

THE VATICAN OBSERVATORY



VATT
at 30

annualREPORT2023



THE VATICAN OBSERVATORY



STAFF

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- GUY J. CONSOLMAGNO, S.J., *Director*
- GABRIELE GIONTI, S.J., *Vice Director*
- PAVEL GABOR, S.J., *Vice Director for VORG*
- RICHARD P. BOYLE, S.J.
- DAVID A. BROWN, S.J.
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- RICHARD D'SOUZA, S.J.
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- JEAN-BAPTISTE KIKWAYA-ELUO, S.J.
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- ALESSANDRO OMIZZOLO
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CONTENTS

CHAPTER ONE, **6**
LETTER FROM THE DIRECTOR

CHAPTER TWO, **10**
VATT AT 30

CHAPTER THREE, **18**
2023 A YEAR IN REVIEW

CHAPTER FOUR, **54**
SUMMER SCHOOL 2023

CHAPTER FIVE, **60**
MEETING AND OUTREACH

CHAPTER SIX, **74**
PUBLICATIONS

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CHAPTER ONE

LETTER FROM THE DIRECTOR

In this Annual Report we look back not only at the year 2023 but also back over the thirty years since the dedication of the Vatican Advanced Technology Telescope in Arizona.

As seen on our cover, the year 2023 marked the thirtieth anniversary of “first light” at our Vatican Advanced Technology Telescope, or VATT — the Alice P. Lennon Telescope and the Thomas J. Bannan Astrophysics Facility. In September, we celebrated with a weekend of events in Tucson.

We began the festivities with a gala dinner on September 29 at the Hacienda del Sol Guest Ranch Resort, Tucson. Major General Charles F. Bolden, Jr., was our featured guest. General Bolden served as NASA Administrator from 2009 to 2017; before then, he flew on four Space Shuttle missions. At the dinner, I had the pleasure to sit with the General in front of our attendees and lead him in a fascinating discussion of his personal history, what it is like to fly in space, and his own journey as both an astronaut and a man of faith. You can find this interview as a podcast on our site: <https://www.vaticanobservatory.org/general/from-humble-beginnings/>



Major General Charles F. Bolden, Jr. and Br. Guy Consolmagno, SJ

The next day, Christopher Corbally and Paul Gabor led a tour to the VATT on Mt. Graham. On Sunday, October 1, at Ss. Peter and Paul Church near our Tucson community, we held a Memorial Mass and reception in the memory of the late George V. Coyne, the past Director of the Vatican Observatory who spearheaded the construction of the telescope. Finally, on October 2, the VATT was featured at the Steward Observatory's Public Evening Lecture Series, with panelists discussing the telescope's history and future.

I remember that weekend in September, 1993, when we celebrated the telescope's “first light”. That was also the

week I first arrived in Tucson as a member of the Vatican Observatory. Of course, I knew Tucson well already; I had been a student at the Lunar and Planetary Laboratory of the University of Arizona (and an early member of its Department of Planetary Sciences) back in the 1970s. In fact, that's where I first met George Coyne, when he was a research faculty member there.



Fr. George Coyne, SJ

The Specola was a very different place in 1993. The Annual Report of 1992 (published in 1993) was a much smaller and thinner book than what you hold in your hands now. Just to use one simple metric, in that report are listed 63 publications by Specola staff. By contrast, 153 different publications are listed in the 2022 Annual report!

The annual report itself has a different format now than it had in 1993. Now we include extended articles giving a deeper look into the work we do here, both in science and in outreach. This new style was introduced by José Funes, Coyne's successor, reflecting an increased awareness that the mission of the Vatican Observatory is not only to do the science, but to show the world how the Church supports this science.

There is one obvious reason for the near-tripling of the publication output of the Specola: today there are many more of us working and publishing under the aegis of the Vatican Observatory. In 1993, there were only six active Jesuit astronomers and six more adjunct scholars or research affiliates. By 2023, both of those numbers had doubled. Virtually all of that growth in staff can be attributed to George Coyne, who as director worked hard to encourage young Jesuits to join the observatory. He also devised the idea of adjunct scholars, who today are such a vibrant and important facet of this observatory.

Likewise, the place where we do our work has changed significantly. José Funes oversaw our 2009 move in Castel Gandolfo from the old Papal Palace to a new site in the papal gardens near Albano. This site gave us an expanded space for our library and archives, a climate-controlled vault for our historic astronomical plates, and a remarkable meteorite repository and laboratory. And not least among the facilities here are classrooms, offices, and dining facilities for both our Summer Schools and other scientific workshops. These facilities, along with an upgraded internet system, have brought our Castel Gandolfo site back into being a center of Specola activity.

Meanwhile, of course, the biggest change in Tucson from 1993 is that we now have a fully functioning VATT. With our telescope we can now carry out the kind of survey research — along with the occasional “I wonder if this would work?” explorations — that simply aren’t possible with larger telescopes. The VATT holds an essential place in the ecosystem of astronomical telescopes: discoveries made with small telescopes can later be confirmed or explored more thoroughly with the better known ‘scopes orbiting in space or located in Chile or Hawaii.

All this growth can be seen in this 2023 Annual Report. Here, you’ll read about our Summer School and the VVVX Workshops held in Castel Gandolfo; research on the physical properties of meteorites; and the results of surveys, the study of “peculiar stars”, and other new discoveries observed at the VATT.

You will also read about work that our astronomers are doing beyond our own facilities, in conjunction with space telescopes and space missions that have filled the news. Richard D’Souza was on a team that got time on the Hubble Space Telescope; Robert Macke has been invited to NASA’s Johnson Space Center to begin measurements of material brought back by the OSIRIS REx mission from asteroid Benu. And we remain deeply involved with international astronomical societies, ranging from the International Astronomical Union (IAU) to the Meteoritical Society, and other astronomical societies in Europe, Italy, and the United States.

As for “showing the world”, I will mention just two items. On March 24, the New York Times ran a front-page story about Specola astronomers being honored as the namesakes of a number of newly-discovered asteroids. And in December, the work of Richard D’Souza (first described in the 2018 Annual Report) was the cover article for the popular astronomy magazine *Sky and Telescope*!

Of course, the Specola was active in a number of these fields, and an important participant with the IAU, even in

1993. But this integration of our scientists into so many of the frontiers of modern astronomy (and may I just also include the theoretical work in cosmology and the work in history, faith, and science being done by so many of us, as reported here) shows just how much our observatory has grown on the foundations laid thirty years ago.

Let me end by pointing out one essential player who has made so much of this work possible: the Vatican Observatory Foundation and all its benefactors. The Foundation supports the upkeep of the telescope, including the project of its robotization, now well underway. The Foundation fully funded the 2023 Vatican Observatory Summer School. And it also sponsored the thirtieth anniversary events described in the beginning of this letter. The Foundation, too, has undergone remarkable growth under the leadership of its chair, Mickey Pohl. It reminds us that what we do is the work of a community much larger than only those of us represented in this Annual Report.

It is our privilege at the Vatican Observatory to carry out this noble enterprise. Together let us open up the very heavens that proclaim the glory of God.



Mr. Mickey Pohl

for Guy Consolmagno S.J.
Br. Guy Consolmagno, S.J.
Director, Vatican Observatory



Br. Guy Consolmagno, S.J.

Personnel News

Beginning in August, the Observatory was delighted to host Fr. Cy OPEIL SJ of the Department of Physics, Boston College, for a year’s sabbatical. Opeil has been a longtime collaborator with Consolmagno and Macke, measuring the physical properties of meteorites (as described in their annual reports). He is also a collaborating scientist on the NASA OSIRIS-REx mission, and will be making measurements of the thermal properties of the materials returned by that mission from asteroid Benu.

Two of our Jesuit staff observed landmarks this year. On June 5, Jean Baptiste KIKWAYA ELUO celebrated the 25th anniversary of his ordination to the priesthood. And September 7 was the 60th anniversary of Chris CORBALLY’s entry into the Society of Jesus.

We are delighted to report the wedding of our long-time staff member Assunta RODIA and Elia Lai. It took place on September 8, at the Church of Santa Maria Maggiore, in Lanuvio.

Speaking of anniversaries, we note with joy that our beloved former Superior and Vice Director, Fr. Sabino MAFFEO, enjoyed his 101st birthday in retirement at the Canisio community in Rome. He is the oldest member of that community, and still in good physical health.

At the end of this year, Richard BOYLE will officially receive the status of “emeritus” astronomer, having reached his 80th birthday on March 4. Of course, as is obvious from reading this year’s Annual Report, this by no means signals any pause in his remarkable scientific output!



Fr. Boyle and His Holiness Pope Francis, in 2019

The 2019 Annual Report described in some detail Boyle’s research, which for many years has centered on the use of the VATT for photometry of many different types of astronomical objects. Primary among them are stellar clusters, but his work has also focused (literally!) on objects ranging from quasars to asteroids.

Boyle entered the Society of Jesus on August 14, 1961, and was ordained on June 7, 1975. Soon after he earned his doctoral degree in astronomy at Georgetown University, he joined the Vatican Observatory in 1981; in the mid 1980s he worked as a postdoctoral fellow at the Edinburgh Observatory and then worked with colleagues in Lithuania to develop the Vilnius photometric system for stellar classification. With the opening of the VATT thirty years ago (as described in this report), Boyle had the ideal instrument for these sorts of measurements. He served for many years as instrument scientist for this telescope, and today continues with the delicate task of scheduling the various observers competing to use this telescope.

In addition, of course, he has also been an outstanding member of our community... as an avid bicyclist, gardener, and occasional cook! He and Corbally hold the longest tenures at the Vatican Observatory, and has helped shape us through the many changes over the last forty years into the institution that we are today. We look forward to many more years of him living and working with us in Tucson!

Museum of the Bible *Washington DC*: The Vatican Observatory contributed a small exhibit of historical artifacts for the Museum of the Bible’s exhibition, “Scripture and Science: Our Universe, Ourselves, Our Place.” They included the Solar and Astronomical Quadrant made by Abbé Berthiaud, circa 1885; two photographic plates from the Carte du Ciel project; and a sample of the Pultusk Meteorite. The exhibit opened on January 20, 2023, closing on January 15, 2024.



CHAPTER TWO

VATT AT 30

In September of 1993, the Vatican Observatory Research Group celebrated “first light” at its new Vatican Advanced Technology Telescope (VATT), consisting of the Alice P. Lennon Telescope and the Thomas J. Bannan Astrophysics Facility. This past September, thirty years later, we took the opportunity to reflect (appropriately enough for a telescope with a revolutionary mirror) on where we’ve come from and where we hope to go. Over the weekend of September 29 – October 2, a number of events were held in Tucson to celebrate this anniversary, as discussed in the Director’s letter. Fr. Chris Corbally was the Jesuit astronomer who shepherded the construction of the telescope. Here he presents an overview of the opportunities and challenges that led to the development of the VATT.

The Opportunity

The early 1980s was an exciting time for the Vatican Observatory to begin its association with the University of Arizona (UA). We needed a new astronomical facility; our telescopes at Castel Gandolfo, moved there from Rome in the 1930s to escape its growing light pollution, were becoming useless owing to the continually increasing glow from waste lighting. Meanwhile, Steward Observatory at UA was beginning its investigation of “honeycomb mirrors” as the heart of a new generation of telescopes.

Why honeycomb? The bees have it right in finding the structure with the lightest weight and greatest strength. Add the possibility to each cell of blowing air through its base, and one has a way to “air condition” the whole large network of cells making up the mirror. This internal ventilation would bring all the cells to the same temperature as the nighttime air and help achieve the best “seeing” or sharpness of images.

An innovation developed at Steward Observatory was to cast this honeycomb structure of glass in a spinning, rather than static, furnace. The spinning had the effect of shaping the upper surface of the glass into a parabola, a shape close to the final shape desired in the mirror. The faster the spinning, the deeper the curve of the mirror becomes, and so a very short focal length can result. A short focal length mirror can be held by a short mount, which in turn can be put into a compact dome or enclosure. All this reduces construction costs, and even makes the concept of a mirror as large as 8.4 meters possible.

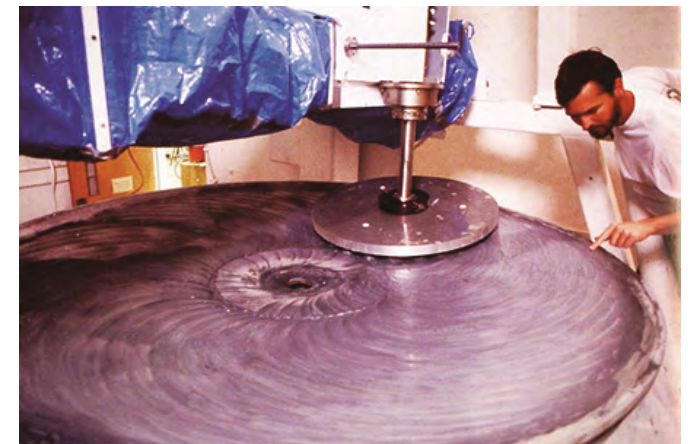


The mirror of the VATT as it was formed with a parabolic surface in the rotating furnace

Finally, to polish such a huge mirror, even if out of the furnace it is close to its final shape, would take forever with a conventional spherical “lap” or polisher. So the idea arose of flexing the lap to the shape suitable for each part of the mirror surface it reached. The concept is called “stressed lap polishing”, something that needs the lap’s shape to be controlled by a computer 1,000 times a second.

