

Commemoration of Attilio Ferrari

(Turin, May 10th, 1941-Turin, October 7th, 2022)



Prof. Attilio Ferrari became a member of the Academy of Sciences of Turin in 1996. He was deeply committed to the mission of the Academy: in his 26 years of membership, Attilio promoted an impressively large number of events and activities. Attilio passed away in the Fall of 2022 leaving a vast and precious legacy to all the people who knew him as a scientist, as a teacher, as a science popularizer, and as a friend.

Here, I will not touch upon the private life of Attilio. I will only mention the most relevant aspects of his professional activity: Attilio was bursting with ideas, and he accomplished a large number of projects, which represents only a fraction of the numerous projects he actually conceived.

1. Science

Attilio graduated in physics at the University of Turin in 1964 with a thesis whose title was “Applications of General Relativity to the Models of Quasars”. Attilio’s advisor was prof. Gleb Wataghin. Wataghin was a giant in physics; he had been member of the Academy of Sciences of Turin since 1950. As a young boy, Wataghin moved with his family from Ukraine to Turin after World War I. Here, he graduated in physics; he was a versatile physicist, at the same time a theorist and an experimental physicist. He was mindful of the new physics, especially quantum mechanics, that was emerging in the ’20s and ’30s of the twentieth century. His attention never diminished: when, in the ’60s, the first quasars were discovered, Wataghin did not miss the opportunity of providing

Attilio with a hint on a forefront topic for a thesis in physics, a suggestion that Attilio gladly welcomed.

After his graduation, Attilio served as a teaching assistant at the University of Turin until 1968, when he moved to Princeton University. In the '60s, Carlo Castagnoli, Gleb Wataghin, and Alberto Masani had initiated an intense research activity on cosmic ray physics. Castagnoli knew Bruno Coppi, a physicist a few years older than Attilio who worked at Princeton University. Castagnoli suggested Attilio to move to the United States to work with Coppi. With the enthusiasm of his age, Attilio moved to Princeton. The following year, Coppi was offered a position at the Massachusetts Institute of Technology (MIT), in Cambridge, MA. Coppi thus moved there and took along Attilio, who, on turn, took along his wife Gabriella and his newborn son, Raffaele; their stay in Cambridge saw then the birth of their daughter Monica.

At MIT, Attilio met Russell Kulsrud, a gigantic personality in the field of plasma physics. Meeting Kulsrud made Attilio fall in love with plasma physics, particularly when applied to astrophysics. This research field was at the forefront of science in those years. The '60s were exciting years for astrophysics: the cosmic microwave background was discovered, radioastronomy made impressive progress both experimentally and theoretically: the number of observed radio galaxies, where radio emission originates by their jets of ionized matter emerging from their active galactic nuclei, increased exponentially. In addition, in 1967, the first pulsar was discovered by Jocelyn Bell.

In this lively environment, Attilio did not miss the opportunity of working on this new hot topic. With Remo Ruffini, he estimated the energy taken away by gravitational waves from NP0532, the pulsar within the Crab Nebula.¹ This work had a reasonable impact when it was published, but the number of citations has exponentially increased for the last few years, after gravitational waves were actually detected: this work of Attilio's represents a pioneering result returned to the limelight.

Attilio and his family decided to come back to Turin in 1970. From 1970 to 1982, Attilio was researcher at the Institute of Cosmogeophysics of the National Council of Research (CNR), associate professor of Radioastronomy at the University of Turin until 1986, full professor of Astronomy at the same university until 2011, and emeritus professor of the Department of Physics afterwards.

In the '70s, Attilio was somehow the astrophysical soul of the Turin group of physicists, including Castagnoli, Wataghin, and Masani, who worked on cosmic ray physics: cosmic rays are particles that hit the atmosphere of the

¹ A. Ferrari, R. Ruffini, *Theoretical Implications of the Second Time Derivative of the Period of the Pulsar NP 0532*, in «The Astrophysical Journal», 158, 71, 1969.

