MG13

MARCEL GROSSMANN AWARDS

STOCKHOLM 2012

ICRA and ICRANet

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MARCEL GROSSMANN AWARDS
and
TEST

ICRANet
and
ICRA

The AlbaNova University Center was founded in 2010 jointly by Stockholm University and the Royal Institute of Technology. It houses departments from the two founding universities in the fields of physics, astronomy and biotechnology. With its open and gentle architectural qualities, the center serves as an appreciated workplace for scientists and students in the more than 40 research groups and education departments within the center. The wide scope of research at AlbaNova has contributed to an excellent atmosphere for interdisciplinary communications and collaborations. In the fields of cosmology, astronomy and fundamental physics, a good example is provided by the success of the multi-departmental Oskar Klein Centre, established within the AlbaNova environment.

AlbaNova
FYSIK ASTRONOMI BIOTEKNIK

13th Marcel Grossmann Meeting

July 2012, Stockholm, Sweden

Institutional Award

AlbaNova University Center
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

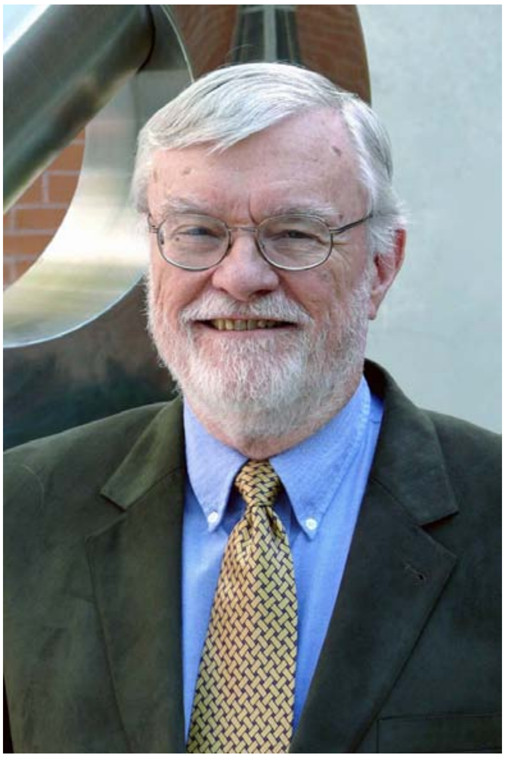
Individual Awards

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 Isaak 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.

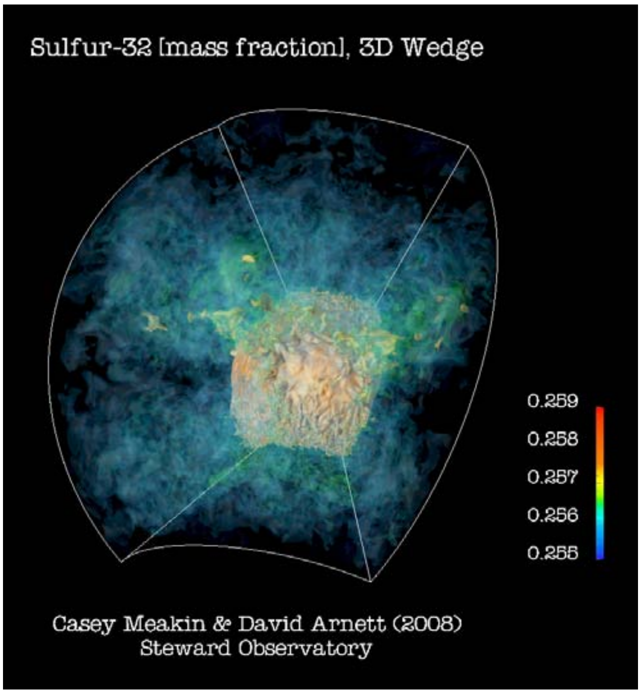
Filippo Frontera
for guiding the Gamma-ray Burst Monitor Project on board the BeppoSAX satellite, which led to the discovery of GRB X-ray afterglows, and to their optical identification.