These ideas, produced by Roger Angel and his key helpers John Hill and Buddy Martin, are wonderful in theory. In March of 1985, during my first year with the Vatican Observatory in Arizona, a prototype 1.8 meter honeycomb mirror was cast to test out the theory. The furnace, housed in a deconsecrated Synagogue on the UA campus, spun at 15 times a minute and gave the mirror a focus no further above its center than the mirror was wide. Hence, it had a remarkably compact focal ratio of 1.0, or $f/1$, never previously achieved for a telescope’s primary mirror. It would subsequently pioneer the stressed lap polishing to become a mirror fit for a unique telescope.

We had now the makings for the story of an “Angel” mirror from a Synagogue needing a good home, and of the Catholic Church as a traditional refuge of orphans. Through a suggestion from Nick Woolf, the 1.8 m $f/1$ mirror was offered to the Vatican Observatory. Father George Coyne, then Director, was courageous enough to accept the offer, providing that Steward Observatory remained involved in what became known as the Vatican Advanced Technology Telescope (VATT). Subsequent vigorous fundraising among old and new generous friends brought the names of two principal donors to its description: The Alice P. Lennon Telescope and the Thomas J. Bannan Astrophysics Facility.



Lapping smooth the back of the VATT mirror

The Construction

A construction project needs a team. For VATT its members were Bob Nagel (Director of Steward Observatory Technical Division), Dan Blanco (Multiple Mirror Telescope Engineer), Nick Woolf (Steward Observatory Professor and Project Scientist), and myself (Christopher Corbally, Project Scientist). Nagel and Woolf were old hands at telescope building. Young Blanco was new to the game and loaned by the Multiple Mirror Telescope to gain experience for the eventual upgrading of that telescope with an “Angel Mirror”, while I needed to learn the whole trade, from the engineering aspects to those of administration. Fortunately, the team was backed by Buddy Powell, who was both well-experienced with all aspects of telescope construction from Cerro Tololo in Chile (the southern station of the US’s National Optical Astronomy Observatories) as well as with Jesuits, since the Vatican Observatory astronomer Fr. Martin McCarthy had been a frequent visitor there—McCarthy had collaborated with its Director, Victor Blanco. Yes, Dan was Victor’s son!

The VATT team started meeting in November 1986. We had the heart of the telescope, namely its primary mirror, and its intended location, Arizona’s Mount Graham. These two factors guided VATT’s design.

We were asked whether the telescope would be on an equatorial mount, where one axis points at the north pole, or on an altitude-azimuth mount, which is like a gun turret. Another question was whether the secondary mirror would be the then-standard Cassegrain type or that of a Scottish optical designer, the Gregorian type. To such questions our answer was, “Yes.” It would be one or the other, depending on what optimized the performance of the telescope and minimized its cost. Gradually it became clear that, with the new Vatican telescope, we should take the “Gregorian Chance” (pun intended). So VATT would become an “alt-az” telescope with Gregorian optics. This decision guided the final design and fabrication of its mount (the gold and white part one can see) by L&F Industries and the purchase of its unusually small dome.

The design of the whole astrophysics facility (telescope dome, control and maintenance rooms, and living quarters) was dictated by its location. While at one stage we were considering the Santa Rita mountains to the south of Tucson as an alternative site, we were delighted to get the go-ahead for Mount Graham in November 1988 through the Arizona-Idaho Conservation Act. But the Act’s extreme limitation of acreage for the three telescopes that would be atop the mountain (the Large Binocular Telescope, the Submillimeter Telescope, and the VATT) meant we needed a really compact

facility, one that would still keep thermal separation between the telescope section and the control-plus-living area. This was essential to preserving the excellent sharpness of the images on Mount Graham from being distorted by stray bubbles of warm air. Woolf’s wonderful imagination eventually produced a design that we all thought would work, and that is what we see today, thanks to our partnership with M3 Engineering, a local architect-engineering company. That it was M3’s first engagement in a telescope facility led to some “interesting” moments during the construction, but everyone has to learn.

Ah, the construction at last! We signed the contract with a local company, T.L. Roof, early in 1990 and site clearing for both VATT and the Submillimeter Telescope began that summer. Both telescopes had to use the same general contractor and architect since space was extremely limited, but that did make for friendly weekly “tailgate meetings” on the mountain for all involved, including myself. We quickly learnt that Mount Graham, at an elevation for the site of 3,200 meters (10,500 feet), allows a rather short construction season.



The geographical location of Tucson and Mount Graham, home of the VATT

A longer-than-usual 1990-91 winter led to a rush to complete the concrete foundation work in what remained of summer 1991. The next winter co-operated and so construction in the summer of 1992 went well. The exterior was completed and both the telescope mount and dome were installed before the 1992-93 winter came. Interior work could continue through that winter, providing much relief about maintaining a schedule. A busy spring and summer led to the installation of the VATT primary mirror and achieving “first light” up at its primary focus just a few days before the dedication on September 18, 1993. We all breathed a sigh of relief!



The construction of the telescope silo (the round section to the left) and the dorms and astrophysics laboratory (the larger building to the right) took place during the summers of 1991 and 1992; these images are from mid summer 1992. In the bottom photo, from left, are Fr. Martin McCarthy SJ; Barney Bannan, brother of major donor Thomas J. Bannan; and Barney’s wife, Charlotte Bannan.



Commissioning, First Science, and Upgrades

You might expect that, after its dedication, VATT was ready for science. Not quite. The dedication happened at the earliest possible time since we had elderly donors whom we needed to acknowledge and thank publicly. In July of the next year, 1994, the secondary mirror and its micron-precision control was installed and produced the first real images at “second light”. By the following January, other controls were in place and the first scientific observations began. These were for a project aimed at finding Massive Compact Halo Objects (MACHOs), thought to possibly explain the universe’s “dark matter”, in M31 (the Andromeda Galaxy), with the help of a CCD camera loaned from Columbia University by the project’s principal investigator. Two Vatican astronomers, Richard Boyle and myself, were involved in the project, which turned out to be perfect for a telescope in shakedown mode: tracking a single object through the night sky. Well, some MACHOs were found in M31, but not enough to explain the dark matter the galaxy should contain. A null result like that can be most helpful. It keeps one searching for the right answer, and as far as dark matter is concerned, the search is still going.

Though commissioning of VATT officially ended with the start of science, in truth, this advanced technology telescope needed a lot of tweaking in subsequent years. As Nagel wisely counselled me in 1990 (when the recently delivered mount was being modified out at Ryan Airfield, before even getting it to Mount Graham): “Relax, Chris. A telescope is a living thing. When you stop working on it, it dies.” A significant “tweak” came through the Kresge Science Initiative Grant, a gift that was hard won by Coyne and some skilled fundraising. The upgrade began in March 1999, with substantial completion a year later, and it brought VATT close to its planned optical and mechanical performance and reliability.

It was only “close” to what had been planned for two reasons. The first is that electronics and mechanics have a limited lifetime, especially at high elevations like VATT’s, and will need replacing and upgrading regularly. One such upgrade came in the summer of 2008, when new networking and computing equipment, provided by a grant from Hewlett Packard (HP), was installed. This equipment certainly proved to HP that it could add to the efficiency of high altitude observing.

Another grant, from the Papal Foundation in 2014, provided the computers and software that allow us to operate the telescope remotely from the UA campus.

The second reason concerns a dream of the design team. We knew that VATT, with its many systems, would be a complex telescope to operate, as many a frustrated observer can attest, and so we always envisaged it as being eventually automatic. That would allow the observer to concentrate on getting the best science data rather than on operating the telescope. With joy, then, I learned in the fall of last year of a most generous donation by The Thomas Lord Charitable Fund along with a personal donation from its chair, Mrs. Judy Alstadt. Subsequently a contract has been signed with ProjectSoft HK for the full robotization of VATT. So, under VATT’s current director, Paul Gabor, observers will not only have an automatic telescope, but even one to which they can send an observing script and wake up in the morning to new data. As early as the fall of 2024, VATT will become “VATTY Don”, in memory of Don Alstadt, Mrs. Alstadt’s late husband.

VATT’s Niche for Science

VATT’s scientific niche has always been that of long-term surveying or monitoring, the kind of work for which it has been difficult to get observing time on the many other telescopes available to us and other observers through the UA. I have experienced the “difficult” aspect during a spectroscopic survey of nearby stars, which at the time could only be done on a UA telescope. Since 2010 VATT has had a medium-resolution optical slit spectrograph, VATTSpec, which has admirably taken care of that difficulty.

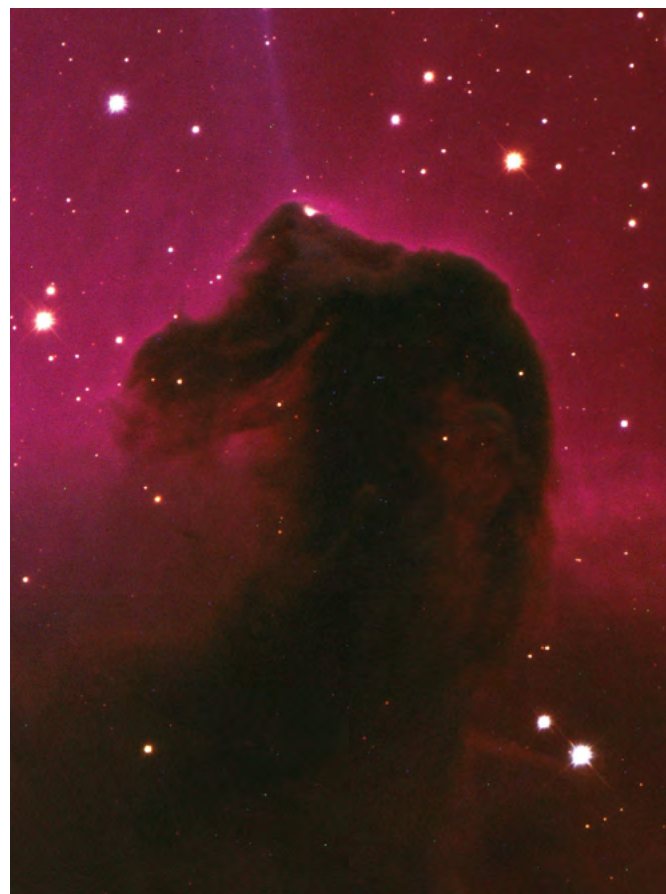
Not only are the availability and optics of VATT special, but its site is too. At 3,200 meters elevation it has some 30% less atmosphere above it than at sea level, so its targets experience less absorption by the atmosphere, making infrared observations in particular more efficient. A vivid example was provided by Nick Woolf to me in 2023:

I don’t only design and help make telescopes, but I use them too. One of the scientific problems we had was that in searching for Earth-like planets around other stars, we needed to know what the Earth looked like from outside our atmosphere; especially we wanted to know how the gases of its atmosphere appeared in the spectrum. I used Earthshine on the Moon to study this, and the first observations were made from Kitt Peak, but that observatory was too deep in the Earth’s atmosphere to show enough. So we made more observations with VATT, and measured how water vapor, oxygen, carbon dioxide and methane all showed up in the near infrared spectrum of the Earth.

I remember these observations by Nick and his team with VATT well. It was a really windy night on Mount Graham. The gusts would have closed any other 1.8-m telescope, but VATT's squat profile and responsive alt-az drive kept the images steady.

It is well to note how other institutions found VATT to be good for short term projects and testing new equipment. The first has been mentioned, the 2K large format CCD camera on loan from Columbia University in 1994, used until Steward's imaging laboratory gave first a 2K and in 2007 a 4K CCD camera. In 1996, a low-resolution optical spectrograph was provided by the Planetary Science Institute of Tucson. It was the one used by Nick Woolf and company. Later that year came the Arcetri (Italy) Near-Infrared Camera. From late 2002 through 2003 VATT hosted CorMASS, a low-resolution infrared slit spectrograph. This spectrograph came from the 60-inch telescope on Mount Palomar, where it had been used to follow up an all-sky infrared photometry survey (2MASS). It was in transit to New Mexico's Apache Point Observatory. Indeed, it proved so efficient in VATT's skies, for reasons given above, that its transit became hastened.

More permanent has been the collaboration between VATT and the National University of Ireland Galway. In 2009 the latter located the Galway Ultra Fast Imager (GUFI) at VATT. The agreement with NUI Galway



The Horsehead Nebula, imaged at the VATT

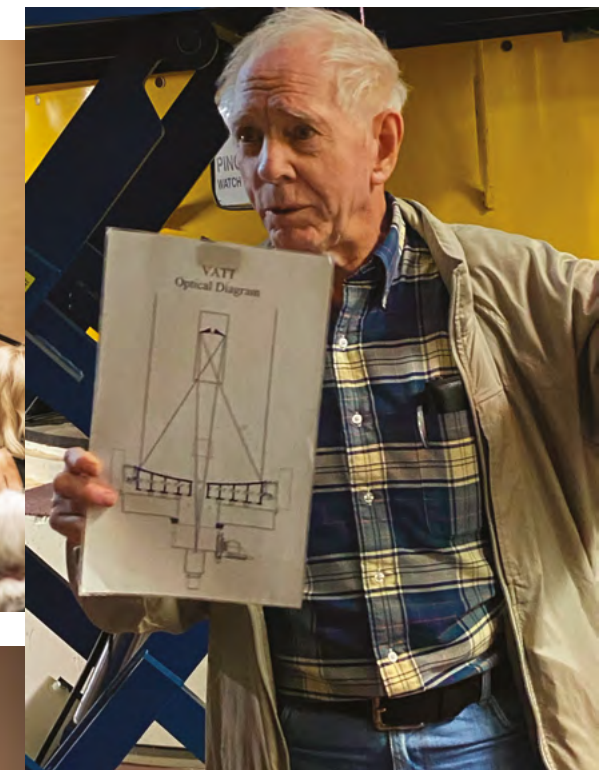
continues to the present as a second generation Marana camera is now incorporated into GUFI.

