MG16

MARCEL GROSSMANN AWARDS

Online Meeting, 2021

ICRANet and ICRA

MG XVI

MARCEL GROSSMANN AWARDS

ONLINE MEETING 2021

and

TEST

July 5, 2021, online

Individual Awards

Goes to

DEMETRIOS CHRISTODOULOU

"For his many lasting contributions to the foundation of mathematical physics including the dynamics of relativistic gravitational fields. Notably for: contributing in 1971, at the age of 19, to derive with Remo Ruffini the mass-energy formula of black holes as a function of their angular momentum, charge and irreducible mass. Christodoulou turned then to the study of partial differential equations and mathematical physics, to which he remained dedicated for the rest of his career. Highlights in this area include the theoretical discovery of the nonlinear memory effect of gravitational waves (Phys. Rev. Letters 1991), the monograph (1993) in collaboration with Sergiu Klainerman on the global nonlinear stability of the Minkowski spacetime, the monograph (2009) on the formation of black holes in pure general relativity by imploding gravitational waves, and the monographs (2007 and 2019) on the formation and further development of shocks in fluids."

Goes to

GERARD 't HOOFT

"for his persistent devotion to the study of the quantum field theory boundary conditions at the black hole horizon".

Goes to

TSVI PIRAN

"for extending Relativistic astrophysics across international frontiers, a true companion in the search for the deeper meaning of Einstein's great theory".

Goes to

STEVEN WEINBERG

"for unwavering support for the MG meetings since their inception, a true companion in the search for the deeper meaning of Einstein's great theory".

Institutional Awards

"for the creation of the world's best X-ray map of the entire sky, for the discovery of millions of previously unknown accreting supermassive black holes at cosmological redshifts, for the detection of X-rays from tens of thousands of galaxy clusters, filled mainly with dark matter, and for permitting the detailed investigation of the growth of the large-scale structure of the universe during the era of dark energy dominance".

Goes to:

S.A. LAVOCHKIN ASSOCIATION

- presented to its Designer General **Alexander Shirshakov**

MAX PLANCK INSTITUTE FOR EXTRATERRESTRIAL PHYSICS (MPE)

- presented to Professor **Peter Predehl**, Principal Investigator of eROSITA

SPACE RESEARCH INSTITUTE (IKI) OF THE RUSSIAN ACADEMY OF SCIENCES

- presented to Professor **Rashid Sunyaev,** Principal Investigator of SRG Observatory in Russia

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.

Professor **DEMETRIOS CHRISTODOULOU**

"For his many lasting contributions to the foundation of mathematical physics including the dynamics of relativistic gravitational fields. Notably for: contributing in 1971, at the age of 19, to derive with Remo Ruffini the mass-energy formula of black holes as a function of their angular momentum, charge and irreducible mass. Christodoulou turned then to the study of partial differential equations and mathematical physics, to which he remained dedicated for the rest of his career. Highlights in this area include the theoretical discovery of the nonlinear memory effect of gravitational waves (Phys. Rev. Letters 1991), the monograph (1993) in collaboration with Sergiu Klainerman on the global nonlinear stability of the Minkowski spacetime, the monograph (2009) on the formation of black holes in pure general relativity by imploding gravitational waves, and the monographs (2007 and 2019) on the formation and further development of shocks in fluids."

Demetrios Christodoulou

It was back in 1967 that Achille Papapetrou mentioned the case of the 16 year old Demetrios Christodoulou to John Archibad Wheeler. Wheeler interviewed Demetrios in Paris and brought him immediately to Princeton where he was registered as an undergraduate at the university. After one year he entered the graduate school and started collaborating with me. At the time I was working with Wheeler on the effective potential approach to geodesics co-rotating and counter-rotating (see e.g. reference in The Classical Theory of Fields (Landau and Lifshitz, 1980) in the Kerr metric (later renamed as ISCO; see e.g. (Gravitation Misner, Thorne, Wheeler. 1973). In parallel, Frank Zerilli was working on the gravitational radiation emitted by the fall of a test particle in a Schwarzschild black hole (Zerilli 1970). From these limited conceptual arena Charles Misner and later Kip Thorne launched a program for the detection of gravitational waves on the Earth; see e.g. Misner 1974, Abbott et al. 2016, Abbott et al. 2017. See however Davis et al. 1972, Rodriguez et al. 2018 and J.A. Rueda et al. 2018.

A new approach started with the arrival of Demetrios: he was just creating mathematics following his needs. We identified the reversible and irreversible transformations of a Kerr black hole. Wheeler advanced a thermodynamic analogy. I addressed the need of identifying the concept of irreducible mass(from the Italian "irriducibile"), and was Demetrios's contribution to integrate, overnight, the differential equation for infinitesimal reversible transformations which led to the finite mass-energy formula of a Kerr black hole. That evening, while walking back home through IAS woods, I expressed to Wheeler the great relevance of the newly found formula by Demetrios and proposed to let Demetrios be the single author of this article, admiring his great mathematical talent. Wheeler agreed. The Editor of PRL objected since in that two pages article the Fig. 2 by Wheeler and myself was still unpublished. Actually that Fig. 2 followed a discussion I previously had with Penrose in Florence (Penrose 1961) which allowed us to present there the "Penrose Process". Some difficulties in achieving this process were obvious from the example in Fig. 2, which Roger later recognized himself (Penrose & Floyd 1971). The Editor finally agreed on our written request and the paper appeared on September 17, 1970 (Christodoulou, 1970). On January 1971 appeared my article with Johnny introducing the Black Hole (Ruffini & Wheeler, 1971), with the new physics we were developing in Princeton, including the concept of the "ergosphere". On march 1 1971 we submitted the mass formula of the Kerr Newmann metric, including the relation between the surface area of the horizon and the irreducible (Christodoulou & Ruffini, 1971). On March 11, 1971 the same results were independently confirmed by Steven Hawking, extending further the applicability of our equation (Hawking 1971).