Earth and generate secondary showers of other particles; cosmic rays clearly originate from astrophysical sources, including supernova remnants and active galactic nuclei, the scientific fascination of Attilio.

The scientific activity of Attilio dealt with pulsar magnetospheres, acceleration mechanisms of relativistic particles, plasma instability in astrophysical sources, high-energy processes in astrophysics, to mention the main topics. In the '70s, it was realized the relevance of investigating complex physical phenomena with numerical simulations. Attilio thus initiated a group of young theoretical astrophysicists to develop this approach for the investigation of magneto-hydrodynamic phenomena and specifically the physics of stellar and extragalactic jets. This group is now solid at the Department of Physics and at the Astrophysical Observatory in Turin; the numerical tools of this group are now highly sophisticated: the code Pluto, whose development has been led by Andrea Mignone in Turin, is commonly used worldwide to investigate the physical processes of astrophysical plasmas.

Attilio kept intense and active collaborations around the world: he was member of the FLASH Center for Computational Science at the University of Chicago – United States Department of Energy; member of the Center for Magnetic Self-Organization of the American National Science Foundation; member of the Center for High-Energy Plasma of MIT.

Attilio also conceived the project JETS, a joint venture of the University of Turin and the Polytechnic of Turin with the aim of realizing real jets in a laboratory. He was member of various collaborations and participate in a few space missions, including BeppoSAX, AGILE, and Fermi, for the gamma ray observation of high-energy astrophysical processes.

Attilio never stopped travelling around the world: for some time he worked at the Max-Planck Institut für Extraterrestrische Physik in Garching bei München, in Germany, and at the Institute of Astronomy in Cambridge, where he met Margaret J. Geller. The friendship with Geller inspired Attilio to initiate, some years later, a group of cosmology in Turin, which involved myself.

Within these collaborations, Attilio was awarded the Bruno Rossi prize for the mission AGILE in 2012, the Dutch National Fund Medal for scientific research in 2015, the Physics World Breakthrough of the year in 2017 as a member of the multimessenger team for the detection of electromagnetic and gravitational signals from the merging of neutron stars. This latter prize closes the loop with one of the first works of the young Attilio on the magnetospheres of neutron stars and the emission of gravitational waves, that was mentioned earlier.

2. Institutional Activity

In addition to his intense scientific activity that I outlined very briefly, Attilio was active on other fronts. One of these fronts was the institutional activity. Attilio was director of the Astronomical Observatory of Turin from 1986 to 2001. Today the institution is called Astrophysical Observatory because its activity changed from being substantially astronomical to astrophysical. Part of this change was due to Attilio who inherited the direction of the Observatory from Mario Girolamo Fracastoro, who also was a member of the Academy of Sciences of Turin and its president from 1988 to 1991. Fracastoro was director of the Observatory from 1966 to 1984. Before Attilio's directorship, Alberto Masani, who was one of Attilio's mentors, was director of the Observatory for two years.

During his directorship, Fracastoro boosted astrometry, which is the accurate measurement of the position of celestial bodies on the celestial sphere. Astrometry was indeed the main activity of the Observatory before the arrival of Fracastoro, but Fracastoro had a wider perspective: he involved the Observatory in the development of the Hipparcos space mission, that was later launched when Attilio was already director, in 1989. Attilio provided further boost to astrometry: he well understood how astrometry is the cornerstone of astrophysics, as demonstrated by the fundamental results obtained by Hipparcos and by the current Gaia space mission. The Observatory is again involved in this latter mission and has been obtaining other relevant results especially in our understanding of the dynamics of the Milky Way.