There are fascinating details about other science from VATT in past Annual Reports under our staff's personal contributions. Here are samples:

- Richard Boyle has surveyed stars through the 7-filter combination of the Vilnius Photometric System to probe the depths of the nebulae in which stars are formed and to characterize the role of clusters of stars in the history of our Milky Way galaxy (see the 2019 Annual Report).
- David Brown has been collaborating in feeding the light of stars from VATT to the Potsdam Echelle Polarimetric and Spectroscopic Instrument (PEPSI) beneath the Large Binocular Telescope, VATT's neighbor on Mount Graham. He continues to help this survey by analyzing the resulting spectra to characterize stars that do, or may have planets around them (see the 2021 Annual Report).
- Christopher Corbally has found on VATT the considerable time needed to take spectra of hundreds of stars spread throughout the sky that are candidates to be of the peculiar "Lambda Boötis-type". Their distribution will help solve the now 80-year-old problem of what is causing their peculiarity and their role among a galaxy's stars.
- Jean-Baptiste Kikwaya, with his time on VATT, regularly follows up on the discovery of Near-Earth Objects, those comets and asteroids that have been nudged into orbits coming close to the Earth. He finds in their photometry an indication of how they are tumbling through space and their combinations of elements, which determines their type.

• Alessandro Omizzolo has used VATT for his observations of peculiar galaxies, but it is a long way from his Padua home. When the telescope becomes robotic, thanks to the prolonged efforts of Paul Gabor, it may well again become attractive to Omizzolo and his colleagues.

These examples just touch on the telescope's contribution to science. A significant part of its future contribution lies in the follow-up needed for the interesting objects that all-sky surveys with large telescopes will supply. VATT, with its excellent location (far from large population centers and their light pollution), its curiously stubby telescope mount and adjoining carefully crafted astrophysics facility, has a unique place in the history of telescope construction, a productive scientific record, and a bright future in joining the squads of robotic telescopes dedicated to future science.



Celebrations of the VATT's thirtieth anniversary took place over the weekend of September 29. Top left: At the Friday dinner, Br. Guy Consolmagno drew out stories from Major General Charles F. Bolden, Jr., of his life as an aviator, astronaut, and head of NASA. Top right, Fr. Chris Corbally explains the optics of the Alice P. Lennon Telescope during the Saturday tour. Middle left: Members of the Foundation Board with General Bolden. Middle right, Fr. Gabriele Gionti with General Bolden. Bottom: Gionti with visitors at the Thomas J. Bannan Astrophysical Laboratory.

CHAPTER THREE

2023 A YEAR IN REVIEW



In February, Ray Butler and grad student Mick Ryan came from the University of Galway with the Andor Marana sCMOS camera to conveniently replace the EMCCD GUFi camera. The Marana camera has a field of view on VATT of 5 x 5 arcmin whereas GUFi had only 1.5 x 1.5 arcmin, or 3 x 3 using a field lens. We got familiar with using the Marana by exposures in two broad-band filters on two globular clusters, despite some inclement weather. I did further work the next month on these two clusters, and further testing in the Spring for measuring the thermal noise and stability of the temperature control at -45°C.

In the third week of June, Aaron Golden came from the University of Galway to VATT with me to use the Marana on a brown dwarf star. The camera ran reliably for the most part.

Then at the end of October, Mick Ryan returned to VATT with me to use the Marana for the topic of his doctoral research, the detection and frequency of bolides impacting the atmosphere of Jupiter. We used a Chroma methane (CH₄) filter for enhancing the contrast for detection. Recall the massive impacts made by Comet Shoemaker-Levy 9 in 1994.

Ryan set the exposure time for making continuous exposures to be a tenth of a second. Since readout between exposures is negligible, one second gives ten images, 60 seconds 600 images, 600 seconds (ten minutes) 6000 images. A high pressure system over Arizona gave practically cloudless skies for the two weeks at VATT. The Andor Solis controlling software had some problem connecting to the camera at startup; but once connected did run fine for the night. Jupiter at opposition shone bright for about eight hours above thirty degrees altitude. We did have two comets to observe at the beginning and end of the night. So we got roughly eight hours per night for about ten nights or almost three million images of Jupiter, including its Galilean moons and its Red Spot which showed its rapid rotation.



One of the roughly 2 million images of Jupiter made at VATT with the Marana sCMOS camera in a methane filter by M. Ryan to detect bolides impacting Jupiter's atmosphere

Ryan has prepared a Python program that will inspect our images to detect bolides making impact in the methane atmosphere. The program will compare neighboring images within the millions of images acquired to detect bolides big enough to mark the atmosphere. By this use of the fast readout Marana camera at VATT viewing Jupiter, we hope to contribute to the research on the detection and frequency of bolides impacting the planet.

Besides this planetary research, I continue observational research by VATT in galactic structure and stellar evolution by observations on ten open clusters using the Vilnius Photometric System.



The year 2023 began for me at our Vatican Observatory Research Group (VORG) location in Tucson, Arizona in a very quiet way, continuing the PEPSI research collaboration after having submitted our pilot paper. As mentioned in past Annual Reports, the PEPSI (Potsdam Echelle Polarimetric and Spectroscopic Instrument) project is a scientific collaboration between the Vatican Observatory and the Leibniz Institute of Astrophysics in Potsdam (AIP), Germany. Through it, the Vatican Observatory's Lennon

Telescope and Bannan Facility on Mt. Graham (in Arizona) have been used in conjunction with the PEPsi spectrograph (attached to the Large Binocular Telescope, LBT), also on Mt. Graham, in order to determine many precise parameters of the stars we have been observing. The hope is to find out how stars and the exoplanets that revolve around them are related, especially chemically.

In February, there was work to do for the Vatican Observatory Foundation (VOF). First, there was staffing a VOF booth in the exhibition hall (gym) next to the Cathedral of Saints Simon and Jude in Phoenix, Arizona as part of the fund-raising activities connected to the World Day of the Sick on February 4. A second VOF activity involved staffing a booth with Chris Kennedy and Katie Steinke in the exhibition hall of the Los Angeles Religious Education Congress at the Anaheim Convention Center, February 23-26. Between those two events, at the invitation of the Pontifical Catholic University of Puerto Rico in Ponce, I participated in the 11th Catholic Congress on the Public Life during February 14-18, giving a talk on February 17, titled “The Relationship Between Science and the Christian Faith”.

Next, it was on to Pennsylvania in order to give a talk to Catholic schools in the Archdiocese of Philadelphia at the St. Albert Initiative on Science and the Catholic Faith, March 24-26. This was followed by a trip to Kenrick-Glennon Seminary in St. Louis, Missouri in order to give a theological day of reflection to the major theologians on April 19. This was followed by a talk at Santa Cruz School middle school in Tucson on May 1, and then giving the commencement address at the Regina Coeli Hybrid School graduation on May 13 in Phoenix. Then a quiet period of research ensued during June-August at VORG, focusing once again on the PEPsi project and a project with Jesuit physicist Fr. John Cunningham (Fordham University, NYC; Loyola University, New Orleans) using the Lennon Telescope.

In June, I was appointed temporary Treasurer of the Vatican Observatory Foundation until December 31. In this capacity, I have been handling the finances of the VOF, opening a new bank account for, and taking part in the yearly audit of, the Foundation in November.

In August, I travelled to our Vatican Observatory headquarters in Castel Gandolfo, Italy in order to work on research projects from that location. From there, I travelled to the AIP in Potsdam, in order to confer with our partners, Martina Baratella and Klaus Strassmeier, September 25-29. It was a very productive meeting, planning for the next step in the collaboration. I then took part in a weeklong conference at the Vatican

Observatory, “The VVVX Survey: Exploration and Future Infrared Synoptic Science”, held October 9-13, during which I gave a talk on October 10.

I returned to Tucson on October 31, and I immediately began to take part in the yearly audit of the VOF. At the end of November, I travelled to Gretna, Nebraska in order to lead a retreat at Cloisters on the Platte retreat house during November 30 - December 3. The rest of December was given to transferring the position of Treasurer to my successor.



By 2019, the stress on my health of too much travel was taking its toll and I had resolved to cut back. Then Covid came, and the rest of the world conspired to keep me off the road for more than a year. Things slowly ticked back to normal, of course; and finally, in 2023 I immediately found myself on the road again.

The major trips this year included two weeks in Scotland and England at the beginning of February; a series of trips around the US Midwest (Chicago, Milwaukee, Minnesota, with stops en route to Arkansas and Seattle) from mid-March through most of April; off to California for a series of events from August through the middle of September; and then presentations in Honolulu and a series of talks over two intense weeks on the east coast, from Buffalo to Washington, DC.

What keeps me on the road so much? It’s never only one thing. The trips usually begin when I am invited to give talks, both scientific and faith-science related. At the same time, in my travels I am able to meet up with donors and supporters of the Vatican Observatory Foundation. And one of those trips was to attend a scientific conference, which remains the essential ingredient of all the other work I do. The trick to keeping me sane and healthy is to travel by train as much as possible, and so far, that seems to be helping out.

So many events stand out in all this travel... watching a Secchi disk in action on Lake Tahoe; looking through the Mt. Wilson 100-inch telescope; touring the USS Arizona

and other sites at Pearl Harbor. Through it all, my hosts everywhere have been wonderful and welcoming.

I continue to participate in research on the physical properties of meteorites, described elsewhere by my colleague Br. Bob MACKE. I presented our work on lunar meteorites at the annual meeting of the Meteoritical Society in August. At that meeting I also took up my duties as vice president of the Society, with the expectation that I will take over as president in 2025.

Another highlight of the year was the publication, with Chris Graney, of our book *When Science Goes Wrong*. Meanwhile, I have submitted the manuscript for another book which, with luck, will come out next year. Stay tuned!



On Lake Tahoe, CONSOLMAGNO got to use a Secchi Disk! Fr. Angelo Secchi SJ was the 19th century astronomer who first classified stars by their spectra; but he also invented this device to measure the clarity of lake and ocean water.



What do you do when a star that you and others have been observing flickers and disappears? Other than saying “Goodbye”, start puzzling why. That is what my fellow participants in online meetings of the Spectroscopy Discussion Group did in early spring this year.

The story is about TU Tau, a C-N type Carbon star and its A-type companion star, “TU Tau B”. When Richard Gray, Appalachian State University, was examining the carbon stars picked out among the 9 million LAMOST spectra he had classified by MKCLASS, the companion star stood out in the spectrum revealing the two. (Fig. 1, next page)

Gray saw that the longer-wavelength part dominated by the carbon star was normal, but the shorter-wavelength part, from the A-star, had an unusual chemical composition. It had enhanced abundances of nuclear s-process elements, such as Strontium and Barium. This suggested that the A-star is being contaminated with these elements by mass transfer from the carbon star. Gray asked me to get spectra of the combination with VATT, which I did on various occasions. The enhanced elements had gone, but the spectra indicated the companion was a star surrounded by a thin shell. Further investigation of VATT’s high signal-to-noise spectra showed unequivocal evidence that the A-star companion is accreting carbon star material. (Fig. 2)

This companion was worth closely monitoring. The Spectroscopy Discussion Group, with their geographically distributed telescopes, helped early this year. Curiously, the A-star companion started flickering in strength, sometimes almost disappearing, and on April 26 it disappeared completely, both photometrically and spectroscopically. A VATT spectrum that I took in October confirmed that it still hadn’t reappeared.