The thesis was successfully discussed by a committee including Eugene Wigner (see Fig. 1), one of the closest collaborators of Albert Einstein and David Wilkinson (see Fig. 2), the head of the NASA WMAP mission, and Johnny and myself as supervisors. The new message was clear: Black Holes, far from being a sink of energy, were energy sources emitting "in principle" 50% of their mass energy, being extractable (Christodoulou & Ruffini, 1971).

 

Fig. 1 and Fig. 2: Demetrios during his thesis presentation with Eugene Wigner (Fig. 1) and David Wilkinson (Fig.2). Myself and Johnny were supervisors, ready to intervene in case of need, but no need of intervention was necessary! Wigner elaborated the aphorism of Niels Bohr "Interesting = wrong" in the most definite "very interesting if true = totally wrong".

Demetrios turned soon to the study of partial differential equations and mathematical physics, to which he dedicated for the rest of his career and results were published in four monographs: (Christodoulou and Klainerman 1994, Christodoulou 2007, Christodoulou 2009, Christodoulou 2019). In 1968, Johnny proposed to Demetrios the collapse of a "geon" composed of massless scalar field as a second topic for his thesis. It took almost forty years for him to solve this problem, extended by Demetrios to the focusing of gravitational waves leading to black hole formation (Christodoulou 2009).

A “long march” started on 12 December 1970 with the launch of the Uhuru satellite by Riccardo Giacconi. Early in 1971 an almost daily conversation with him and Herb Gursky at the Smithsonian Astrophysical Observatory, leading to the discovery of binary X-ray sources. This was soon followedby the announcement of Cygnus X1 identified as the first black hole in our galaxy (Ruffini 1973); see e.g. Gursky & Ruffini 1975, which contained as well the first publicannouncement of the Discovery of Gamma Ray burst, as well as Giacconi & Ruffini 1980, 2009; see Fig.3).

Fig. 3: In the second row, from left to right, there are, among others: E. T. Newman, S. Chandrasekhar, R. Giacconi, R. Ruffini, A. Treves, A. Hewish, D. Arnett, G. I. Taylor, J. Wilson, R. Penrose, as well as J. Bahcall, T. Damour, T. Piran et al..

Today, after fifty years, this “long march” has reached a definite result: through the grandest observational multi-wavelength effort in the history of mankind, from space, ground and underground observatories, we are finally finding evidence that black holes are “alive” and their “extractable energy” in our mass formula (Christodoulou & Ruffini, 1971), is the energy source of the most energetic cosmological sources: gamma ray bursts (GRBs),the active galactic nuclei (AGNs) as well as the ultra-high energy cosmic rays (UHECRs) (Ruffini et al. 2021 and references therein). Their “inner engine”, has three independent components: 1) a Kerr black hole which is neither in a stationary state nor in vacuum, 2) a background magnetic field aligned with the black hole rotation axis, and 3) an extremely diluted fully ionized plasma (Moradi et al. 2021).There is no role in this inner engine for ISCO. Indeed a new electro dynamical field equations describe the synchrotron radiation emitted close to the black hole horizon, they point to a discrete and repetitive emission of “blackholic quanta” in the MeV and in the GeV. The magnitudes and the emission time scales of these quanta, for M87 and GRB 130427A, are expressed as a function of the above three parameters (Rueda & Ruffini, 2021). A long lasting GeV emission with a luminosity decreasing as a temporal power law, allows for the first time in GRBs, the determination of the black hole mass and spin as well as their time evolution perfectly fulfilling our mass energy formula (Christodoulou & Ruffini, 1971): a long lasting emission process profoundly different from the traditional process of continued gravitational contraction.

Remo Ruffini

*P*rofessor **GERARD 't HOOFT**

"for his persistent devotion to the study of the quantum field theory boundary conditions at the black hole horizon".

Prof. Gerard 'T Hooft

Prof. Gerard 't Hooft has been a full Professor at the Utrecht University (the Netherlands), since 1977. Nowadays, he is an Emeritus Professor at that University. During his career, he has paid extended scientific visits to CERN (Geneva), Harvard, Stanford, Princeton and Duke University, NC.
In 1999, together with M. Veltman, he received the Nobel Prize in Physics, awarded by The Royal Swedish Academy of Sciences, *"For elucidating the quantum structure of electroweak interactions in physics"*.
Prof. 't Hooft main subjects of research includes:

– Gauge Theories for the sub-atomic particles and forces, various aspects and ingredients of what is now called "The Standard Model of the sub-atomic particles: renormalizability, topological features such as magnetic monopoles and instantons, 1/N expansions.