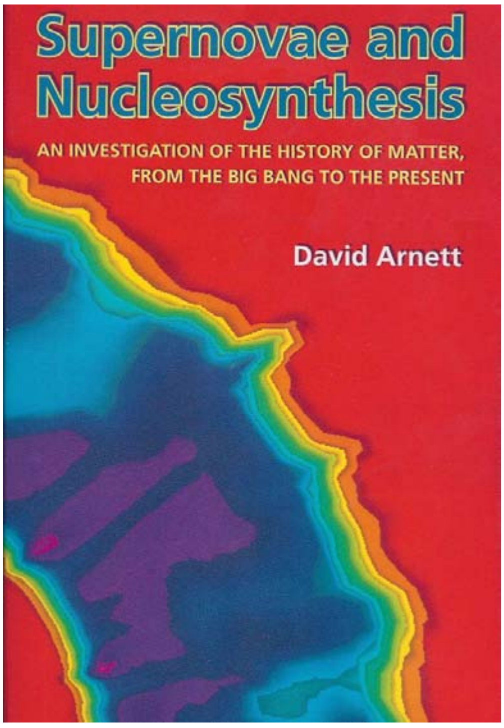
Each recipient is presented with a silver casting of the TEST sculpture by the artist A. Pierelli. The original casting was presented to His Holiness Pope John Paul II on the first occasion of the Marcel Grossmann Awards.



David Arnett

The lower left figure shows a section of a 20 solar mass star just prior to core collapse. Displayed is the sulfur-32 abundance, which is a product of oxygen thermonuclear fusion, and which indicates the complex turbulent flow. The evolution is subject to nonlinear instabilities which break spherical symmetry, and may cause eruptions prior to core collapse. This research is part of a unique project, conceived by Arnett, begun with a dissertation by Meakin, which studies the effects of turbulence and dynamics during the late stages of stellar evolution. The unexpected complexity of the approach to core collapse, and the symmetry breaking which occurs, has implications for the mechanism for explosion of core collapse supernovae. The complexities of these simulations have been captured in simpler physical models which will be used to refine the understanding of key uncertainties the stellar evolution (mixing and angular momentum transport) and will clarify the evolutionary path to gamma-ray bursts. Arnett (1965) did the first numerical simulations of core collapse in which neutrino transport was explicitly calculated, and obtained an estimate of neutrino energy within a factor of two of that observed in Supernova 1987A. He pioneered the quantitative study of nucleosynthesis in both hydrostatic and explosive environments. He has long been interested in the combined use of computer power and classical methods, having discovered the analytic solution for the light curves of Type Ia supernovae, the events which were the basis for the discovery of cosmic acceleration. Lower right: cover of Arnett's classic textbook.





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."

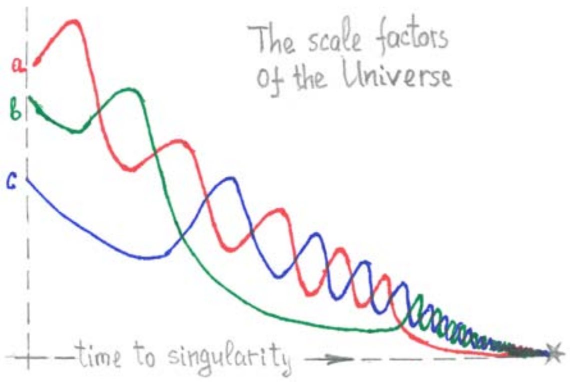
GEORGE COYNE
for his committed support for the international development of relativistic astrophysics and for his dedication to fostering an enlightened relationship between science and religion.

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.

Vladimir Belinski

Isaak Khalatnikov

Landau Institute for Theoretical Physics
Chernogolovka (Moscow)



V. Belinski: studied at the Engineering-Physical Institute (Moscow) and after that worked in the Landau Institute from 1969 to 1989 where he earned his doctorate in 1981. He is now a professor at ICRANet (Pescara, Italy).

I. Khalatnikov: graduated from Dnepropetrovsk State University (Ukraine) with a degree in Physics in 1941, earning his doctorate in 1952. He Joined the Landau group in 1945 and was the founder of the Landau Institute for Theoretical Physics in Chernogolovka (Moscow).