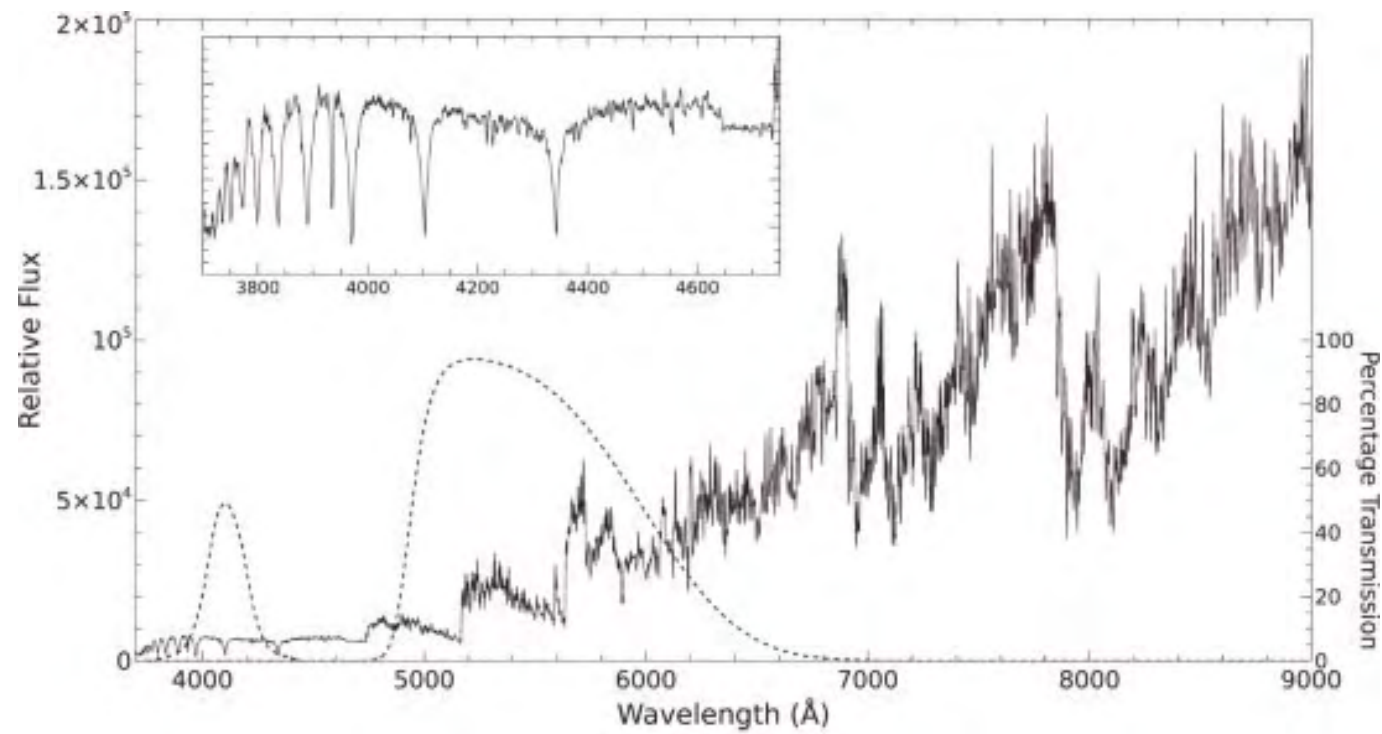


Fig. 1 - The LAMOST December 20, 2013, spectrum of TU Tau. The carbon star dominates at the longer wavelengths whereas the A-star companion (also shown in the inset) dominates in the blue-violet. Passbands for the Strömgren-v filter (dashed, centered near 4100 Å) and the Johnson-V filter (dashed, centered near 5500 Å) are also included. The flux through the Strömgren-v filter is almost exclusively from the A-star companion. The flux through the Johnson-V filter is dominated by the carbon star with a small contribution from the A-star companion

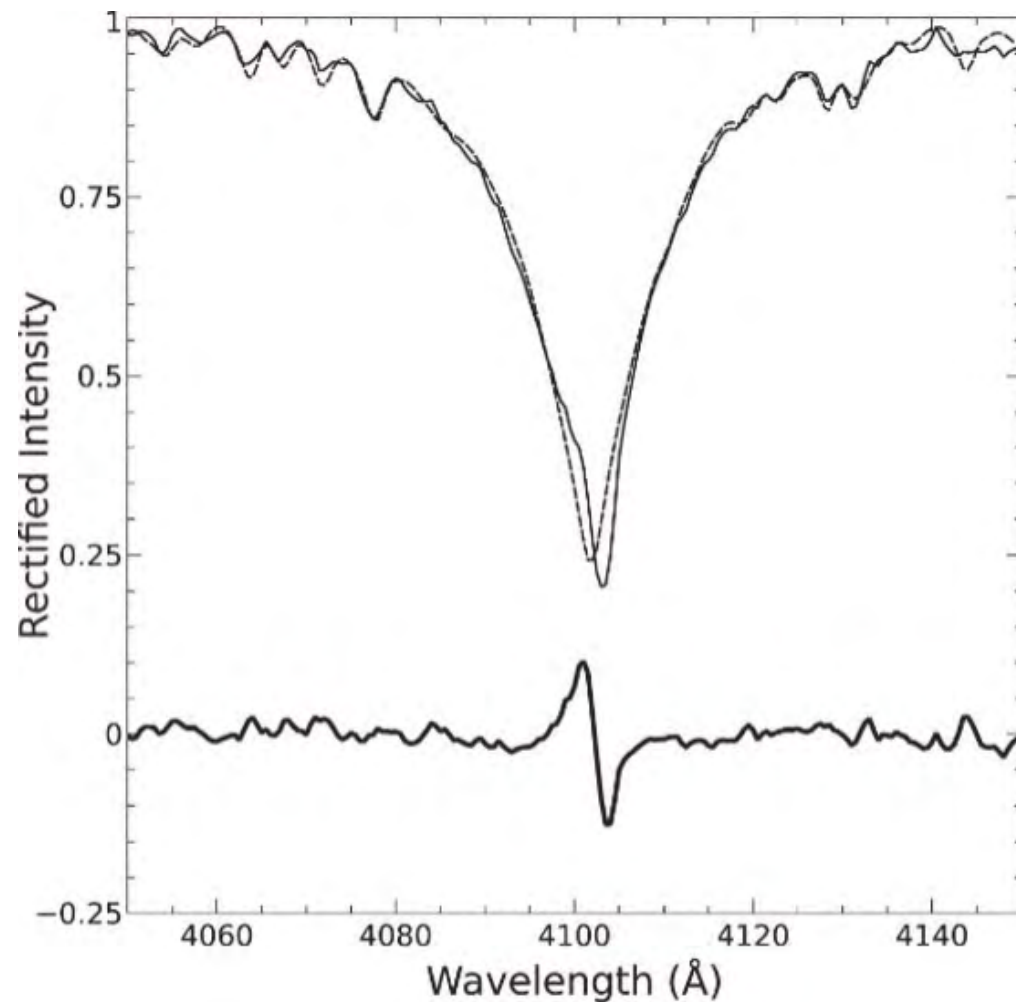
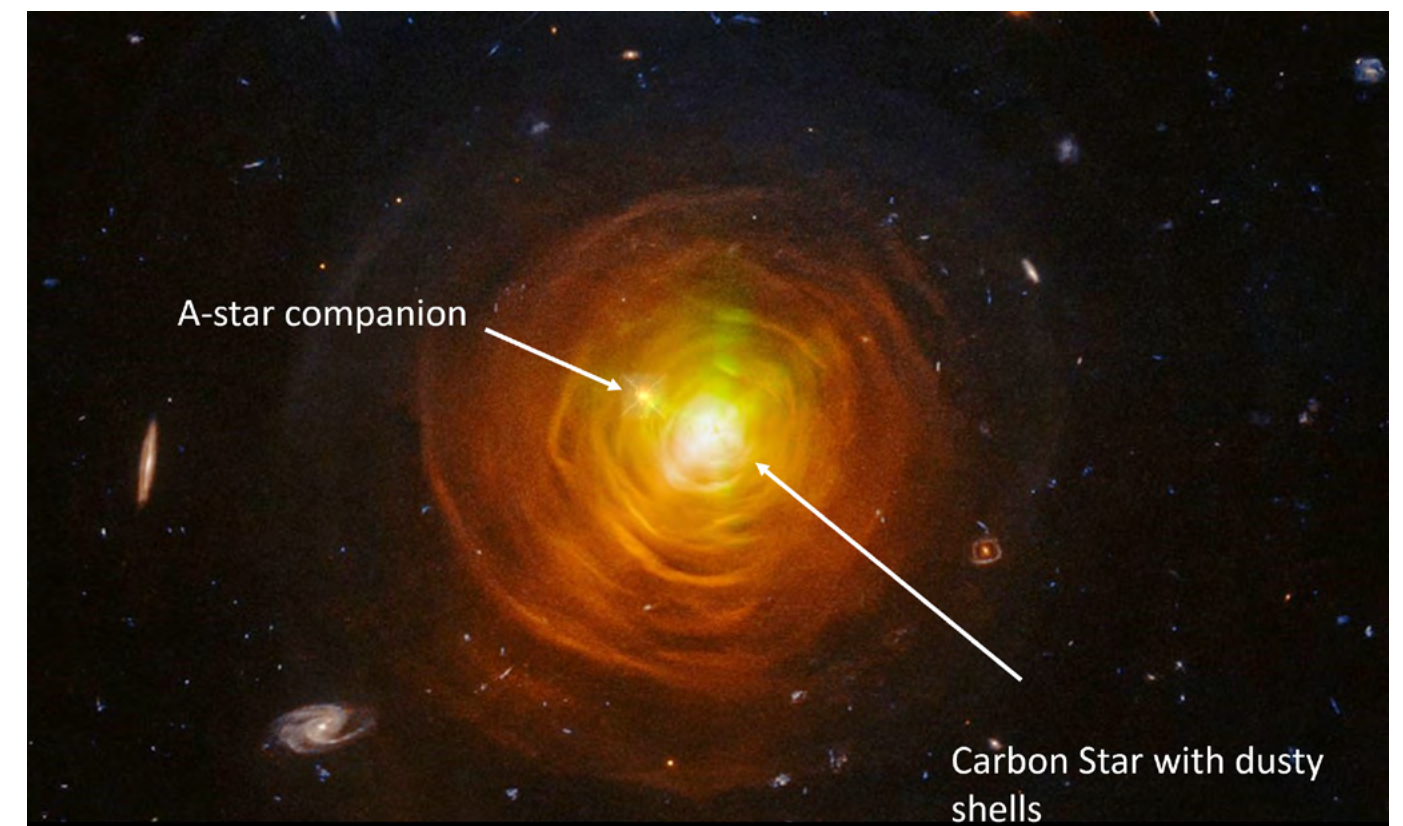


Fig. 2 - The solid line in the upper plot shows the H-delta profile of the 10/25/2021 VATT spectrum of TU Tau B. The symmetrical dashed line shows the H-delta profile of the A2 III-IV standard star. The red-shifted core of TU Tau B is easily seen. The bold solid line in the lower plot shows the difference spectrum (TU Tau B – A2 III-IV standard). What is revealed is an inverse P-Cygni profile, a spectroscopic signature of material being accreted onto a star

Our best guess as to what is happening is illustrated by the HST picture (below) of the carbon star, CW Leonis, showing the complex shells and arcs of such a star. It has our A-star companion added. The companion has likely disappeared behind the carbon star's dusty shells.

We think that in a few million years the TU Tau system will be completely different: the carbon star will have thrown off its outer shell, creating a short-lived planetary nebula, transforming the core of the star into a white dwarf; the A-star companion will evolve to become a G or K-type red giant showing unusually high abundances of the s-process elements. In this way, TU Tau will transform itself into what astronomers call a *Barium Giant*. TU Tau gives a glimpse of a stage of this process that we have never seen before. For the first time, a Barium Giant has been caught in the act of forming!

Regarding interdisciplinary research and writing, this has again been a productive year. Margaret Boone Rappaport (Human Sentience Project) and I, besides continuing to think about neuroplasticity's origins and its function in space missions, explored the connection between ecology and theology in eventual off-world settlements. We were joined by Riccardo Campa (Jagiellonian University, Kraków) for an article that used Biblical examples in extending the concept of “rescue and recovery” found in the law of the high seas, to space incidents with other intelligent and self-aware species that humans may someday encounter.



The TU Tau Scenario illustrated before the A-star disappeared behind the carbon star. (Credit: NASA for HST picture of CW Leonis, with a star added to represent the A-star.)



The focus of my research has turned to constraining the time of the last major-merger of nearby galaxies whose masses are comparable to that of our Milky Way galaxy. We know that our Milky Way suffered a collision about 8-10 billion years ago with a galaxy called Gaia-Enceladus Sausage, which was as big as the Large Magellanic Cloud. This was the last major-merger of the Milky Way. What about nearby Milky Way-mass galaxies?

Over the last few years, I have spent considerable effort trying to understand the size of the galaxies that merged with nearby Milky Way-mass galaxies. My research group quickly came to understand that the stellar haloes of these galaxies were built up by the debris of one or two significant mergers, and that the largest galaxy destroyed often determined the mass of the stellar halo. While we had a way of constraining the mass of the largest merger, it was more difficult to understand when, exactly, it occurred. Dating the age of the merger with Main Sequence Turn Off stars was only possible for the Milky Way and the nearby Andromeda galaxy.

But this year, we were able to use Asymptotic Giant Branch (AGB) stars to understand the approximate date of the last burst of star formation in the stellar halo of a galaxy, and hence the approximate time of the merger. Since the evolutionary time of AGB stars is much shorter than Red Giant (RGB) stars, the ratio of their numbers gives us an approximate constraint on the last burst of star formation. This now allows us to constrain the mass and the time of the last major-merger of nearby Milky Way-mass galaxies.

In a work led by Benjamin Harmsen, we used nearby dwarf galaxies in the Local Group to calibrate the ratio of AGB to RGB stars to the approximate time of the last star formation. I am now collaborating with the stellar evolution group at the Observatory of Rome to understand how to better constrain the theoretical stellar evolution models to obtain this relation for stellar populations of various metallicities.

This summer I guided two students for a summer internship. Using data from the Gaia satellite, they started working on using the Gaia low-resolution XP spectra to study the stellar halo of our Milky Way.