– Theories for the quantization of the gravitational force and black holes: producing models for the quantum properties of a black hole, as derived from Standard Model and General Relativity alone; its topological features such as antipodal identification.

– Fundamental theories underlying quantum mechanics, in particular returning determinism and reality to the dynamics of the tiniest material entities in his universe.

Prof. 't Hooft has been awarded the Wolf Prize of the State of Israel (1982), the Pius XI Medal (Vatican city, 1983), the Lorentz Medal (KNAW Amsterdam, 1986) as well as the Spinoza Premium (Netherlands Organization for Scientific Research NWO, 1995).

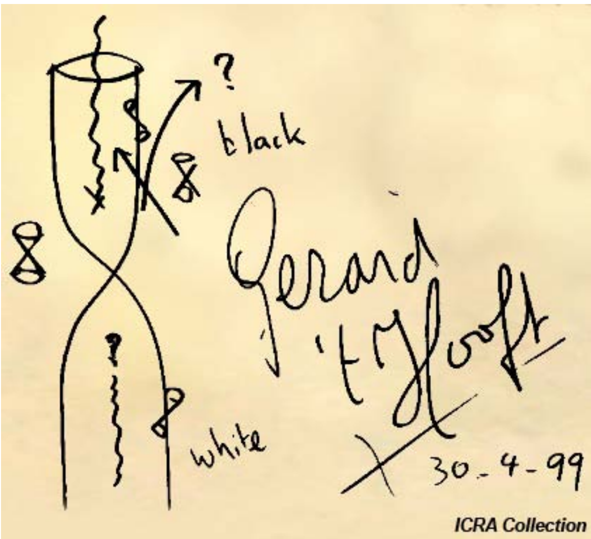

Fig. 2: The signature of Gerard 't Hooft on the wall of ICRA Room 301 (April 4, 1999).

A special event took place at ICRA on April 30, 1999. Prof. Ruffini invited Gerard 't Hooft to Rome to discuss a boundary condition for a quantum field on the black hole horizon, a topic Prof. Ruffini discussed in a previous article "Black-hole evaporation in the Klein-Sauter-Heisenberg-Euler formalism" with Thibault Damour (Phys. Rev. D 14, 332, 1976), but which needed to be examined in more detail. Prof. Ruffini planned to direct Gerard's attention to some specific aspects of this problem. Because we have traditionally been very attentive in spending ICRA travel funds, ICRA offered Gerard to come to Rome on a reduced fare weekend ticket arriving Friday and departing Monday. He had a great relaxing weekend together with Prof. Ruffini following his seminar, which among other things allowed Gerard to sign the wall in our ICRA Room (see Fig. 2) , and during this splendid Rome spring weekend he also was able to find a missing factor of 2 in a formula in Prof. Ruffini's 1971 paper with Demetri Christodoulou on the black hole mass formula. The following October, Gerard received the Nobel prize, which meant that we could no longer get away with bringing him to Rome on a cheap ticket! Ever since Gerard has been in our MG IOC helping us with the preparation of the meetings. We are very happy to announce this MG16 Award to Gerard 't Hooft with the motivating phrase *"for his persistent devotion to the study of the quantum field theory boundary conditions at the black hole horizon"*.

Remo Ruffini

Professor **TSVI PIRAN**

“for extending relativistic astrophysics across international frontiers, a true companion in the search for the deeper meaning of Einstein’s great theory”.

Prof. Tsvi Piran

Tsvi Piran is the emeritus Schwartzmann professor at the Hebrew University of Jerusalem. He obtained his PhD in Physics, in 1976 from the Hebrew University working on the collisional Penrose process. Piran returned to the Hebrew University at 1981after being a post doc at Oxford and Texas and a long term member at the IAS at Princeton. In 1982 he initiated and directed the first ever summer school on Gravitational Waves that took place at Les Houches. Piran was a visiting professor at Harvard, Columbia and New York and a Moore scholar at Caltech.

Piran’s research deals with numerous aspects of relativistic astrophysics, ranging from the foundation of numerical relativity to modeling of observer relativistic phenomena and analytic work on the fate of gravitational collapse. Piran’s research work focuses mostly on black holes and in particular on gamma-ray bursts. He was among the first to point out their cosmological origin and their association with merging neutron stars and heavy r-process nucleo synthesis. Piran’s achievements were recognized in the 2019 EMET prize for Physics.

Professor **STEVEN WEINBERG**

“for unwavering support for the MG meetings since their inception, a true companion in the search for the deeper meaning of Einstein’s great theory”.

Steven Weinberg. Photo courtesy of Matt Valentine.

