

## Curriculum Vitae et Studiorum of Patrizia A. CARAVEO

Born in Milano on April 8th, 1954

Italian degree of Laurea in Physics with Full Academic Honor at the University of Milano in 1977

### Current Standing and Summary of Activities

Currently, PAC is Research Director at the Istituto di Astrofisica Spaziale e Fisica Cosmica in Milano, one of 17 Institutes of INAF, she is also Professor of “Introduction to Astronomy” at the University of Pavia, representative of INAF within the CTAO Council and Associate Editor of the *Journal of High Energy Astrophysics*. In December 2017 PAC completed her second term as Director of the Istituto di Astrofisica Spaziale e Fisica Cosmica in Milano. The milestones of her career are given below.

A world leader in the study of high-energy emission from neutron stars, PAC is well known for her seminal work on Geminga, the first gamma-ray pulsar with no radio emission. Indeed, her career was based in interdisciplinarity in astronomy, from space and from the ground

Her list of publication can be seen at <http://www.iasf-milano.inaf.it/~pat/WEBpage/pat-pub.pdf> . It features:

- 432 paper published on international referee journals
- 150 conference papers (several invited papers)
- Hundreds of papers for the general public
- 2 books

***However measured, her impact factor is very high. ADS, the system widely used by the astronomical community, quotes an h index >110, with more than 47.000 citations.***

Indeed, in 2014 PAC has been included by Thomson Reuters in the list of **Highly Cited Researchers** for Space Science, an area which encompasses a total of 100 scientists worldwide.

PAC won the prize **Premio Nazionale Presidente della Repubblica** in 2009 and shared with her Swift, Fermi and Agile colleagues the **Bruno Rossi prize of the American Astronomical Society in 2007, 2011 and 2012.**

In 2014 she received the **Outstanding Achievement Award** from the Women in Aerospace European Society.

In 2017 she was awarded the title of **Commendatore** dell’Ordine al Merito della Repubblica Italiana  
PAC has organized (either as main organizer or as member of the organizing committee) many Conferences and Summer Schools. She is often invited to give review lectures on topics ranging from unidentified  $\gamma$ -ray sources to the multiwavelength behaviour of Isolated Neutron Stars to the role of women in Science. PAC is actively promoting women in STEM careers and her position is stated in a recent pamphlet entitled “Uomini e donne: stessi diritti?” (Castelvecchi, 2017)

PAC has been thesis adviser for tens students working both for their degree of Laurea (M.Sc) and of Dottorato (PhD).

PAC is active in science communication: she write regularly (several times a month) for Italian newspapers, blogs and magazines and she often lectures for the general public.

PAC is the reference point of a web site dedicated to high energy astrophysics which can be found in <http://www.iasf-milano.inaf.it/> selecting “divulgazione”

PAC is fluent in Italian, French and English

## Scientific Achievements and Ongoing Research

The scientific career of PAC now spans almost 40 years. It can be characterized by a first 10 y period dedicated mostly to data analysis and interpretation of gamma-ray astronomy (ESA's COS-B) and X-ray astronomy (NASA's Einstein, ESA's Exosat) data.

In the second decade, the field of interest widens to include the full range of observational multiwavelength astronomy, with significant emphasis on optical observations and to include also interpretative work.

In the last two decades, PAC has further broadened her interests, to include work on instrument design and mission planning, as well as managerial tasks at national and international level.

After a significant contribution to the COS-B data analysis which led to the **Cos-B Catalog of gamma-ray sources**, PAC took part from the start to the chase which led to the discovery and understanding of "Geminga" through multiwavelength astronomy. This required the use of practically all means of space and ground based astronomy including space missions, such as SAS-2, HEAO-1, COS-B, Einstein, Exosat, Ginga, Rosat, Egret, EUVE, ASCA, HST and Hipparcos, and ground-based telescopes, such as the CFHT and ESO's 3.6 and NTT.

The results on Geminga opened a new chapter in high-energy astrophysics: the study of unidentified  $\gamma$ -ray sources. This subject is now being pursued by several groups world-wide, but Geminga remains the first example of a celestial object identified through its gamma-ray emission.

To broaden the study of compact objects (neutron stars and black holes), generally through correlation with multiwavelength data, she was awarded, either as a PI or as a CoI, dozens of nights at ESO telescopes (VLT UT1, NTT, 3.6m, 2.2m) and about 50 orbits of HST.

Of special interest in the optical field is the first ever correlation between Hipparcos, HST and ground based images of the Geminga counterpart to nail down the absolute position of the neutron star through its extremely faint optical emission, a parameter needed to fold the arrival times of gamma-ray photons collected by SAS-2, COS-B and EGRET over 20 years.