This year will stand out in my recollections as the year of the VATT's thirtieth anniversary. I believe this topic is covered more than adequately by Chris Corbally elsewhere in this Annual Report. That allows me to focus on other memorable 2023 moments.

Apart from the thirtieth anniversary of the VATT, 2023 also marked the 400th anniversary of the Jesuit Province of Bohemia. I attended a conference in Prague organized by Charles University and the Academy of Sciences. The gathering was mainly focused on the history of the pre-suppression Society. I gave a paper on Joseph Stepling, an eighteenth-century Jesuit astronomer and mathematician who not only retained his chair at Charles University after the suppression of the Society in 1773, but also his position as the chair of one of the royal committees for the reform of schools.

I took part in the fourth assembly of the Alliance of Historic Observatories held at Yerkes Observatory. We took one step further on our road to incorporation: we adopted a set of bylaws. I was elected to the board (motion by W. Lowell Putnam IV).

2023 was also marked by the selection process of a new imaging camera for the VATT. We selected Mark Trueblood to chair a science advisory committee (SAC) and recruited a dozen or so experts who contributed their time and expertise. Apart from quasi-monthly SAC teleconferences over nine months, Mark and I conducted a number of visits in person and online with two camera manufacturers: Spectral Instruments and Teledyne. The result is a 75-page report, preparing for a purchase, which I think we will be able to make in early 2024.

Let me conclude with a moral story (of sorts). Mt Graham is located at the 32nd degree of north latitude, like ancient Babylon. Its altitude, however, is 3200 m or

10,500 ft, which places it in the vegetation zone of the boreal forest, also known as *taiga*. In the Alps, which are about 15 degrees further north, only lichens grow at 3200 m. Unlike the Siberian or Canadian *taiga*, Mt. Graham is an island that stands out from the surrounding landscape, dominated by a subtropical semi-desert with saguaro cacti, which limits rainfall even in higher elevations. Cloudless skies and dry air are perfect for astronomy. So far so good.

Uncharacteristically, the 2022/23 winter brought five blizzards. The following photograph shows what formed during just a few hours on Ash Wednesday. Winds were gusting up to 80 mph. The 30-mile road from the foot of the mountain to the telescope was impassable, not only because of snow and snow drifts, but also because of more than twenty fallen trees obstructing the roadway. After any such event, it is impossible to observe for four to five days — firstly, because there is no access to the telescope; secondly, because the building, including the dome, is covered with rime frost and, to prevent ice from falling on the telescope, we cannot open the dome until the frost melts; and thirdly, because the melting snow then keeps relative humidity above the 90% limit for an additional night or two.



Ray Butler and Mic Ryan arrived from Ireland on Ash Wednesday for a five-night observing run. They did not reach the telescope until Friday. The building's propane-fueled central heating refused to come on. Several hours of futile attempts ensued. Calling various plumbers in the area was unfruitful. They all refused the job upon hearing of the location. We purchased some electric spot heaters and managed to get them to the telescope thanks to BOYLE. In the meantime, however, Gary GRAY identified the cause of the problem. The air duct allowing outside air to flow into the combustion chamber had been completely blocked by rime frost, suffocating the flames. Per aspera ad astra.

Technical Notes:

Omar Navarro joined Steward Observatory's Mountain Operations group, and the VATT team, at the beginning of May, in the capacity of "Research & Development Software Engineer III".

The special Covid-19 guidelines were relaxed in 2023, making telescope operations practically indistinguishable from the times before Covid.

Minor VATT upgrade projects continued: commissioning of the guider box, and the automated collimation and collimation maintenance procedure. Gary GRAY continued to supervise the work on the hydrostatic-bearing oil chillers. Trane Technologies proved themselves to be a solid if costly contractor. We also used the Safford-based B&D Air Conditioning for some tweaks of the fan cycle in the chillers.

Michael FRANZ and Chris JOHNSON worked on preparing the VATT for ProjectSoft's automation of the facility. After a detailed on-site technical inspection by Tomas Turek and Vlastislav Andrlé on 1-4 December 2022, ProjectSoft submitted their preliminary design documentation for review on March 31. The reviewers were David Carroll, Nick Emerson, John Ford, Michael

Franz, Chris Johnson, Adrian Loeff (Steward Observatory), Klaus Strassmeier and his team (Astrophysics Institute Potsdam), Mark Bowman (Las Cumbres Observatory), and Mark Trueblood (Winer Observatory). The design-review milestone was reached in early August. ProjectSoft proceeded with final design, purchases of components, and fabrication of the assembly, scheduling the Factory Acceptance Tests in Hradec Kralove for the week of January 15. The installation shall take place in April-May 2024.

In instrumentation, the new ZWO ASI 294MM camera was installed and replaced the Andor (Apogee) Aspen CG8050 as the guider camera. Our collaborators from the University of Galway, Ray Butler and Mic Ryan, accompanied by BOYLE and with the support of GRAY, JOHNSON and GABOR, replaced the core of their Galway UltraFast Imager (GUFI) in February. It is no longer an EM-CCD but a commercial sCMOS-based Andor Marana. University of Galway (Aaron Golden) and the Specola signed a new MOU on June 26.



From September 29 to October 2, I participated in the events in Tucson for the thirtieth anniversary of the “first light” of our telescope in Arizona, the VATT. It was really a nice and well-organized event.



Gionti with retired NASA director, Major General Charles F. Bolden, Jr.

This year has been my first full year as vice-director of the Specola at Castel Gandolfo. I took charge on August 1, 2022. I was helped in understanding the role by Fr. Paul Mueller, the previous vice-director. At the beginning, I mainly worked on how to manage the employees of the Specola and on understanding the connection between the Specola and the other departments in the Governorate of the Vatican City State. The Specola depends on the Governorate: financially, for the maintenance of the buildings, for air conditioning and heating, and for all other technical issues. It took me a while to understand all the procedures to follow in order to get things done (and to be honest, I still have not understood well which is the best procedure to follow). But I was quite fortunate to receive the substantial help and support of Sr. Raffaella Petrini, SFE, the Secretary General of the Governorate.

This year we also finalized the agreement between the Specola and the Vatican Museums in order to start guided visits, organized by the Museums, to the Specola domes at Castel Gandolfo. Claudio COSTA trained a group of guides to operate the oldest telescope of the Specola, the Carte du Ciel, which dates to 1891. These guides consist of graduate students and early postdocs in astronomy from research institutions around the Rome area. The guides were also trained in speaking to tour groups about the museum exhibits installed in the domes building; these exhibits feature the history and instruments of the Specola. It is now possible to make reservations for a tour of the domes through the website of the Museums. On October 24, we had an inaugural tour, with about 150 visitors.

Summer School 2023 was another prominent event. We had a group of twenty-four international students participating in classes on Artificial Intelligence and Big Data in astronomy, taught by various professors. It was my first experience in running all the practical needs of the school and of this international group.

Of course, the job as vice-director has taken a lot of time away from active scientific research. Last fall, I discovered that there was a “bug”, a singularity, in my attempt to prove inequivalence, on physical grounds, between Jordan and Einstein frames. This year, I proved, with the help of Matteo GALAVERNI, that by “gauge-fixing” and reducing the Hamiltonian phase space it is possible to show that there exists a Hamiltonian canonical transformation from the Jordan frame to the Einstein. Although these names, Jordan and Einstein frames, sound quite awkward, they have been used in the study of cosmological inflation, which is a model that predicts a very fast expansion of the universe in its early times. Cosmological inflation explains why the temperature of the Cosmic Microwave Background Radiation, the very first light of the universe, is the same at all points.

We proved the mathematical equivalence of the two frames, in the sense that the solutions of the equations of motion in one frame can be mapped into the other frame, where they are solutions of the corresponding equations of motion in that frame. But we are not sure that the two frames are physically equivalent; more work should be done in this direction.

I have also started two other projects with Sergio Cacciatori (Università degli Studi dell’Insubria). One is an attempt to understand the unit of measurement and space-time points in the Jordan and Einstein frame argument. The second is a tentative attempt to understand “time” in quantum gravity.

I am also organizing a cosmology conference for June 2024, “Lemaître Conference 2024”, with four friends and colleagues of mine: Massimo Bianchi (U. Rome Tor Vergata), Sergio Cacciatori, Matteo GALAVERNI, and Fabio Scardigli (Politecnico di Milano). We already have a number of very good speakers for the conference and we hope to repeat the success we had with the Lemaître workshop in 2017.



This year did not start well for me, as numerous COVID vaccines did not work well and I had to recover from this unpleasant disease. Fortunately, the symptoms themselves did not last long thanks to the drugs that overpowered them, but I had to stay in isolation because the virus remained in my body for a long time, as the tests showed.

In February, the bulletin of the International Astronomical Union (WGSBN 3/2) announced the approval of names of asteroids discovered on the Vatican Advanced Technology Telescope (VATT) by K. Černis and R. P. BOYLE. These included: (551878) Stoeger, (560794) Ugoboncompagni, (562971) Johannhagen, (565184) Janusz, (582928) Smriglio.

Asteroid 565184 (or 2017 BK129) was first observed on February 22, 2012, and its confirmation procedure was not short. It has the following official description: “Robert M. Janusz (b. 1964) is a Polish Jesuit priest, philosopher and physicist noted for his study of star clusters and interstellar matter using data taken in the Vilnius System at the Vatican Advanced Technology Telescope. His philosophical work is noted for its discussion of field theory, computer science, and the mathematical nature of the universe.”

We prepared with great interest for the Summer School, which this year was on Machine Learning (ML). I hoped it would open up insight into the large quantity of data from astronomical images that are provided by the VATT. Many of the classes were innovative and inspiring. The methods used in ML and in various types of statistical tests, however, lack the precision of the direct model of the Vilnius photometric system, which was developed in response to the experience

of the difficulties and advantages of other systems. We have not yet managed to explore all of the issues discussed at the school this year.

Thanks to the publication of XP spectra of stars provided by GAIA, we are also developing the correlation of synthetic spectra with the Vilnius system. In the figures here we see a typical XP spectrum in the Vilnius filter range.