Steven Weinberg is a member of the Physics and Astronomy Departments at The University of Texas at Austin. His research has covered a broad range of topics in quantum field theory, elementary particle physics and cosmology. He has been honored with numerous awards, including the Nobel Prize in Physics, the National Medal of Science, the Heinemann Prize in Mathematical Physics and in 2020, the Breakthrough Prize. He is a member of the US National Academy of Sciences, Britain’s Royal Society, and other academies in the USA and abroad. The American Philosophical Society awarded him the Benjamin Franklin Medal, with a citation that said he is “considered by many to be the preeminent theoretical physicist alive in the world today.” His books for physicists include *Gravitation and Cosmology*, the three-volume work *The Quantum Theory of Fields*, *Cosmology* and published in April of 2021, *Foundations of Modern Physics*. Educated at Cornell, Copenhagen, and Princeton, he also holds honorary degrees from sixteen other universities. He taught at Columbia, Berkeley, M.I.T., and Harvard, where he was Higgins Professor of Physics, before coming to Texas in 1982.

Fig. 1: Chuo Pei Yuan and Cheng Ning Yang at MG2 in Trieste, Italy (1979).

The Sixteenth Marcel Grossmann Meeting (MG16) is a very special one in many respects: it will take place during a pandemic and in spite of the many difficulties, we have decided not to postpone it but to organize it as a virtual meeting. As described on the MG series webpage, these meetings started in 1975 with the first meeting at the International Centre for Theoretical Physics (ICTP) in Trieste (Italy) that I organized with Nobel Prize winner Abdus Salam. A second meeting followed in 1979, with a significantly larger participation including Nobel Laurate Cheng Ning Yang and a Chinese delegation led by Chuo Pei Yuan (see Fig. 1), including Fang Li-Zhi who had accompanied me during my entire first visit to China in 1979. The first truly international MG meeting followed in 1982 in Shanghai (China):this represented an especially important step forward both for the meeting and for China. A multi-millennia *"motto"* in China, which was then proclaimed on banners everywhere, read *"Friends from all over the world are welcomed"*. We were soon at an impasse over the participation of scientists from Israel, since no diplomatic relations existed between China and Israel at that time and the Israeli scientists were not to be allowed to attend the meeting. A long negotiation began. The boundary conditions were clearly set by Steven Weinberg, a member of the present MG16 IOC: no MG meetings on Einstein's theory of general relativity could occur without the participation of Israeli scientists. The intervention of Yuval Ne'emann, also a member of the MG IOC then as well as the Minister of Science of Israel (see Fig.2), proposed a compromise that would admit at least one Israeli scientist. I went to Beijing alone, meeting every morning for a week with 12 Chinese representatives led by Chuo Pei Yuan going over all possible options. I stayed in an isolated villa not far from Tiananmen Square, accompanied by the 3 volumes of Matteo Ricci (RI MA TO) to keep me company. No solution was in sight the entire week. At the last moment, just before my departure, an agreement was finally reached allowing two Israeli scientists into China. The historic compromise would admit Gerard Tauber and Tsvi Piran into China using a special ICRA travel document I had proposed for them to be able to participate in the meeting, accepted by the Chinese Ambassador in Rome. This modified the thousand year Chinese *"motto"* to read *"Scientists from all over the world are welcomed"*. The event was extremely beneficial for China and signaled the truly international nature of the MG meetings.

Fig. 2: From right to left: Chaim Weizmann, President of Israel; Yuval Ne'emann, Minister of Science of Israel; R. Ruffini.

Fig. 3: From right to left: Arrigo Finzi, Remo Ruffini, Gerard Tauber and Konrad Bleuler.

I kept on meeting Tauber in the years which followed (see Fig. 3). Soon after, Yuval Ne'emann visited China. The development of bilateral relations, including military cooperation and economical tights, grow exponentially until the establishment of normal diplomatic relations between Israel and China in 1992.

Given their key role played in the foundations of the MG meetings, I am very happy to propose on behalf of the MG16 IOC, two special Marcel Grossmann Individual Awards: one to Steven Weinberg for *"for unwavering support for the MG meetings since their inception, a true companion in the search for the deeper meaning of Einstein's great theory"* and another one to Tsvi Piran, *"for extending Relativistic astrophysics across international frontiers, a true companion in the search for the deeper meaning of Einstein's great theory"*, in the words of John A. Wheeler's photo dedication to myself (see Fig. 4).

Fig. 4: Albert Einstein, Hideki Yukawa and John. A. Wheeler with a hand-written dedication to Remo Ruffini "To Remo Ruffini, companion in the search for the deeper meaning of Einstein great theory. With warm regards, John Wheeler 5 April 1968".

Remo Ruffini

Institutional Awards for the Spektrum-Roentgen-Gamma (SRG) mission

"for the creation of the world's best X-ray map of the entire sky, for the discovery of millions of previously unknown accreting supermassive black holes at cosmological redshifts, for the detection of X-rays from tens of thousands of galaxy clusters, filled mainly with dark matter, and for permitting the detailed investigation of the growth of the large-scale structure of the universe during the era of dark energy dominance".