The constant scientific theme of PAC's contribution to science is the phenomenology of galactic compact objects. Special attention is given to isolated neutron stars, their velocity distribution, their distances and their relations to supernova remnants. **PAC is a recognized leader in the study of neutron stars behavior at different wavelengths.**

The existing evidence for optical emission from isolated neutron stars is largely the work of her group. **Using HST, she secured parallactic distance measurements of Geminga and the Vela pulsar.** These remain the first absolute measurements of neutron stars' distances.

More breakthrough results on Geminga, as well as on other neutron stars, were possible thanks to XMM-Newton. **A long observation of Geminga yielded the detection of its "tails", i.e. two diffuse features that trail the source as it moves through the interstellar medium (Science dedicated their cover to this result).** The data also yielded phase resolved spectroscopy for the source, unveiling the presence of an exceedingly small hot spot which is seen only for a fraction of the pulsar rotation.

Later, XMM-Newton observation of 1E 1207.4-5209 (another neutron star) yielded the first ever evidence of multiple cyclotron absorption lines which made it possible **the first direct measure of a neutron star magnetic field.**

For her contribution to the understanding of Geminga, as the first radio quiet neutron star, in 2009 she was awarded the “**Premio Nazionale Presidente delle Repubblica**”, the highest award for science in Italy

In parallel, PAC took active part in the development of several high-energy missions, such as the Spectrometer Instrument of the **Integral** mission (in close collaboration with the French Space agency CNES), the Italian mission **AGILE**, and the NASA missions **SWIFT** and **GLAST**, now known as Fermi.

She was also involved in the New Generation Space Telescope (NGST, later renamed James Webb Space Telescope) the successor of the Hubble Space Telescope, for which she led the science case for the industrial study on the 'On board data management', and, more recently, in the EXIST phase A study.

PAC is now the leader of the Italian participation to the Cherenkov Telescope Array (CTA), a project devoted to very high-energy astronomy from the ground, where Italy is one of the major partners.

Within the National Institute of Astrophysics (INAF), PAC is responsible for the exploitation of the Fermi data which are changing our view of the gamma-ray sky. Fermi has shown that a sizable fraction of previously unidentified galactic gamma-ray sources are indeed radio-quiet gamma-ray pulsars, similar to Geminga. This result, published in 2009, was judged by the Science editors one of the most important findings of the year.

Radio pulsars, however, should not be given for granted since, even the best studied ones, can yield surprising results. In September 2010 the Crab doubled its gamma-ray flux and remained unusually bright for few days. As member of both Agile and Fermi collaborations, **PAC understood the profound and revolutionary meaning of this result and hurried to submit a Director Discretionary Time proposal to the HST.** This first observation started a monitoring programme aimed at nailing down the production site of the variable gamma-ray emission, such programme is still ongoing.

In parallel, PAC is also coordinating a joint SWIFT-FERMI programme aimed at the understanding of the still mysterious, unidentified Fermi  $\gamma$ -ray sources a fraction of which are also investigated through deep observations performed by the Chandra and XMM-Newton X-ray observatories. Indeed, thanks to the focussed effort by PAC's group in Milano the number of gamma-ray pulsars with good X-ray observations has doubled in a very short time.

In recognition of her leading role in the study of the high-energy emission of isolated neutron stars, PAC was invited to write a review paper for Annual Review of Astronomy and Astrophysics. The paper, entitled “**Gamma-Ray Pulsar Revolution**”, appeared in September 2014.

Indeed, the pulsar revolution is continuing with the evidence that the gamma-ray excess in the galactic centre could indeed be due to gamma-ray pulsars rather than to dark matter the nature of which remains elusive and represents the next frontier to be addressed, hopefully by the Cherenkov Telescope Array.

PAC has also supported the idea to exploit the capabilities of wide field gamma-ray instruments to search for counterparts of gravitational waves. The efforts are now starting to bring results which will certainly shed light on such events.