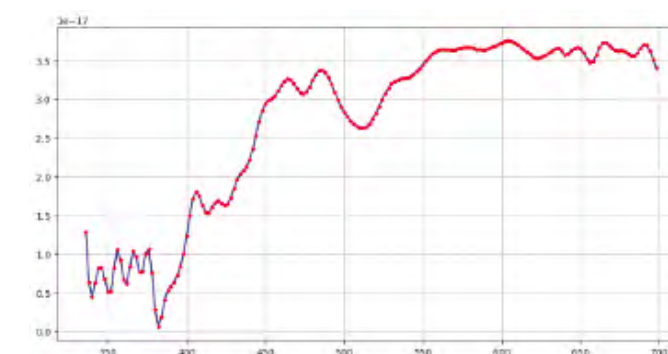


Fig. 1. Typical XP GAIA spectrum in the Vilnius filter range

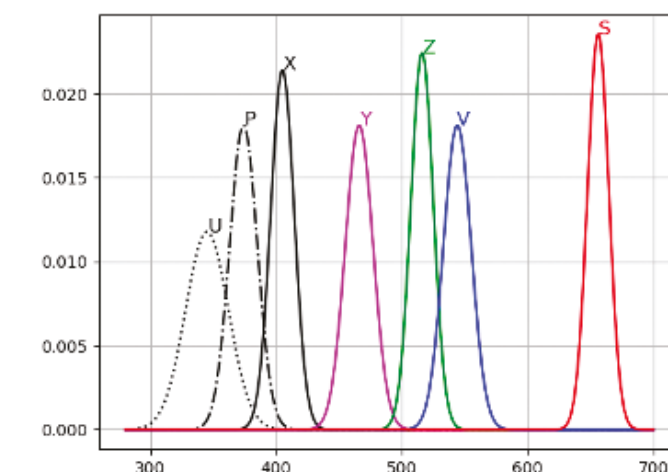
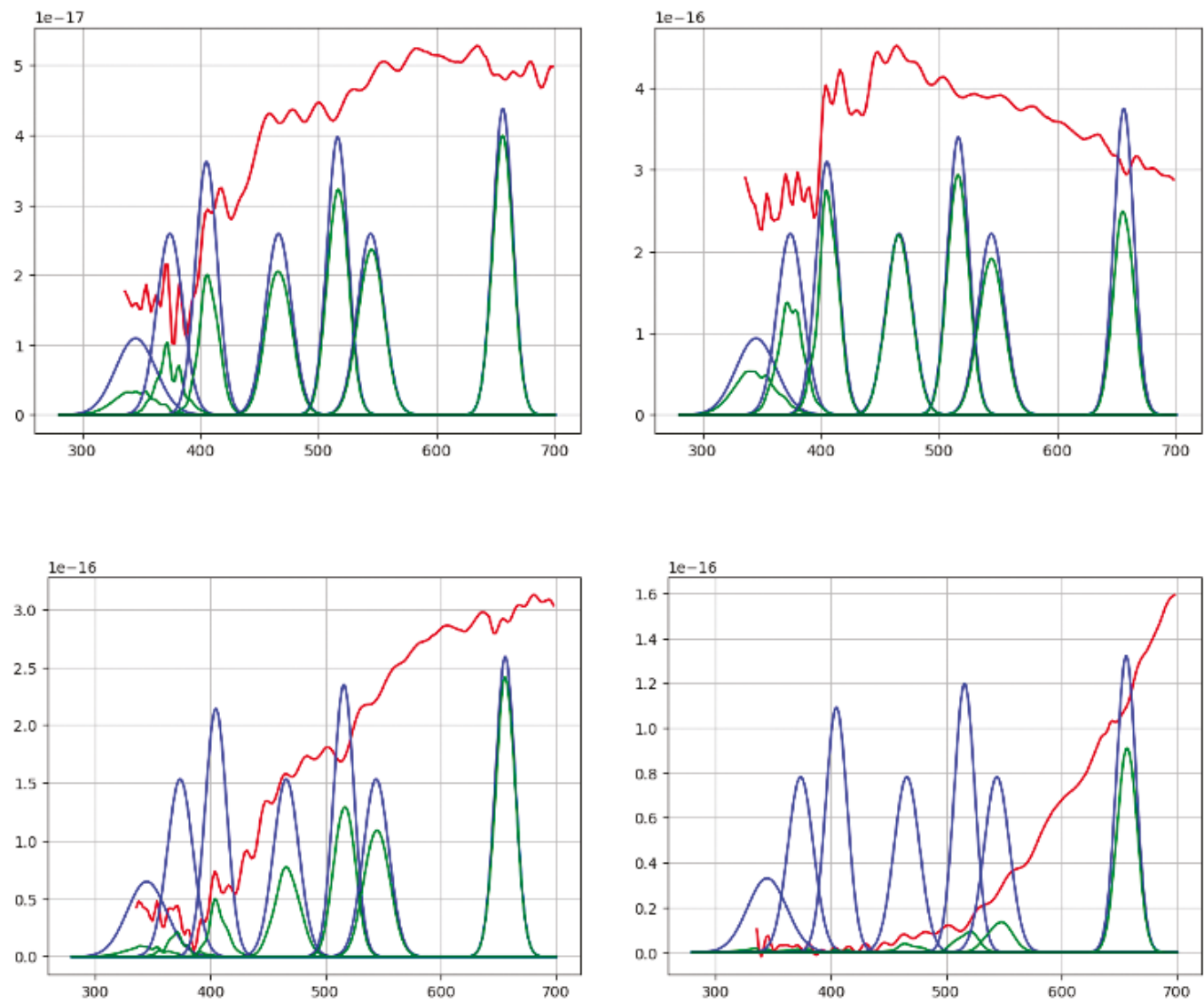


Fig. 2. Synthetic Vilnius filters, normalized, on the wavelength axis [nm]

The following graphs show the XP GAIA spectra (red), Vilnius filter positions (blue), and the spectral contribution to the synthetic stellar magnitudes (green).



Observations in the Vilnius System on the VATT this year were prepared by R. P. BOYLE. After the last observations in December, we will include this data in the full image repository.



When I was ordained a priest in Kinshasa on July 5, 1998, I had no idea that I would celebrate my silver jubilee of priesthood many miles away in the Diocese of Tucson. There is only one thing that comes in my mind: this is what being a Jesuit means. A Jesuit is at one place today, and tomorrow, he will be at a totally different place. It means being missioned. We Jesuits are missioned.

My deepest thought during this year of my silver jubilee of priesthood has been God's fidelity toward me, an imperfect sinner and a weak human being. At the same time, I have thought about my own history, how all of that started. I have realized the joy I had in discovering that my call was not based on any of my merits, but on God's will that I serve him as a Jesuit priest. Calling this reality into my mind, I have realized that that was exactly what has been keeping me going and will certainly keep me going.

I have three projects on which to report. The first regards Near-Earth Objects. This year my collaborators and I organized several observation campaigns resulting in observation, reduction, and analysis of more than twenty objects. Four of these objects were reported in a paper published by the Minor Planet Bulletin (Kikwaya and Hergenrother, 2023). We reported the lightcurve and type for each Near-Earth Asteroid, with type defined by color computed using the spectrophotometry method. For instance, the lightcurve of 2023 KQ indicates its span period to be 0.70 ± 0.01 hours (Fig. 1) with an amplitude of 0.195 ± 0.041 . Its colors suggest that it belongs to the S-Complex types (Sq, Sc), confirmed through the comparison between its relative reflectance and observed asteroid spectra (Fig. 2) and those of laboratory meteorites (Fig. 3).

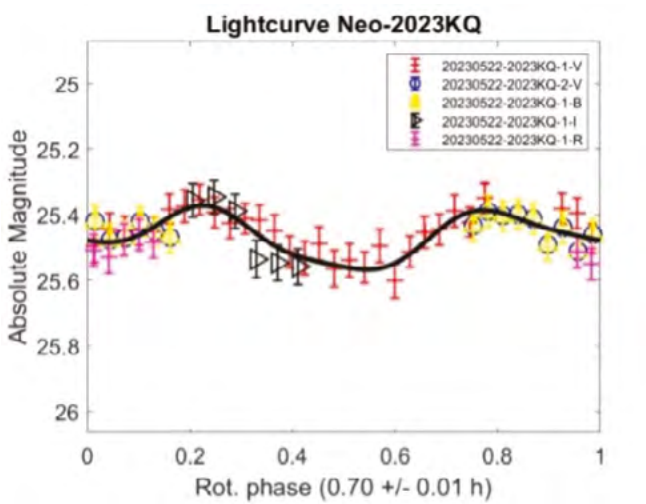


Fig. 1 - Lightcurve of 2023 KQ

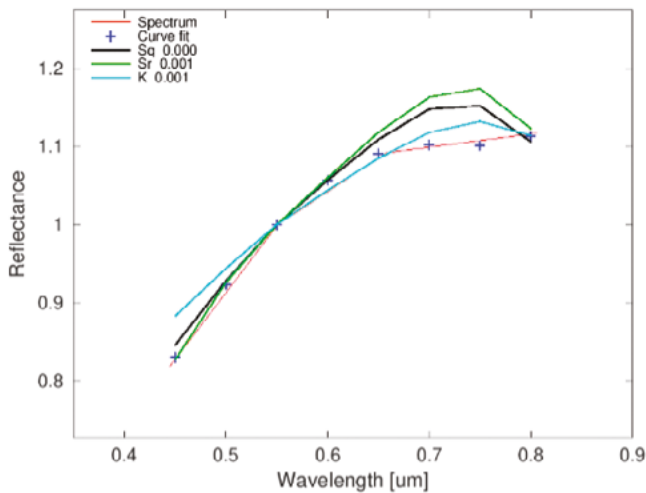


Fig. 2 - Sq, Sr and K are spectra that match 2023 KQ

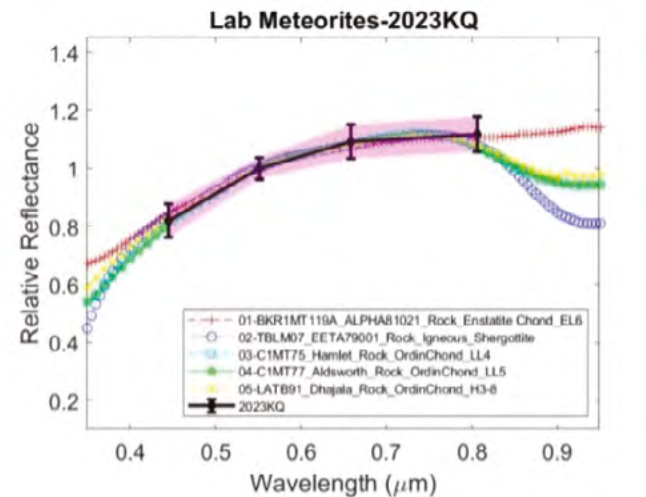


Fig. 3 - 2023 KQ matches 5 meteorite spectra

The second project is on fireball meteors. In collaboration with the Paris Observatory and its Fripon camera network, we collected images until April of some ten objects (meteoroids brighter than -3 magnitude). None produced meteorites, but we were able to find that some major meteor showers, particularly the Geminids, contained meteoroids bigger than the normal millimeter-size, indicating that the size distribution of one particular meteor shower might not be uniform. This finding gives and sustains the hope that a fireball capable of producing recoverable meteorites from a meteor shower is possible. That will then allow us to study in the laboratory meteorites coming from a particular meteor shower.

The third project consists in studying small or faint meteors. Our cameras collect a lot of data, and each night what has been observed can be seen on the Vatican Observatory website (<https://www.vaticanobservatory.org/meteor-cams/>). We are studying the origin (parent bodies) of these meteors by computing their orbits and also their Tisserand parameters. There are three different groups of parent bodies of meteoroids, signaled by their specific Tisserand parameters: asteroids, with a Tisserand parameter more than 3; Halley-type comets, with a Tisserand parameter less than 1; and Jupiter-family comets, with a Tisserand parameter between 1 and 3. We are particularly interested in Jupiter-family comets whose Tisserand parameter is more than 3 as that indicates that even though they are comets, they behave like asteroids. This raises questions, particularly about the formation and evolution of the solar system: do comets that are originally Halley-type undergo changes in their compositions while locked inside the solar system (findings of the NASA Stardust mission)?

I organized two public talks in Kinshasa (Congo), and one at Castel Gandolfo. I went to Congo for my annual visit to the Jesuits from my Province, and also to my family. I left on September 12, just one week after students there started a new school year. This allowed me to get in touch with students at our two high schools, Boboto Jesuit High School and Bonsomi Jesuit High School. After I returned

from Congo, Sisters of the Sacred Heart in tertianship in Rome came to visit the Specola Vaticana and attend two lectures: one on the history of the observatory, by Father Robert JANUSZ; one on the DART mission, by me. They enjoyed the visit. It was the first time for most of them to learn that the Roman Catholic Church has an observatory and does science, and to see a real telescope.



This year, my schedule and my efforts were dominated by preparations for the arrival of the asteroid sample being delivered by the OSIRIS-REx spacecraft. I joined the sample analysis team back in 2021, when I was asked to help develop and build an ideal-gas pycnometer to measure density and porosity of the specimens from the asteroid Bennu that would be brought back to Earth. I began this year in Tucson, working on a prototype of the device. We took it to NASA Johnson Space Center (JSC, in Houston, TX) in March for a dress-rehearsal of the sample analysis procedure. From that exercise, we got feedback and approval for the final design.

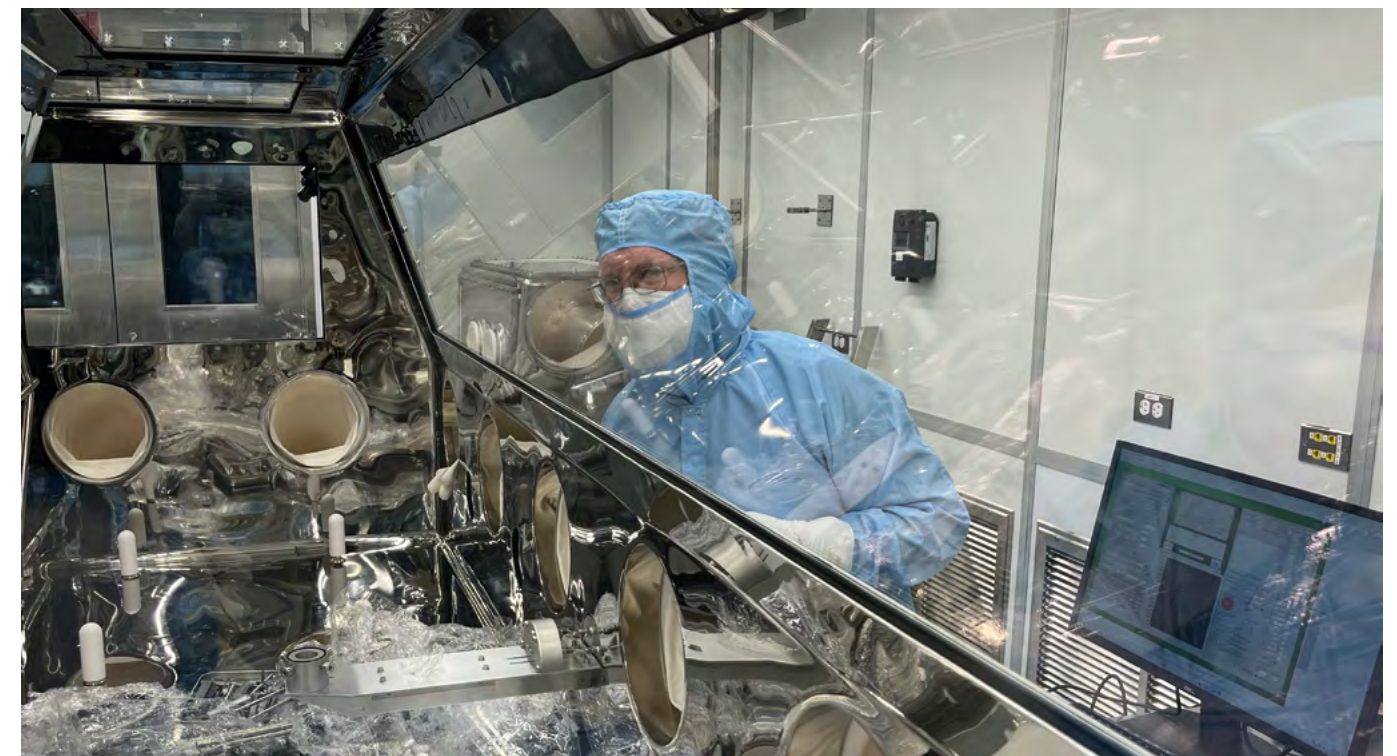
Most of the spring and summer was spent in procuring or manufacturing the approximately 380 parts that went into the device. To complicate matters, I had to be back

in Italy all spring and summer to renew my residency permit, so most of my time was spent searching for parts online and coordinating with a few people in Tucson to arrange for the manufacture of the pieces. Since I didn't have the prototype of the pycnometer as a reference, I constructed a computer model in Blender with all the pieces individually represented so I could keep track of all the parts and how they fit together. Assembly was done at NASA JSC by my colleague, Dr. Andy Ryan, based on my assembly instructions. By some miracle it not only came together, but it worked, and even more miraculously it mounted properly to the clean room glove box where measurements would take place.