Goes to:
S.A. LAVOCHKIN ASSOCIATION
- presented to its Designer General **Alexander Shirshakov**

MAX PLANCK INSTITUTE FOR EXTRATERRESTRIAL PHYSICS (MPE)
- presented to Professor **Peter Predehl**, Principal Investigator of eROSITA

SPACE RESEARCH INSTITUTE (IKI) OF THE RUSSIAN ACADEMY OF SCIENCES
- presented to Professor **Rashid Sunyaev,** Principal Investigator of SRG Observatory in Russia

On Tuesday June 29, 2021, the following 31 Astro-Ph appeared:

1. https://arxiv.org/abs/2106.14517
2. https://arxiv.org/abs/2106.14518
3. https://arxiv.org/abs/2106.14519
4. https://arxiv.org/abs/2106.14520
5. https://arxiv.org/abs/2106.14521
6. https://arxiv.org/abs/2106.14522
7. https://arxiv.org/abs/2106.14523
8. https://arxiv.org/abs/2106.14524
9. https://arxiv.org/abs/2106.14525
10. https://arxiv.org/abs/2106.14526
11. https://arxiv.org/abs/2106.14527
12. https://arxiv.org/abs/2106.14528
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27. https://arxiv.org/abs/2106.14546
28. https://arxiv.org/abs/2106.14547
29. https://arxiv.org/abs/2106.14548
30. https://arxiv.org/abs/2106.14549
31. https://arxiv.org/abs/2106.14550

S.A. LAVOCHKIN ASSOCIATION
presented to its Designer General **Alexander Shirshakov**


Dr Alexander Shirshakov

S.A. Lavochkin Association created the Navigator space platform carrying German eRosita and Russian ART-XC X-Ray Telescopes, organized the launch of SRG Orbital X-Ray Observatory to the second Lagrangian point of the Sun-Earth system at a distance of 1.5 million km from the Earth and managed the observatory flight and the daily reception of its scientific data on Earth for 23,5 months.

Dr Alexander Shirshakov, Designer General of the S.A. Lavochkin Association, is specialized in design, manufacture, testing, launch and control of S/C for scientific purposes. Among those S/C launched, there are the «Radiostron» Astrophysical Observatory (2011) and the «Spektr-RG» space observatory (2019), while the planned S/C launches are «Luna-25» and «Exomars».

Dr Shirshakov started his career in 1973, working as an engineer of the State Unitary Enterprise «NPO named by S.A. Lavochkin» in Khimki (Russian Federation). Starting from 1989 he has played multiple roles within the Lavochkin Association, been appointed head of the group, head of the sector, head of department, deputy head of the complex, head of the branch, director of the center, deputy head of the Design Bureau, deputy General Designer and deputy General Director.

Dr Shirshakov is an editorial board Member of the reviewed edition of «Vestnik of Lavochkin Association». Since 2017, he is also member of the General Designer council. He has been awarded Honored Mechanical engineer of the Russian Federation as well as Agency-level award of the Russian Federal Space Agency.

MAX PLANCK INSTITUTE FOR EXTRATERRESTRIAL PHYSICS (MPE)
presented to Professor **Peter Predehl**, Principal Investigator of eROSITA

Professor Peter Predehl

eROSITA is the soft X-ray telescope on-board the Russian-German Spektr-RG mission which was successfully launched from Baikonur on July 13, 2019 and placed in a halo orbit around the L2 point. 30 years after ROSAT, eROSITA performs an all-sky survey with an unprecedented sensitivity, spectral and angular resolution. Clusters of galaxies are the largest collapsed objects in the Universe. Their formation and evolution is dominated by gravity, i.e. Dark Matter, while their large scale distribution and number density depends on the geometry of the Universe, i.e. Dark Energy. X-ray observations of clusters of galaxies provide information on the rate of expansion of the Universe, the fraction of mass in visible matter, and the amplitude of primordial fluctuations which are the origin of clusters of galaxies and the whole structure of the universe. eROSITA has been designed to detect at least 100.000 clusters of galaxies and to detect systematically more than 3 Million obscured accreting Black Holes. eROSITA will also allow to study the physics of galactic X-ray source populations, like pre-main sequence stars, supernova remnants and X-ray binaries. The eROSITA telescope consists of seven identical Wolter-1 mirror modules. A novel detector system has been developed by MPE on the basis of the successful XMM-Newton pn-CCD technology. MPE is the scientific lead institute of eROSITA, responsible for the development of the instrument, the operation, the analysis software and data archive. Peter Predehl led this development as Principal Investigator of eROSITA and German lead scientist of the SRG mission for more than 15 years until the completion of the first of eight surveys in 2020. At this time eROSITA has already discovered more than 1 Million X-ray sources, more than all X-ray observatories of the last 50 years together. This demonstrates, that the design goals of the mission will easily be fulfilled.