## Career Milestones and Organizational Responsibilities

- 1977-1978** Collaborateur Temporaire Etranger at the Service d'Astrophysique of the Centre d'Etudes Atomique de Saclay (France)
- 1978-1982** CNR fellow for "Analysis and Astrophysical Interpretation of Gamma-Ray Astronomy data" at the Consiglio Nazionale delle Ricerche (CNR), Milano. In parallel to gamma-astronomy work with the ESA COS-B mission, PAC starts intense activity as Guest Observer in X-ray astronomy, both with the US Einstein Observatory and the European Space Agency (ESA) EXOSAT mission.
- 1978-1985** Member (later official Milano representative) of the Data Reduction Group of the Caravane Collaboration of the COS-B mission.
- 1982 becomes Staff Scientists at the IFCTR/CNR, Milano**
- 1987** Winner of a NATO senior fellowship at the Service d'Astrophysique (Saclay, France) for the preparation of the multiwavelength observing program for the low energy gamma-ray astronomy CNES (French Space Agency) mission SIGMA
- 1987-1988** Member of the Phase A study for the ESA Gamma-Ray Astronomy mission GRASP
- since **1987** she starts her activity as an optical observer, first as a Co-Investigator and then as a Principal Investigator at various telescopes, mostly at the European Southern Observatory (ESO).
- 1989** invited back to Saclay to carry-out the multiwavelength campaign for the understanding of the SIGMA low energy gamma-ray sources
- 1989-1999** Member of the System Team for the EPIC instrument, now successfully flying (since 1999) on the ESA cornerstone mission XMM-Newton, with special interest in optical/IR observations
- 1990-1995** Vice President of the Italian Space Society
- Since **1990** she has been taking an active part in the Hubble Space Telescope observations both as PI and as CoI
- 1994** becomes **CoInvestigator** for the Spectrometer Instrument (SPI) on ESA's Gamma-Ray mission INTEGRAL, with hardware responsibilities towards CNES
- 1997 wins a position of Primo Ricercatore (Senior Staff Scientist) at the IFCTR/CNR, Milano**
- 1997** nominated European Coordinator for the observing time allocation of the EPIC experiment on XMM-Newton
- 1998** : member of the NASA Science Team for the GLAST (Gamma-Ray Large Area Space Telescope, later renamed Fermi) mission
- 1998** : **CoInvestigator** of the NASA **SWIFT** mission dedicated to the study of Gamma-Ray Bursts (PAC has been responsible for the ground station)
- 1998** **CoInvestigator** and key person for **AGILE**, the first small mission of the Italian Space Agency dedicated to gamma-ray astronomy
- 1999** Leader of the Science Team for the ESA study "Next Generation Space Telescope (NGST, later renamed James Webb Space Telescope, JWST) Data Management"
- 1999** **CoInvestigator** for the NASA GLAST mission, now known as **Fermi**
- 1999 and 2002** Member of the XMM-Newton Time Allocation Committee
- 1999–2002** member of the ESA Science Working Team for NGST

- 2000** Member of NASA's Chandra X-Ray Observatory Time Allocation Committee
- 2001-2003** member of the Astronomy Working Group of the European Space Agency
- since 2002 Research Director at the IASF-INAF Milano**
- 2002** « Qualification aux fonctions de Professeur des Universités », section 34 : Astronomie, Astrophysique, full professor title for French Universities.
- 2005-2008** serves as Co-leader of the GLAST (Fermi) Working Group devoted to the strategy for gamma ray source identification.
- 2005** member of NASA's Hubble Space Telescope Time Allocation Committee
- 2007** Co-Chair of the Astronet Panel “High-energy, astro-particle astrophysics and gravitational waves”
- 2009 Winner of the Italian prize “Premio Nazionale Presidente delle Repubblica”**
- 2011-2017 Director of the Istituto di Astrofisica Spaziale e Fisica Cosmica (IASF) of the Istituto Nazionale di Astrofisica (INAF)**
- 2012 INAF representative within the international ultra-high energy research project CTA (Cherenkov Telescope Array)
- 2013 Chair of the Astronet Panel “High-energy, astro-particle astrophysics and gravitational waves”**
- 2013 member of the AERES (French research evaluation agency) evaluation committee for CEA
- since 2013 Representative of INAF within the Resource Board of the Cherenkov Telescope Array
- since 2013 Associated Editor of the Journal of High-Energy Astrophysics (JHEA, Elsevier)
- since 2013 member of the Consiglio Direttivo of the Italian Astronomical Society (SAIt)
- 2014 selected by Women in Aerospace Europe for their Outstanding Achievement Award**
- 2014 included in the Highly Cited Researchers list by Thomson Reuters**
- 2014 main organizer of the conference *10 years of discovery* held in Roma to celebrate SWIFT 10<sup>th</sup> anniversary. Editor of JHEA special issue devoted to SWIFT legacy papers
- since 2015 Representative of INAF within the Council of the Cherenkov Telescope Array Observatory**
- 2015 Organizer of the Summer School “Towards the Cherenkov Telescope Array and Future Gamma-ray Experiments” 27-31 July Sexten
- 2015-2017 Member (adviser) of the **Italian delegation to ESA's SPC**
- 2016 INAF representative in the negotiation which selected Bologna as the location of the CTAO Headquarters
- 2017 awarded the title of **Commendatore** dell'Ordine al Merito della Repubblica Italiana
- 2017 Organizer of the Summer School “gamma-Ray Astrophysics with CTA” July Sexten
- 2018 member of the scientific committee of the **Space Economy Evolution Lab** at Bocconi University

Since 1997, she is contract professor at the University of Pavia for Introduction to Astronomy