The OSIRIS-REx capsule arrived on September 24, 2023. I have spent the fall commuting between Tucson and Houston to conduct measurements on the precious specimens it delivered.

The other space mission I am involved with, Lucy, passed by the asteroid Dinkinesh on November 1 and found out that it was a binary, with a small asteroid orbiting it!

In other science-related news, I continue my various collaborations measuring physical properties of meteorites. For example, my collaborators Opeil, CONSOLMAGNO, Britt, and I finally finished writing a paper on the thermal properties of lunar meteorites that we have been picking away at for several years.



Br. Macke in the OSIRIS-REx clean room at NASA Johnson Space Center, Houston TX, during the installation of the pycnometer that he built to study rocks from the asteroid Bennu

Outside the laboratory, I continue to tinker in my modest makerspace, and make videos for my YouTube channel, Macke MakerSpace. This past year included a few videos about the pycnometer, as well as a new project in which I try to design and build a clock from scratch, without



Br. Macke posing with the model of the Church of St. Ignatius that he is making for the Jubilee Year 2025

researching how clocks are actually constructed. Also, the rector of the Church of St. Ignatius in Rome asked me to make a model of the church, much like the one I made two years ago, for installation during the Jubilee Year 2025. I began work over the summer, but decided to make it bigger! It is HO scale (1:87), with a length of about 1 meter. I have already constructed the facade, and have started on the main structure. The completed project will be installed in the church in December of 2024.

This year the Vatican meteorite collection grew by one stone, a 125-gram specimen of the iron meteorite Gebel Kamil. This was a gift from Marvin Killgore (Southwest Meteorite Laboratory). The growth of the Vatican meteorite collection is largely dependent on the generosity of donors and benefactors.



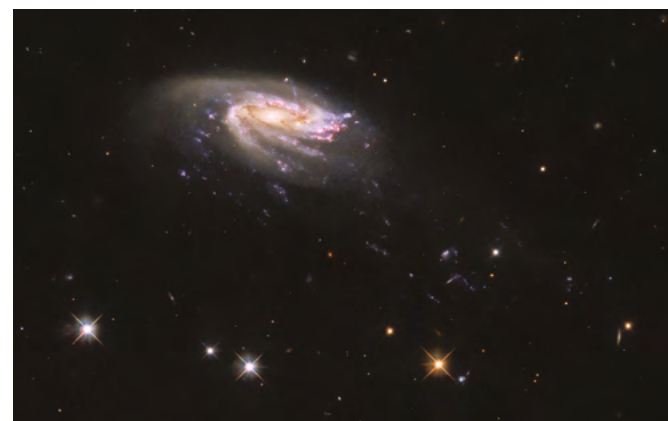
The specimen of the meteorite Gebel Kamil that was donated to the Vatican Observatory



My work during this year has been mainly devoted to the organization of the 2023 Summer School; I was the Dean of that school. Thus my scientific work report is small. However, three papers on which I have collaborated have been accepted for publication during this year. Taking advantage of the UV data coming from the Indian telescope UVIT and from HST, these papers concern jellyfish galaxies and in particular their UV emissions. I also gave two online talks about observational cosmology and theology in Novara and Fabriano.

Credit for all the images below: ESA/Hubble & NASA, M. Gullieuszik and the GASP team

JO206



The jellyfish galaxy JO206 trails across this image from the NASA/ESA Hubble Space Telescope, showcasing a colourful star-forming disc surrounded by a pale, luminous cloud of dust. A handful of bright stars with criss-cross diffraction spikes stand out against an inky black backdrop at the bottom of the image. JO206 lies over 700 million light-years from Earth in the constellation Aquarius, and this image of the galaxy is the sixth and final instalment in a series of observations of jellyfish galaxies. Some of Hubble's other observations of these peculiar galaxies — which range from grandiose to ghostly — are available here.

Jellyfish galaxies are so-called because of their resemblance to their aquatic namesakes. In this image, the disc of JO206 is trailed by long tendrils of bright star formation that stretch towards the bottom right of this image, just as jellyfish trail tentacles behind them. The tendrils of jellyfish galaxies are formed by the interaction between galaxies and the intra-cluster medium, a tenuous superheated plasma that pervades galaxy clusters. As galaxies move through galaxy clusters they ram into the intracluster medium, which strips gas from the galaxies and draws it into the long tendrils of star formation.

The tentacles of jellyfish galaxies give astronomers a unique opportunity to study star formation under extreme conditions, far from the influence of the main disc of the galaxy. Surprisingly, Hubble revealed that there are no striking differences between star formation in the discs of jellyfish galaxies and star formation in their tentacles, which suggests the environment of newly-formed stars has only a minor influence on their formation.

JW39



The jellyfish galaxy JW39 hangs serenely in this image from the NASA/ESA Hubble Space Telescope. This galaxy lies over 900 million light-years away in the constellation Coma Berenices, and is one of several jellyfish galaxies that Hubble has been studying over the past two years.

Despite this jellyfish galaxy's serene appearance, it is adrift in a ferociously hostile environment; a galaxy cluster. Compared to their more isolated counterparts, the galaxies in galaxy clusters are often distorted by the gravitational pull of larger neighbours, which can twist galaxies into a variety of weird and wonderful shapes. If that was not enough, the space between galaxies in

a cluster is also pervaded with a searingly hot plasma known as the intracluster medium. While this plasma is extremely tenuous, galaxies moving through it experience it almost like swimmers fighting against a current, and this interaction can strip galaxies of their star-forming gas.

This interaction between the intracluster medium and the galaxies is called ram-pressure stripping, and is the process responsible for the trailing tendrils of this jellyfish galaxy. As JW39 has moved through the cluster the pressure of the intracluster medium has stripped away gas and dust into long trailing ribbons of star formation that now stretch away from the disc of the galaxy.

Astronomers using Hubble's Wide Field Camera 3 studied these trailing tendrils in detail, as they are a particularly extreme environment for star formation. Surprisingly, they found that star formation in the 'tentacles' of jellyfish galaxies was not noticeably different from star formation in the galaxy disc.



The jellyfish galaxy JO175 appears to hang suspended in this image from the NASA/ESA Hubble Space Telescope. Its spiral arms are studded with many pink spots, especially around the top of the galaxy. One arm is sticking out below the galaxy. From it and around the bottom of the galaxy, faint gas streams away, while little gas is visible above the galaxy. This galaxy lies over 650 million light-years from Earth in the appropriately-named constellation Telescopium, and was captured in crystal-clear detail by Hubble's Wide Field Camera 3. A handful of more distant galaxies are lurking throughout the scene, and a bright four-pointed star lies to the lower right side.

Jellyfish galaxies get their unusual name from the tendrils of star-forming gas and dust that trail behind them, just like the tentacles of a jellyfish. These bright tendrils contain clumps of star formation and give jellyfish galaxies a particularly striking appearance. Unlike their ocean-dwelling namesakes, jellyfish galaxies make their homes in galaxy clusters, and the pressure of the tenuous superheated plasma that permeates these galaxy clusters is what draws out the jellyfish galaxies' distinctive tendrils.

Hubble recently completed a deep dive into jellyfish clusters, specifically the star-forming clumps of gas and dust that stud their tendrils. By studying the origins and fate of the stars in these clumps, astronomers hoped to better understand the processes underpinning star formation elsewhere in the Universe. Interestingly, their research suggests that star formation in the discs of galaxies is similar to star formation in the extreme conditions found in the tendrils of jellyfish galaxies.



Here we see JO204, a 'jellyfish galaxy' so named for the bright tendrils of gas that appear in this image to be drifting lazily below JO204's bright central bulk. (On the left it is just touched by a second, faint and dim galaxy.) The galaxy lies almost 600 million light-years away in the constellation Sextans. This image was captured by the NASA/ESA Hubble Space Telescope, and it is the third of a series of Pictures of the Week featuring jellyfish galaxies. This series of images is possible thanks to a survey in which observations were made of six of these fascinating galaxies, including JO204. This survey was performed with the intention of better understanding star formation under extreme conditions.

Given the dreamy appearance of this image, it would be understandable to wonder why jellyfish galaxies should be such a crucible for star formation. The answer is that — as is often the case with astronomy — first appearances can be deceiving. Whilst the delicate ribbons of gas beneath JO204 may look like floating jellyfish tentacles, they are in fact the outcome of an intense astronomical process known as ram pressure stripping.

Ram pressure is a particular type of pressure exerted on a body when it moves relative to a fluid. An intuitive example is the sensation of pressure you experience when you are standing in an intense gust of wind — the wind is a moving fluid, and your body feels pressure from it. An extension of this analogy is that your body will remain whole and coherent, but the more loosely bound things — like your hair and your clothes — will flap in the wind. The same is true for jellyfish galaxies. They experience ram pressure because of their movement against the intergalactic medium that fills the spaces between galaxies in a galaxy cluster. The galaxies experience intense pressure from that movement, and as a result their more loosely bound gas is stripped away. This gas is mostly the colder and denser gas in the galaxy — gas which, when stirred and compressed by the ram pressure, collapses and forms new stars in the jellyfish's beautiful tendrils.



Jellyfish galaxy JO201, with trailing tentacles of stars, hangs in inky blackness in this image from the NASA/ESA Hubble Space Telescope. It has large, faint, reddish spiral arms and a bright, reddish core. These lie over two brighter blue spiral arms. These are patchy, with blotches of star formation. Long trails of these bright blotches trail down from the lower spiral arm, resembling tendrils. The background is black, lightly scattered with small galaxies and stars, and a larger elliptical galaxy in one corner.

As Jellyfish galaxies move through intergalactic space they are slowly stripped of gas, which trails behind the galaxy in tendrils illuminated by clumps of star formation. These blue tendrils are visible drifting below the core of this galaxy, and give it its jellyfish-like appearance. This particular jellyfish galaxy lies in the constellation Cetus, which is named after a sea monster from ancient Greek mythology. This sea-monster-themed constellation adds to the nautical theme of this image.

The tendrils of jellyfish galaxies extend beyond the bright disc of the galaxy core. This particular observation comes from an investigation into the sizes, masses and ages of the clumps of star formation in the tendrils of jellyfish galaxies. Astronomers hope that this will provide a breakthrough in understanding the connection between ram-pressure stripping — the process that creates the tendrils of jellyfish galaxies — and star formation.

This galactic seascape was captured by Wide Field Camera 3 (WFC3), a versatile instrument that captures images at ultraviolet and visible wavelengths. WFC3 is the source of some of Hubble's most spectacular images, from a view of Jupiter and Europa to a revisit to the Pillars of Creation.



The galaxy JW100 features prominently in lower right of this image from the NASA/ESA Hubble Space Telescope, with streams of star-forming gas dripping from the disc of the galaxy like streaks of fresh paint. These tendrils of bright gas are formed by a process called ram pressure stripping, and their resemblance to dangling tentacles has led astronomers to refer to JW100 as a 'jellyfish' galaxy. It is located in the constellation Pegasus, over 800 million light-years away.

Ram pressure stripping occurs when galaxies encounter the diffuse gas that pervades galaxy clusters. As galaxies plough through this tenuous gas it acts like a headwind, stripping gas and dust from the galaxy and creating the trailing streamers that prominently adorn JW100. The bright elliptical patches in the image are other galaxies in the cluster that hosts JW100.

As well as JW100's bright tendrils, this image also contains a remarkably bright area of diffuse light towards the top of this image which contains two bright blotches at its core. This is the core of IC 5338, the brightest galaxy in the galaxy cluster, known as a cD galaxy. It's not unusual for cD galaxies to exhibit multiple nuclei, as they are thought to grow by consuming smaller galaxies, the nuclei of which can take a long time to be absorbed. The bright points of light studding its outer fringes are a rich population of globular clusters.

This observation took advantage of the capabilities of Hubble's Wide Field Camera 3, and is part of a sequence of observations designed to explore star formation in the tendrils of jellyfish galaxies. These tendrils represent star formation under extreme conditions, and could help astronomers understand the process of star formation elsewhere in the universe.

ADJUNCT SCHOLARS



My work at the Vatican Observatory is mainly centered on the study of the history of astronomy with particular regard to the development of astrophysics from its foundation in the mid-nineteenth century to the present time, in the vicinity of Rome.