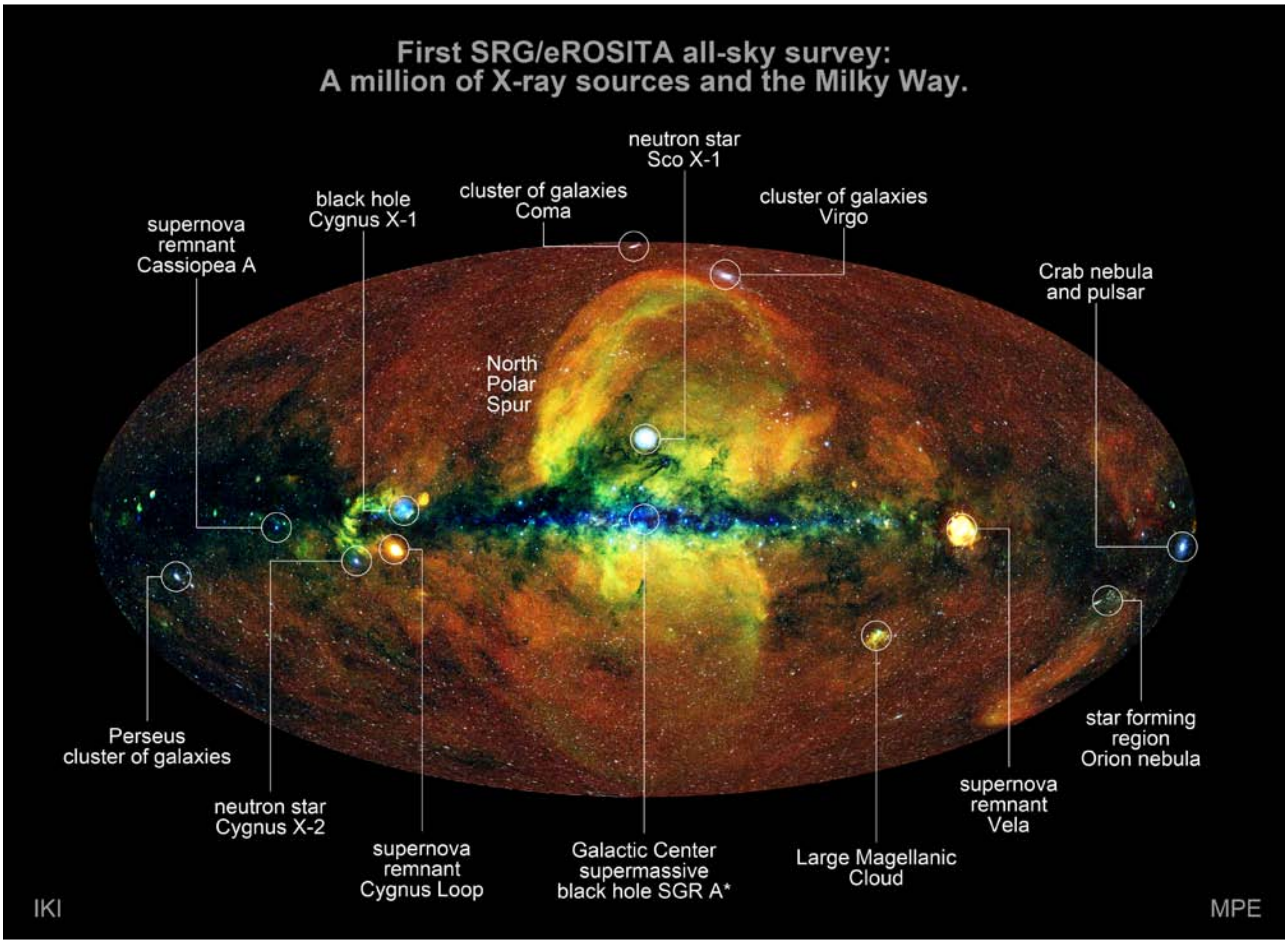
SPACE RESEARCH INSTITUTE (IKI) OF THE RUSSIAN ACADEMY OF SCIENCES
presented to Professor **Rashid Sunyaev**

Professor Rashid Sunyaev

Space Research Institute (IKI) of the Russian Academy of Sciences was responsible for developing the overall concept and scientific program of the SRG Orbital observatory and played a leading role in developing the ART-XC telescope and the entire SRG observatory as part of the Russian space science program carried out by Roskosmos Corporation in the interests of the Russian Academy of Sciences.

During the flight to the L2 point of the Sun-Earth system, SRG with German (eRosita) and Russian (ART-XC named after Mikhail Pavlinsky) X-Ray Telescopes aboard performed calibrations and long duration Performance Verification observations of a dozen of targets and deep fields. Starting in the middle of December 2019, the SRG scanned the whole sky three times. During these scans, SRG discovered two million point X-Ray sources: mainly quasars, stars with hot and bright coronae, and more than 30 thousand clusters of galaxies. There is a competition and synergy in the search for clusters of galaxies between SRG and the ground-based Atacama Cosmology and South Pole Telescopes, which are searching for clusters of galaxies in microwave spectral band using Sunyaev-Zeldovich effect. SRG provided the X-Ray map of the whole sky in hard and soft bands, the last is now the best among existing. The huge samples of the X-ray selected quasars at the redshifts up to z=6.2 and clusters of galaxies will be used for well-known cosmological tests and detailed study of the growth of the large scale structure of the Universe during and after reionization. SRG/eRosita is discovering every day several extragalactic objects which increased or decreased their brightness more than 10 times during half of the year after the previous scan of the same one-degree wide strip on the sky. A significant part of these objects has observational properties similar to the Events of Tidal Disruption of a star orbiting in the vicinity of the supermassive black hole. ART-XC discovered a lot of bright galactic and extragalactic transients.

Rashid Sunyaev is the Principal Investigator of SRG mission in Russia, director-emeritus of the Max-Planck Institute for Astrophysics and Maureen and John Hendricks distinguished visiting professor of the Institute for Advanced Study, Princeton.