Attilio, who was a physicist with a passion for astrophysics and high-energy astrophysics, brought new research fields to the Observatory. He promoted the formation of new groups in the field of solar physics, stellar physics and high-energy astrophysics; and even cosmology at the Department of Physics of the University of Turin. Attilio was a theorist, but he strongly supported the development of technologies applied to astrophysics: he promoted laboratories that are still extremely active today. Indeed, the Observatory contributed to a number of technological aspects of the Euclid space mission, launched on July 1st, 2023, for the measurement of the large-scale distribution of galaxies. Thanks to Attilio's support, the Observatory now has an international renown for its high quality of technological activity and for its role as a data center for space missions, in addition to its research activity. Attilio was a worthy successor of Fracastoro: he understood the relevance of astrometry and, at the same time, enlarged the scientific activity of the Observatory in different and relevant directions, as indicated by the increase by a factor of four of the number of people in the staff of the Observatory that occurred during Attilio's directorship.

Attilio also initiated the group of cosmology at the Department of Physics of the University of Turin. When I met Attilio in 1988 he proposed to me to start this new research field in Turin: there certainly was a grain of recklessness in this proposal to me, as I was an undergraduate student at the time. Nevertheless, he probably guessed right, given that the cosmological group in Turin is now active and lively. It is an example of the courage and boldness which were typical of Attilio's personality.

In addition to the direction of the Observatory, Attilio was active on other fronts. He was a member of the Council for the Astronomical Research (CRA) of the Italian Minister of University and Scientific and Technological Research from 1991 to 1994. He was a member of the Directorship Council and of the Council of the National Consortium for Astronomy and Astrophysics from 1996 to 2001. This institution was the predecessor of the Italian National Institute of Astrophysics (INAF). Along with the directors of other astronomical observatories, Attilio provided a fundamental contribution to the construction of INAF, whose first president was Giancarlo Setti. INAF was formally constituted in 1999 and Attilio was a member of the Directorship Council from 2000 to 2003. Before the creation of INAF, the individual astronomical observatories were independent institutions. They are now astrophysical observatories and local branches of INAF. In an international and global perspective, this new organization is largely more efficient and competitive for the development and the achievements of the national astronomical and astrophysical research.

Attilio also was the INAF representative for the National Scientific Committee for the Antarctic from 2003 to 2007, a member of the Bilateral Committee Italy-Russia for the development of the IGNITOR project for nuclear fusion, and the Italian manager of the agreement between the University of Turin and the Enrico Fermi Institute of the University of Chicago.

Attilio understood the importance of the astrophysical investigation from space and thus conceived and founded, in 1989, the Inter-university Consortium of Space Physics (CIFS) whose purpose was, according to its statute, to «promote and coordinate the participation of the members of the consortium to the experimental scientific activities in space in the field of astrophysics, physics of the Solar System, and physics of the interplanetary plasma, in agreement with the national and international space programs in which Italy is involved». This consortium played a fundamental role in various space missions, including AGILE, mentioned earlier, to optimize the coordination of the activity of the Italian scientific community in space missions.

CIFS also promoted the International School of Space Science (ISSS) which has organized a meeting twice a year since 1991. The school is intended

for master and graduate students interested in space physics. This deep interest of Attilio for students introduces us to another relevant activity of Attilio: teaching.

3. Teaching

Attilio had a great passion for teaching and a great esteem of students. Attilio taught various courses of physics, astronomy and astrophysics to undergraduate and graduate students. His course of Radioastronomy was legendary; it was the first course of Radioastronomy taught at the University of Turin. With the reform of the teaching system in the Italian universities in 1999, the so called 3+2 reform, Attilio contributed to the creation of the Master degree in Astrophysics and Cosmic Physics in 2002. With the new reform of 2010, this Master degree moved within the Master degree in Physics with specialization in Astrophysics.

Attilio's passion for teaching and his attention to students materialized in a textbook of fundamental astrophysics for undergraduate students.² Who has the opportunity of reading his textbook grasps the passion and the enthusiasm that Attilio had in transmitting astrophysics to students.