Understanding the structure of the initial cosmological singularity is one of the most important problems of theoretical physics. The problem appeared 90 years ago when the first exactly solvable cosmological models (A.Friedmann, 1922) revealed the presence of this striking phenomenon - the Big Bang singularity. Only around 1959 did L. Landau formulate the fundamental question of whether this phenomenon is due to the special simplifying assumptions underlying exact models or if a singularity is a general property of the Einstein equations. The problem was solved by Vladimir Belinski, Isaac Khalatnikov and Evgeny Lifshitz (BKL) in 1969. The BKL work showed that a general cosmological solution of the gravitational equations with a singularity exists, in other words, the singularity is not a consequence of the special symmetry structure of exact models. Most importantly BKL were able to find the analytic structure of this generic solution and showed that its behavior has a complex oscillatory character of chaotic type. These results have significance not only for cosmology but also for evolution of collapsing matter forming black holes. The last stage of collapsing matter in general will follow the BKL regime. During the last decade it has been shown (T. Damour, M. Henneaux, H. Nicolai) that the BKL regime is inherent not only to general relativity but also to superstring theories and that the BKL asymptotics create a window into the deep and intriguing hidden symmetries of our world.

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.

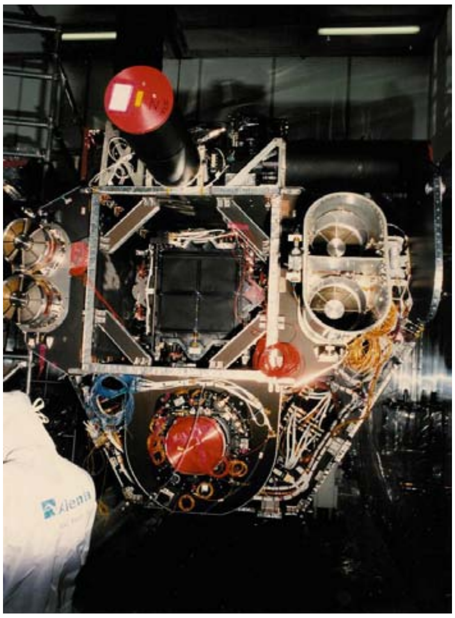
RICCARDO GIACCONI

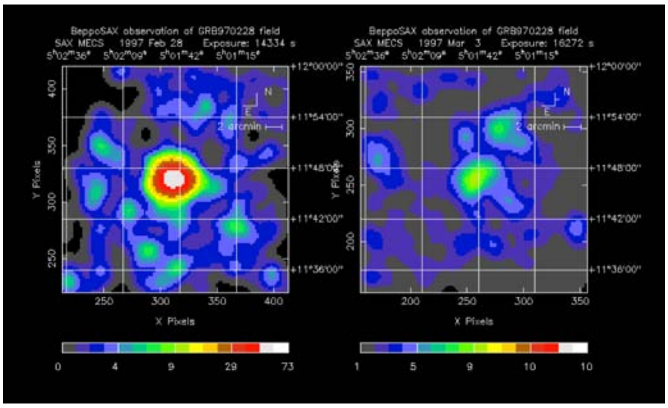
for opening, five successive times, new highways for exploring the Universe.

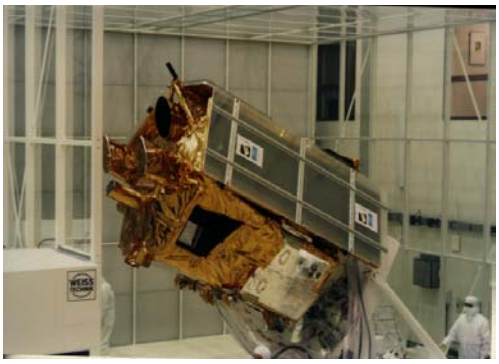
ROGER PENROSE

for extending the mathematical and geometrical foundations of General Relativity.