15th Marcel Grossmann Meeting
July 2018, Rome, Italy

Institutional Awards
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
LYMAN PAGE
“for his collaboration with David Wilkinson in realizing the NASA Explorer WMAP mission and as founding director of the Atacama Cosmology Telescope”

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

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”

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:
Traction 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).

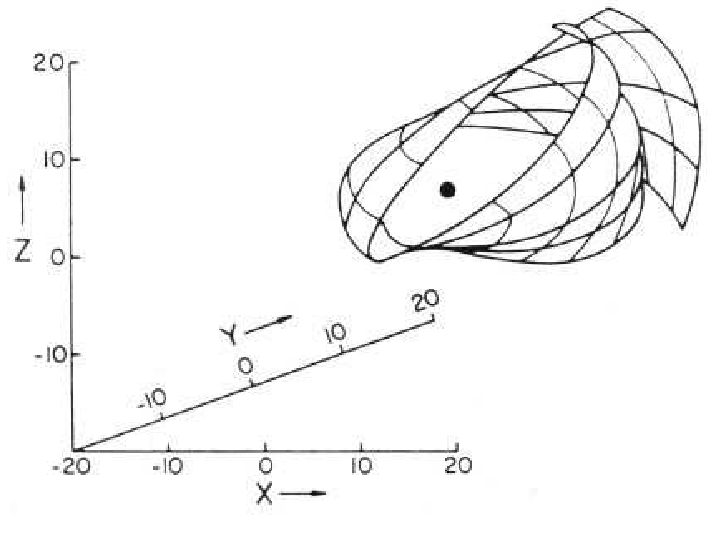
$$\dot{r} = \rho^{-2}\{[E(r^2 + a^2) - a\Phi]^2 - \Delta(\mu^2 r^2 + K)\}^{1/2}$$

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

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

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

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



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).

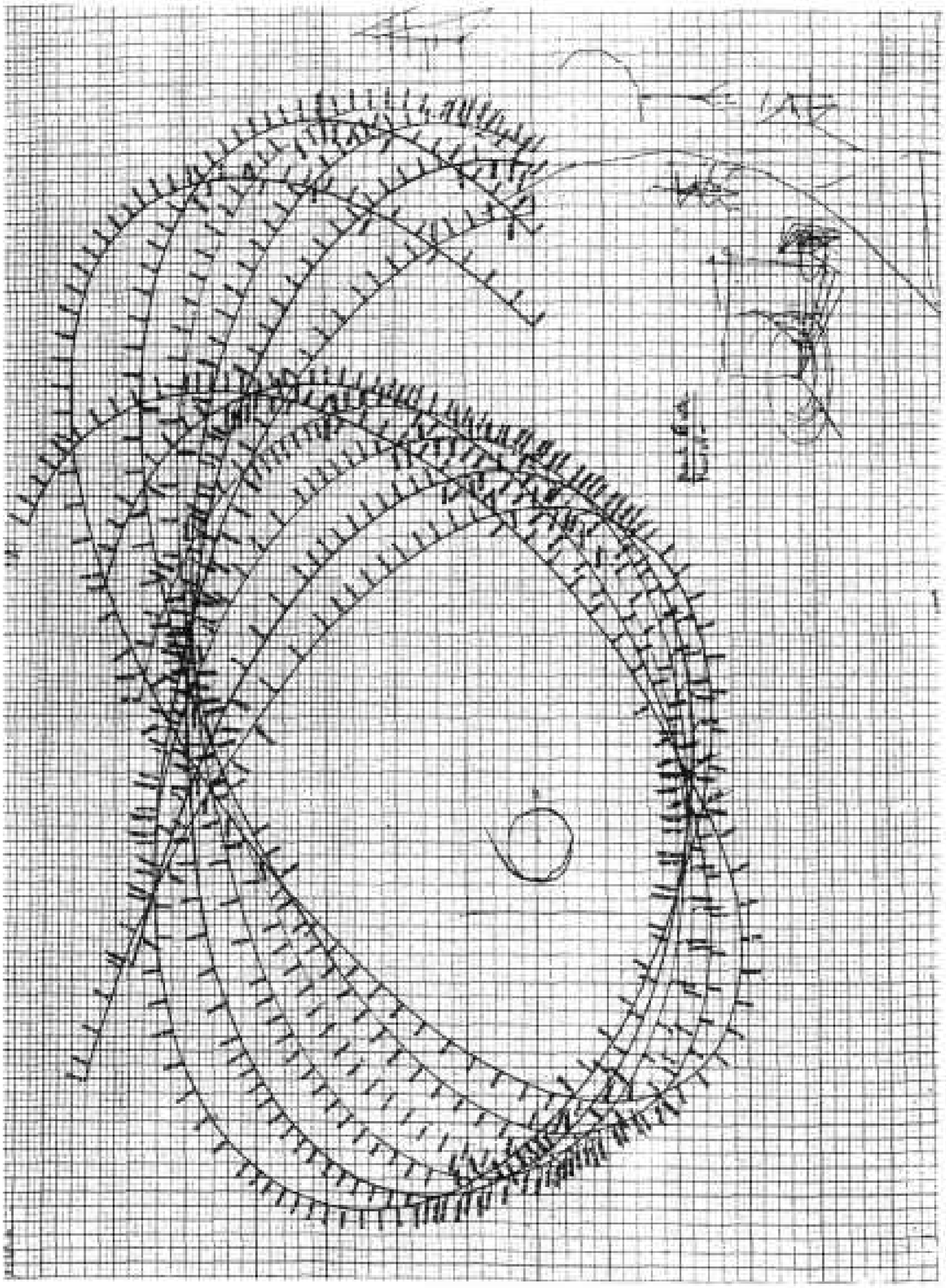
The initiation of this new work has the flavor of a challenge that the sculptor makes to himself, namely to represent the trajectories in a plastic form given their spatial co-ordinates—height, width and length—and to reinterpret them as an aesthetic object, using his own judgement to verify its artistic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