Attilio's attention was devoted to students from all schools, from primary school to university: the popularization of astrophysics and of science in general was another fundamental chapter of Attilio's activity. Indeed, despite all the tasks he accomplished, Attilio found the time to intensely devote himself to popularization.

4. Popularization

In 1996, Attilio founded the Association for the Popularization of Astrophysics (ADA – Figure 1). The Association had the goal of organizing schools of astrophysics for students from primary to high schools and refresher courses for teachers. ADA was very active for more than a decade. Attilio was enthusiast to share his time with young people: he was jovial and loved to play around, especially with young persons. He was an astrophysics enthusiast with a profound desire of passing his enthusiasm to young people.

ADA's activity culminated in 2009, with the organization of the celebrations of the International Year of Astronomy, in the 400th anniversary of

² A. Ferrari, *Stelle, galassie e universo. Fondamenti di astrofisica*, Springer Verlag, 2011.



Fig. 1. Logo of the Association for the Popularization of Astrophysics (ADA). The presence of the figures of a child along with an adult shows the love of Attilio for the young people.

the first use of a telescope for the observation of the sky, and specifically of the Moon, by Galileo Galilei and the publication of Johannes Kepler's book *Astronomia Nova*, where Kepler enunciates his first two laws. For the organization of the celebrations, Attilio involved the University of Turin and the Academy of Sciences, under the high patronage of the President of the Italian Republic. Attilio organized a majestic year of celebrations. Attilio loved any form of art: the logo of the International Year of Astronomy for Turin (Figure 2) was inspired to the stars depicted in Guarino Guarini's dome of the cathedral of Turin, where the Holy Shroud is kept.



Fig. 2. Logo for the celebrations of the International Year of Astronomy 2009 in Turin. The stars in the logo are inspired by the stars of the decoration of the XVII century dome of the Holy Shroud chapel in the Turin cathedral by the architect Guarino Guarini.

The year 2009 was legendary, with 21 public lectures, namely almost two public lectures per month, an exhibition of historical astronomical telescopes, various exhibitions of historical documents and catalogs, pedagogical activities for primary to high-school students, a number of astronomical readings at the Club of Readers of Turin.

Attilio invited a number of distinct scientists in Turin, and particularly at the Academy of Sciences, including the cosmologist Edward (Rocky) Kolb, the Nobel laureate Riccardo Giacconi, and Father George Coyne, director of the Vatican Observatory, who contributed to the rehabilitation of Galileo Galilei by the Catholic Church when John Paul II was Pope. Attilio also organized a concert at the Royal Theater in Turin: *The Planets* by Gustav Holst.

However, the most outstanding achievement of Attilio is the foundation of the Astronomy Park Infini.to, the Planetarium and Museum of Astronomy and Space of Turin. Attilio conceived the idea of a planetarium already at the end of the '80s, in the wake of the activity of popularization of the Astronomical Observatory, an activity initiated by Girolamo Fracastoro. With the support of bank foundations and local institutions, Attilio succeeded in materializing the idea of building a planetarium next to the Astrophysical Observatory. The building now belongs to INAF and the museum and planetarium are managed by the Association Apriticielo, founded by Attilio in 2006. At the beginning, the members of the Association were INAF, the University of Turin, and the City of Pino Torinese. Three additional members joined later: Piedmont Region, Metropolitan City of Turin, and the National Institute of Nuclear Physics (INFN).

The Astronomical Park Infini.to was inaugurated in 2007. Infini.to is a cutting-edge science center. It has a digital planetarium, 1000 m² space for permanent and temporary exhibitions, 40 interactive stands, and a laboratory for visitors. Infini.to is a gem both at a national and European level. Infini.to attracts more than 50000 visitors every year; it organizes laboratories, conferences, colloquia, and events that are not strictly scientific, including music concerts, theater plays, art exhibitions (Figure 3). The great success of Infini.to has also been obtained thanks to the impressive skill and the enthusiasm of its staff of which Attilio always was very proud.