Filippo Frontera







Six months into its operational life the BeppoSAX satellite solved one of the most elusive problems in astrophysics: the galactic or extragalactic origin of the Gamma Ray Bursts (GRB). This was made possible by the strategy of Filippo Frontera, PI of the high energy instrument Phoswich Detector System (PDS), to identify GRBs with the Gamma Ray Burst Monitor (GRBM), part of PDS, then localize them with the Wide Field Cameras (WFC) and immediately point the narrow field instruments (LECS, MECS, HPGSP, PDS) in that direction (see these instruments in the upper right figure). The Italian satellite (shown in the lower right figure), called "BeppoSAX" in commemoration of Giuseppe "Beppo" Occhialini, was a project of the Italian Space Agency (ASI) with a contribution from the Netherlands Agency for Aerospace Programs, and included a significant contribution from the ASI Scientific Committee for the WFC. The project involved several scientists, among them the PI deputy of PDS Enrico Costa, Mission Scientist Luigi Piro and Mission Director Chris Butler. The first success of the project came with GRB 970228. The observation of the narrow field instruments started 8 hrs after the event and led to the discovery of the first X-ray afterglow of a GRB (see lower left figure). The source coordinates were distributed by the GRB team via IAUC and also sent to the Isaac Newton Group of Telescopes in La Palma (among others), where Paul Groot, a PhD student of Jan Van Paradijs at Amsterdam University, made the requested observation. A previously unknown object was imaged and 9 days later was no longer visible. This was the first optical signal of a GRB. The first determination of the cosmological distances of GRBs was made 2 months later by Shri Kulkarni and his team using the Keck telescopes to observe the source GRB 970508 identified by BeppoSAX.

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).

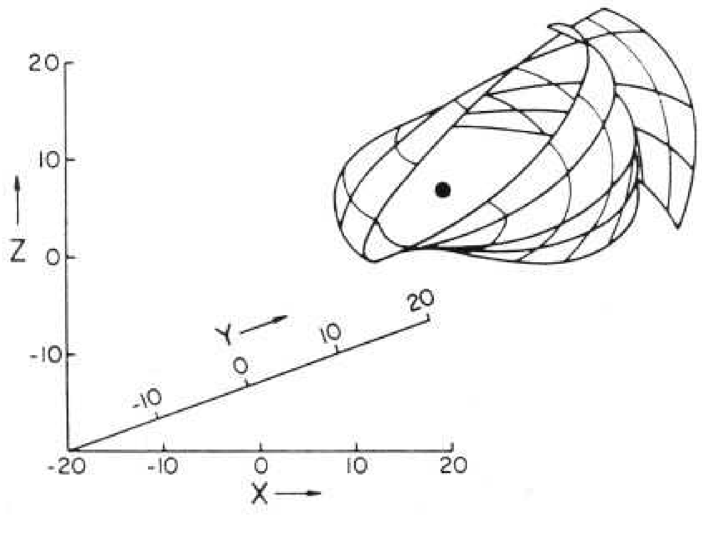
$$\dot{r} = \rho^{-2}\{[E(r^2 + a^2) - a\Phi]^2 - \Delta(\mu^2 r^2 + K)\}^{1/2}$$

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

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

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

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



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).