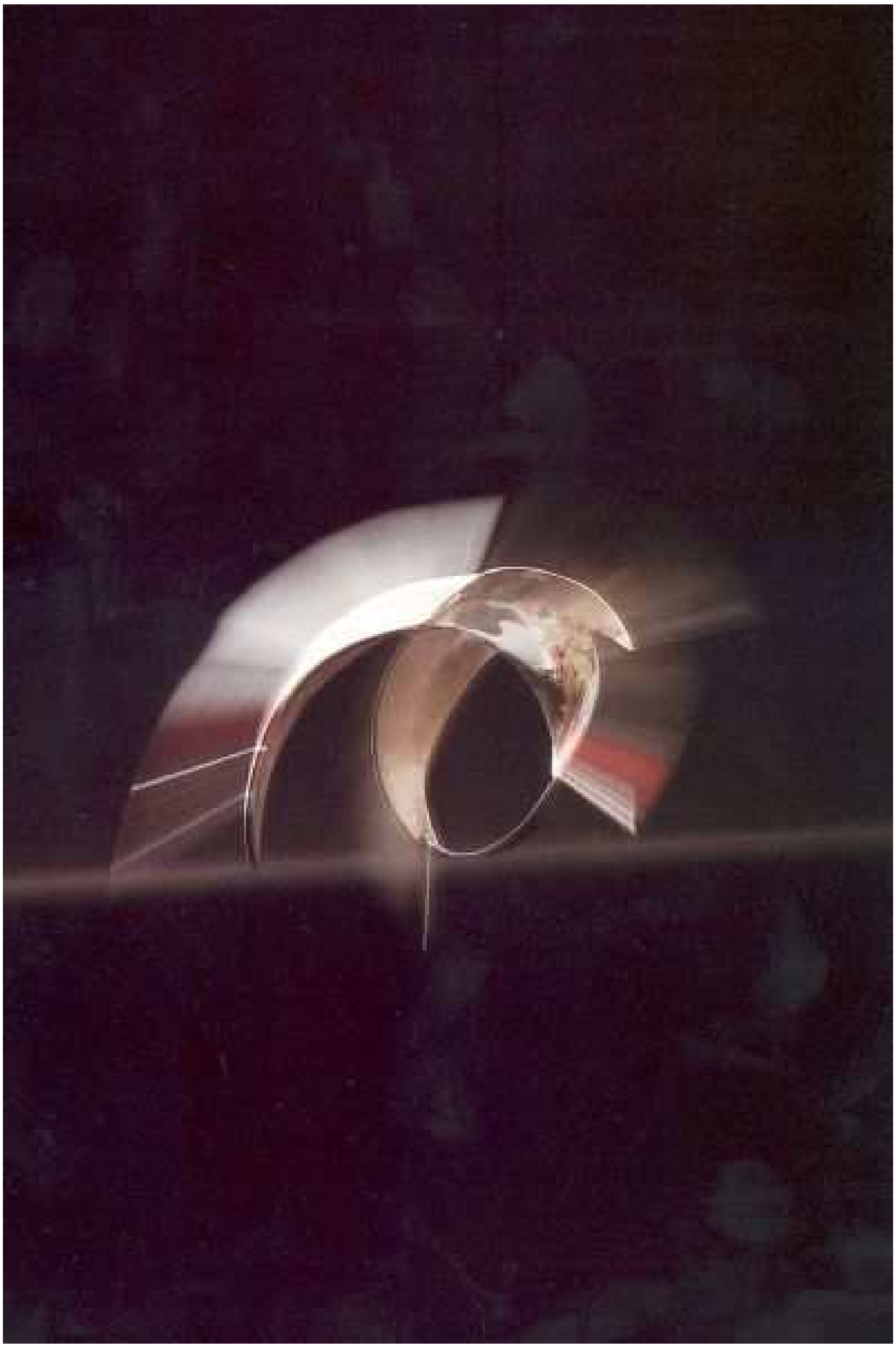
mathematical laws.

In the more recent context, characterized towards the late seventies by strong neo-expressionist and subjectivistic artistic movements, or neo-man-ner-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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Typeset with LaTeX by Bob Jantzen.

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Date of foundation: February 10, 2005

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. New centers are being established in Nice, Rio de Janeiro, Yerevan, Minsk and Isfahan. Projects for additional Centers in Stanford (USA), Central Asia, China, Australasia, Germany and Pakistan 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 is at the service of the scientific institutions and the Member States that wish to cooperate in the field of Relativistic Astrophysics.