistic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

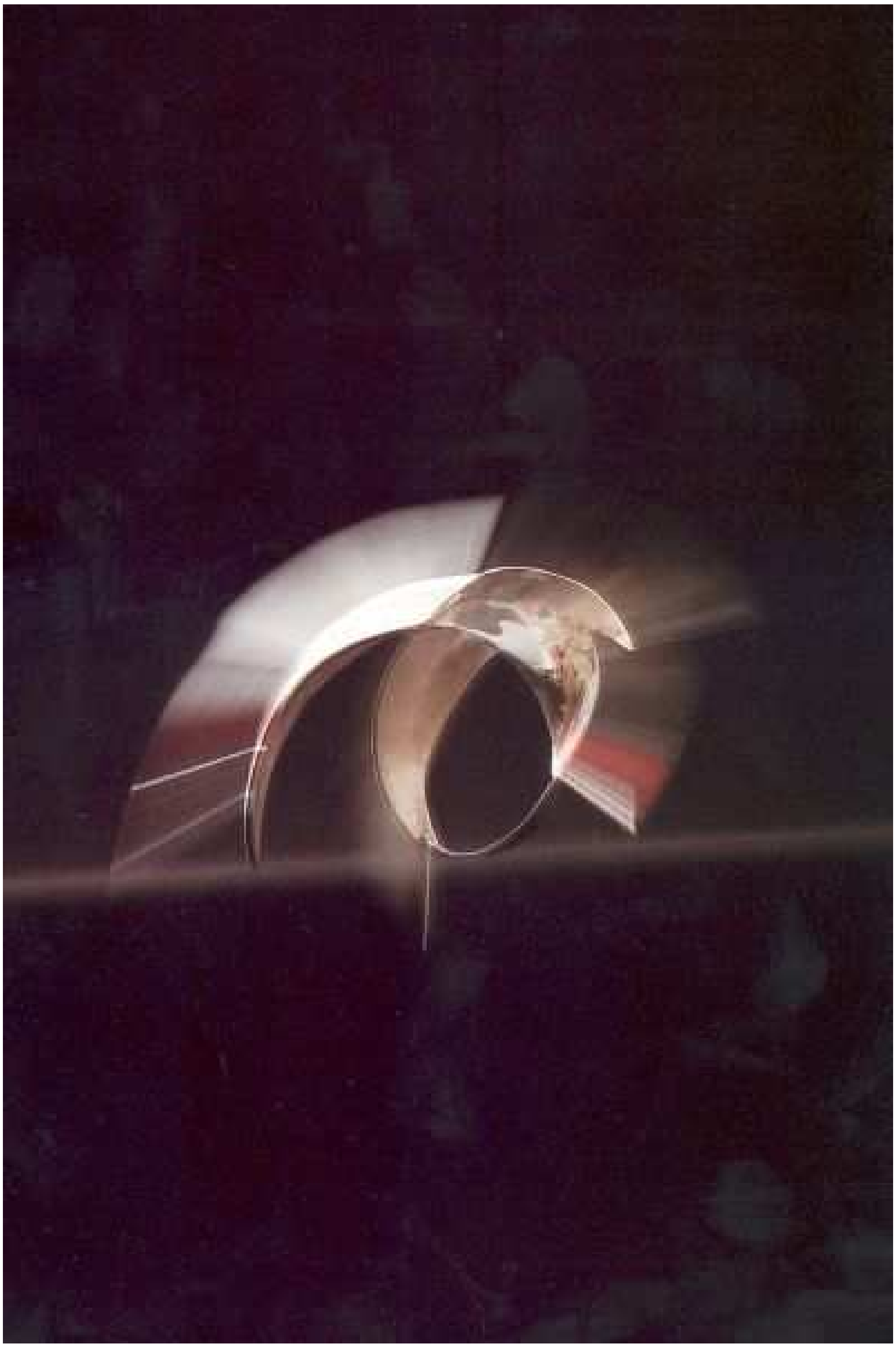
mathematical laws.

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 $340 \times 470 \times 260 cm^3$ 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.

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

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