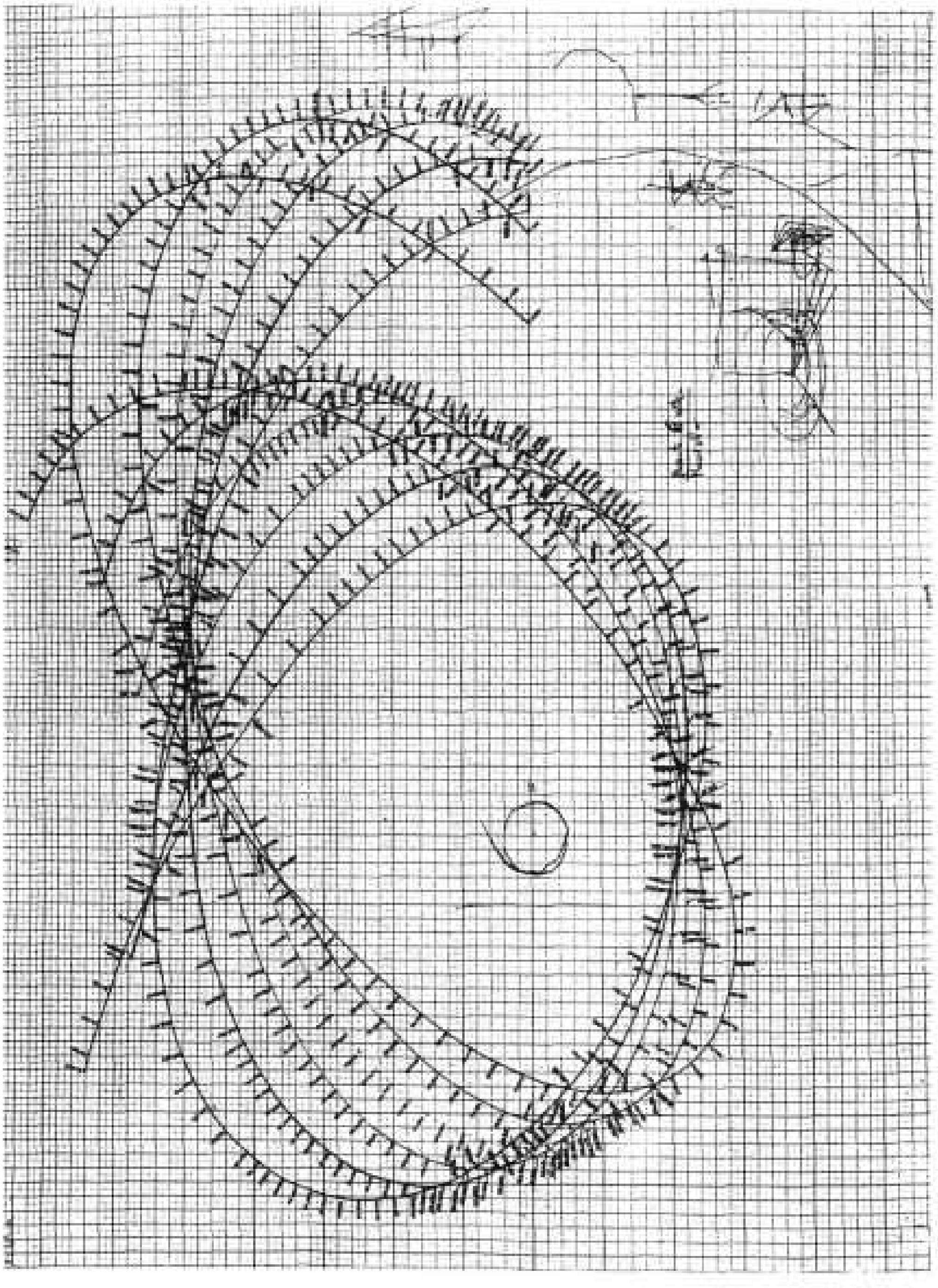
The initiation of this new work has the flavor of a challenge that the sculptor makes to himself, namely to represent the trajectories in a plastic form given their spatial co-ordinates—height, width and length—and to reinterpret them as an aesthetic object, using his own judgement to verify its artistic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