At Infini.to, Attilio invited distinct scientists and personalities, for example Kip Thorne, Nobel laureate in Physics for the gravitational wave detection; in 2019, for the 50th anniversary of the Moon landing, Infini.to hosted the astronaut Charles Duke, from the Apollo 16 mission, who, along with John Young, walked and moved with the lunar rover on the Moon in 1972. Attilio was always successful in attracting people of this stature, just because of his passion for astrophysics and for popularization.



Fig. 3. The Astronomical Park Infini.to: the main entrance; an image of the interiors; the planetarium.

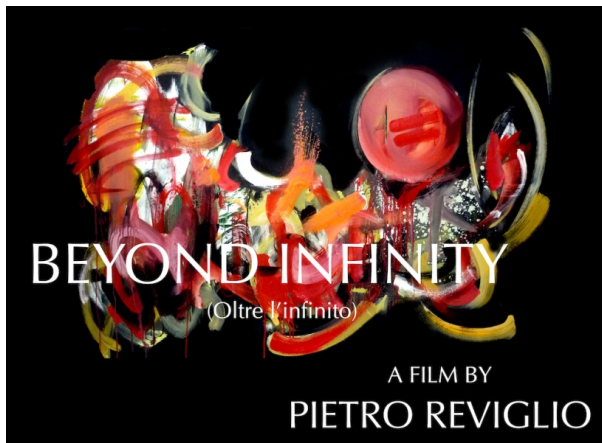


Fig. 4. Poster of the movie *Beyond Infinity* by Pietro Reviglio. The movie is intended to be projected onto a dome of a planetarium, providing an intense, fully immersive experience, that is, at the same time, artistic and scientific.

Attilio was fascinated by art: he commissioned a movie to Pietro Reviglio, an astrophysicist from Turin who became an artist while he studied radio galaxies at Columbia University in New York City. Reviglio's movie, *Beyond Infinity*, was specifically intended to be projected onto a dome of a planetarium: it combines art, cosmology and science (Figure 4). The premiere was at Infini.to in 2017 and the movie received a number of international recognitions around the world.

In 2017, Infini.to celebrated its 10th anniversary. In an interview for that occasion, Attilio refers to the visitors of Infini.to with the words boys and girls. Attilio explains his reason: the visitors of Infini.to are attracted by the curiosity which is typical of young persons. Indeed Attilio felt to be a boy himself: he left Infini.to to all those people that, like the youngest, are moved by the curiosity of knowing the secrets of nature and by the interest stimulated by the human mind that expresses itself in all the disciplines, from art to literature, from history to natural sciences. Apparently, Attilio never stopped to feel a boy, as showed by his never-ending enthusiasm and passion for culture and for life.

On May 15th, 2023, close to his 82th birthday on May 10th that he could not celebrate, in a one-day celebration of Attilio's scientific life, with his family, colleagues, and friends, Infini.to will be named after him: the Planetarium and Museum of Astronomy and Space of Turin «Attilio Ferrari». This dedication is a small sign of gratitude to Attilio for his vast legacy that will be enjoyed both by those persons who did not have the fortune to know him and by those who did.

Acknowledgments. I sincerely thank Gabriella Mortara, Attilio's wife, for our pleasant conversations on their time in the United States and for sharing inspiring family pictures with me. I am also in debt with Edoardo Trussoni and Silvano Massaglia, longtime friends and collaborators of Attilio, for informative discussions on his scientific activity. I also wish to thank Gabriella Ardizzoia, secretary of ADA, and Eleonora Monge, director of Infini.to, for their invaluable help in outlining the intense popularization activity of Attilio. I finally thank all those people who knew Attilio and, one way or another, contributed in shaping my view of his versatile personality that I attempted to describe here.

ANTONALDO DIAFERIO

Assembly of May 10th, 2023