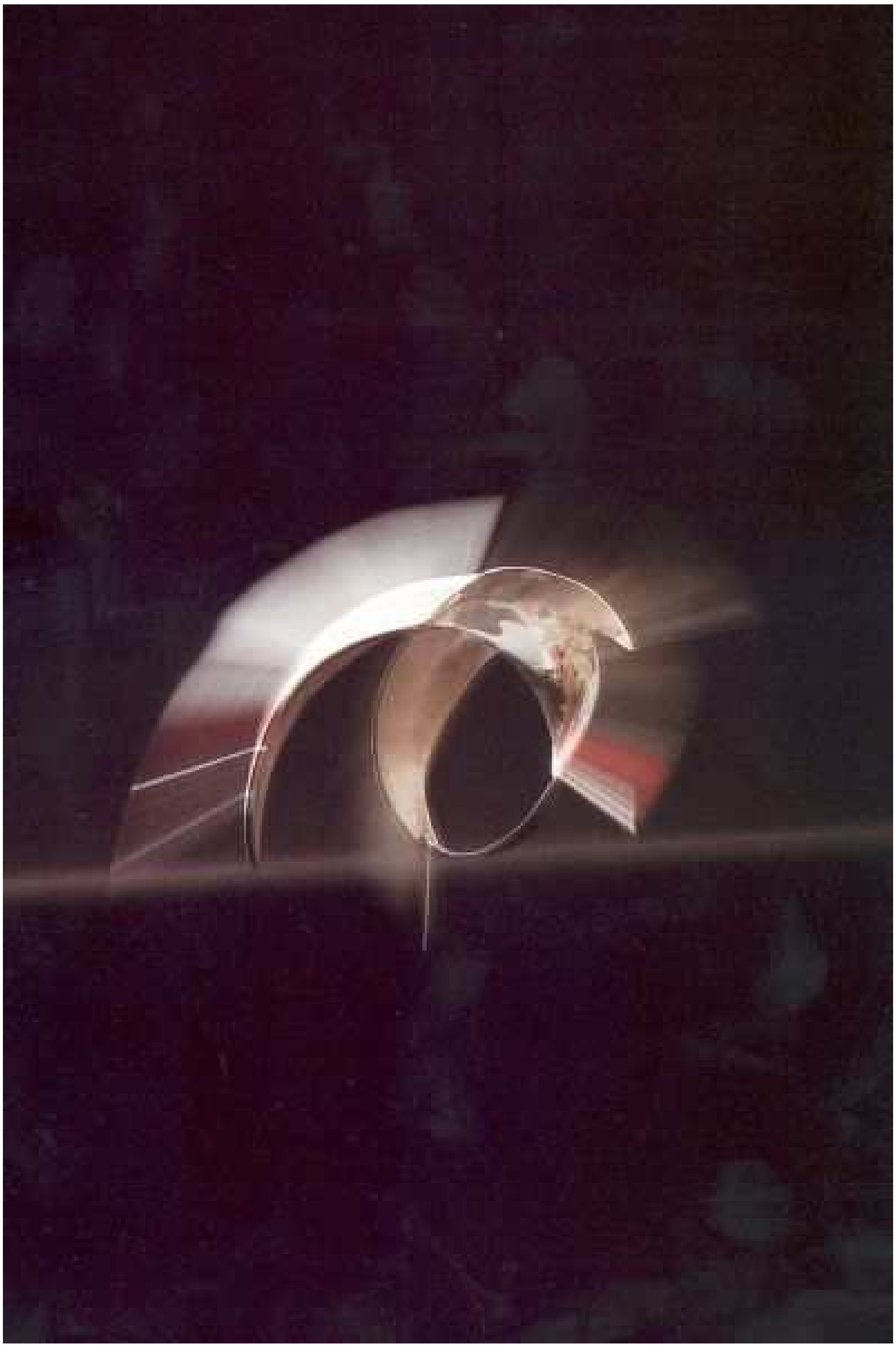
mathematical laws.

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 $340 \times 470 \times 260\text{cm}^3$ 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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ICRANet

International Center for Relativistic Astrophysics Network

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

Date of foundation: February 10, 2005.

ICRANET promotes international scientific co-operation 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; co-operation 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 and the second have been completed and are fully operative in Pescara and at the Sapienza - University of Rome. The third and the fourth ones are being established in Nice and Rio de Janeiro. Projects for additional Centres in Colombia, Stanford (USA), Yerevan (Armenia) and New Zealand are being 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 doctoral program recognized by the following Universities: Freie Universität Berlin, Brazilian Center for Space Research, University of Ferrara, Indian Center for Space Physics, Université de Nice Sophia Antipolis, Sapienza - Università di Roma, Université de Savoie, Shanghai Observatory, Stockholm University. The following Research Centers also participate in this program: Einstein Institute in Potsdam, ICRA and ICRANet, Observatoire de la Côte d'Azur and Tartu Observatory.

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