In collaboration with Rome Astronomical Observatory, I started activities for the bicentenary of the birth of Lorenzo Respighi (1824-1889), director of Campidoglio Astronomical Observatory during the pontificate of Pius IX. Respighi was the inventor of the objective prism which allows an observer to collect simultaneously thousands of spectra. The objective prism technique is currently employed in many observatories. The Specola historical collection of instruments includes some objective prisms which were used at the Vatican Schmidt Telescope.



In view of Holy Year 2025, I participated in a working group, promoted by the Rector of St. Ignazio Church, Fr. Vincenzo D'Adamo, which has the aim to organize events for students and the wider public. I also took part in the general internal discussions on communicating science as part of the Vatican Observatory's projects in the field of outreach and education.

In my everyday life, in addition to family commitments, I am an active member of my parish community of San Fulgenzio in Rome, as a lay minister of the Word and the Eucharist.



Philosophers are keenly aware of the many varieties and styles of thinking that emerged in the course of history. My own style is to work in constant dialogue with developments in the natural sciences, and during this year various opportunities allowed me to continue in this style as I explored themes bordering on spirituality, theology, ecology, and biology.

In November 2022, I was a keynote speaker at Boston College for a conference on "Philosophy as a Spiritual Exercise". My paper was entitled "Trajectories of Ignatian Spirituality in Philosophy of Science and Nature". In early September 2023, I was again a keynote speaker, this time at Westminster College, University of Cambridge, for the "Science Religion Forum" annual conference. This year the



Three main events have marked this year for me. First, the publication of the travel journals of Fr. Angelo Secchi, S.J. in January 2023 (but dated 2022) — a long and complex work which took many years, including the Covid pandemic lockdown time. It was the last expected result of the national committee for the bicentenary of Secchi's birth. It should have been published much earlier, but it appeared later because of publisher's delays. I am happy to have concluded this work. Now I am preparing an edition of correspondence between Secchi and Denza — another major effort — which will be published shortly.

topic was "Humans and Other Animals: Multifaith Responses to the Significance and Symbolism of Animals in Science and Religion Dialogue", and my paper was entitled "Future togetherness: drawing inspiration from Teilhard de Chardin".

As in previous years, my research group at the Gregorian University worked on "The Scientific Mentality and Questions about God". There were nineteen participants this year, with six others corresponding online. The year's highlight is usually a one-day workshop, normally held at the Vatican Observatory premises at Albano. This year's workshop focused on how science is relevant for the future of humanity, and one of the papers was by a Vatican Observatory astronomer Richard D'SOUZA. The participants find such interdisciplinary work significantly inspiring.

In the course of this year, two doctoral students working under my supervision defended their theses: one worked on the role of analogies and models in science and theology; the other worked on ecology and goal-oriented changes in biology. As I write these few lines, I am engaged in this year's set of lectures for graduate students on the philosophy of causation, and in another set of lectures on philosophical issues in ecology. After reading these few lines, can you now see why I think that doing philosophy in dialogue with science can be considerably fruitful and exciting?

The second is my first journey to the US, on the occasion of the annual Scientific Instrument Society (SIS) study tour, which included visits to many scientific museums and institutions in Boston and New England. It was a really exciting experience for me. I have learned much about the historical scientific collections in those territories and met many colleagues from the US. What most marked me were the visits at Harvard and Yale Universities, Dartmouth College and MIT, but I will also always remember the beautiful landscapes of woods and rivers, elegant gardens, houses and streets, skyscrapers and red-brick buildings... and the clam chowder, of course!! I am sincerely grateful to the Specola Vaticana that partially covered the costs of this very formative and enriching experience for me.

The third is the organization of the 42nd Scientific Instrument Commission Symposium in Palermo, last September. It was a really successful meeting — but it cost me many sleepless nights! I was the local host, in charge of the general organization, together with a team of a half-dozen of my colleagues from the INAF Palermo Observatory and the local University. We had to meet many financial and logistic difficulties, owing to the unexpectedly high number of participants (over two hundred, double the usual). I have actually experienced the special assistance of Divine Providence, especially when we realized that the rooms offered by the University were insufficient for so many participants. All other possible venues near the University were too expensive for our limited budget. Quite without hope, I dared to ask the Rector of the Pontifical Faculty of Theology, whose location was perfect for our needs, to host the conference. It is quite unusual for a Faculty of Theology to host a scientific meeting... but he kindly accepted, to my great surprise! The meeting was characterized by a wide attendance, with people from over thirty different nations, from all continents except Oceania. We decided to adopt a very inclusive approach, trying to facilitate the participation of colleagues from

countries that often do not send representatives to conferences like this one. The presence of Muslim colleagues was managed by providing prayer rooms and appropriate food. Colleagues from Israeli, Russia and Ukraine also took part in the meeting. I only regret that some colleagues did not attend the meeting because they could not obtain a visa and find financial support from their institutions. Richard D'SOUZA also attended the meeting, and I was happy that he could also establish relationships with this community of specialists in scientific heritage.

I confess, I felt a deep and joyful emotion all throughout the meeting, in seeing that scientific culture unifies people and helps to build bridges and respectful relationships. In these sad times of wars, it is a hopeful sign that a different world is possible, if we try to welcome each other without prejudices and vetoes, and focus on common interests.

Because of so many engagements, this year I could not spend time at the Specola. It will be better next year, God willing!



Maria Carmen Beltrano (left) interviewing CHINNICI (right) at the Accademia Nazionale delle Scienze detta dei XL on June 8, at the presentation of her book, *Appunti di un Gesuita Scienziato: Diari di Viaggio di P. Angelo Secchi* (*Notes of a Jesuit Scientist: Diaries of the Travels of Fr. Angelo Secchi*)



The year 2023 saw me involved, in addition to the ordinary work within my IT skills that I have been carrying out at the Vatican Observatory for 12 years now, in a project that our director, Br. Guy Consolmagno, strongly wanted and which I was asked to find a way to make it happen. This involved the creation of a virtual tour of the Vatican Observatory museum space inside the Pontifical Villas and the telescopes at the top of the Pontifical Palace of Castel Gandolfo.

This work was made possible thanks to the collaboration of the Italian company *Dimensione3* and was realized by integrating *Matterport Technology*, a world-leading platform for the creation of “digital twins”, and the “Dimensione3” software that allows for the addition of customized interactions and features aimed at enhancing the digital experience and the effective dissemination of the Observatory’s scientific content.



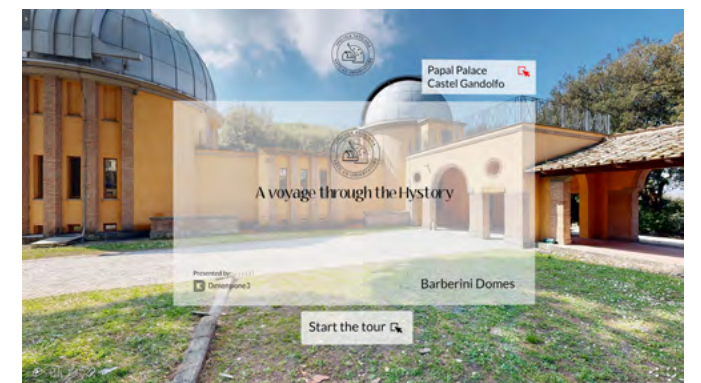
Mr. Giulio Deroberstis (*Dimensione3*) during the 3D scanning work inside the museum space of the Vatican Observatory in March

The realization of the project was based on careful planning of every detail, from the weather and light conditions during the surveys, to the optimal observation points for digital exploration, to the most suitable route for the visitor, and finally to the features that best enhance the historical and scientific content.

The surveying of the locations was carried out with state-of-the-art equipment, which on the one hand allows for high photographic quality, and on the other hand creates the integral 3D model of the spaces. The 3D models, in addition to allowing the creation of a realistic virtual visit, also represent valuable artifacts that become the heritage of the Vatican in terms of a digital archive and at the same time form the basis for the development of new future projects.

Digital exploration of the Vatican Astronomical Observatory’s two historic sites is enhanced with personalized features and interactions. Interactive virtual signage guides the visitor, allowing in-depth historical and scientific insights, interactive links between the two locations, and cross-references to the Vatican Observatory website.

The virtual tour can be accessed from the home page of our institutional website, <http://www.vaticanobservatory.va/>





Claudio
COSTA

During most of 2023, I continued assisting and coordinating the work to complete the restoration of the Vatican Observatory's historic Carte du Ciel telescope. This included the following activities:

- the internal telescope through which the Polar Distance circle is visible has been fully cleaned, and a new diagonal prism has been installed;
- a new LED lamp to illuminate this circle from a rechargeable battery has been installed;
- the objective of the finder of the telescope has been cleaned;
- a new right-angle finder has been installed;
- a new variable focus viewfinder of the Polar distance circle has been installed;
- a new remote controller of the telescope drive has been provided to replace the old one which was accidentally broken;
- a complete re-painting of the Carte du Ciel mount, which restored the original gray paint, was performed in three days by myself, Adrianno Lolli and Romano Reggio;
- a wooden cabinet (recovered from a Vatican Observatory repository), more fitting with the furniture in the telescope's dome, has been installed to replace the old metal one, and a table and chair have been added.

Anticipating the long-awaited public visits to the Carte du Ciel telescope and museum, operated in cooperation with the Musei Vaticani, I trained seven young astrophysicists on the operation of the telescope. Visitors will be able to look at the Moon and the planets through its

eyepiece. These personnel were also instructed on the history of the Specola Vaticana, to be able to assist visitors to the exhibition rooms of the museum below the Carte du Ciel and inside the Schmidt telescope dome. A checklist containing the list of operations to perform before, during and after the visits has been developed and distributed to the operators.

During the year, I led observing sessions with the Carte du Ciel telescope for private visitors, schools and many amateur astronomer groups. On October 25, I led the very first of the new public visits to the Vatican Observatory, together with personnel from the Specola Vaticana and Musei Vaticani. About 150 people (including the Ambassador of Poland to Italy) were divided into groups and were guided by Marzia Campanelli and Riccardo Falsini through the two domes which protect the telescopes and throughout the astronomical exhibition showing the past and current activities of the Observatory.



Mr. Romano Reggio and Mr. Claudio Costa, during the re-painting of the Carte du Ciel mount and optical tube



Marzia Campanelli talking to Polish visitors during one of the very first public visits to the Museum under the historic Carte du Ciel telescope



On Dec 03, Adriano Lolli repainted in gold the Pius XII inscription on the north pillar of the Carte du Ciel scope



As I begin my thirty-eighth year at Bryn Mawr College, I continue to teach courses ranging from quantum mechanics to the mechanics of academic writing. This summer, for the first time since I was an undergraduate in the 1970s, I stepped into the lab to make measurements for publication. I measured the cooling curves for different materials used in the making of teapots, and riffing off of Guy CONSOLMAGNO's method for measuring the volume of meteorites using small beads, measured the capacity of tea infusers. The data will appear in a book on the chemistry of tea.

I spent much of last spring and summer writing that book. In August, I submitted the completed manuscript for *Steeped: The Chemistry of Tea* to the Royal Society of Chemistry Press; the book should be published early in 2024. Over the course of the project, I read more than 500 papers... and drank more than 400 cups of tea!

I am particularly delighted to report that I appeared as a very minor (offstage) character in a science-fiction short story by Sabrina Vourvoulias, "The Memory of Chemistry" which appeared in *Fantasy Magazine* at the end of 2023 (<https://www.fantasy-magazine.com/fm/fiction/the-memory-of-chemistry/>). The story's epigraph also quotes from a post I wrote for the Vatican Observatory blog (<https://www.vaticanobservatory.org/sacred-space-astronomy/ghost-of-elements-spectres-of-the-universe-angelo-secchi-sj/>) during the UN's Year of Light in 2018: "We hunt for the structure of the universe in its ghosts."

I continue to be a part of a grant out of the University of Notre Dame exploring the ways in which the development of intellectual humility might aid students on their paths to becoming scientists and build a stronger, more ethical framework for science. This year, we drafted a primer introducing concepts of intellectual humility and ways to incorporate those concepts into the university science classroom and research training. I enjoyed co-hosting a series on artificial intelligence for the Institute on Religion and Science.

This year, I spent the first semester at the Jesuit School of Theology of Santa Clara University in Berkeley, California. My research plan was to study the concept of nature considering the most recent scientific advancements and the future of humanity and its scientific, philosophical, and theological implications. During this time, ChatGPT spread enormously. Since then, I have focused my studies on this subject.

I participated in a conference organized by the Center for Theology and the Natural Sciences in Berkeley and collaborated with colleagues addressing these topics in our interdisciplinary research group on the Future of Humanity. We published a book in Spanish on the Search for Extraterrestrial Intelligence, *La Búsqueda de Vida Extraterrestre Inteligente: Un Enfoque Interdisciplinario*. We were honored by Natalie Cabrol, Director of the Carl Sagan Center for Research at the SETI Institute, who wrote the foreword of the book. Here is a short summary:

In order to address the Search for Extraterrestrial Intelligent life, in 2016 the authors of the book started a multidisciplinary research group that they called the OTHER Project (Other Worlds, Earth, Humanity and Remote Space). The project is a laboratory of ideas that tries to give a multidisciplinary approach to the search for other inhabited worlds. The search for intelligent life in the cosmos, with the fascination it arouses in public opinion, presents new challenges and new frontiers for science, philosophy and religion. There are many questions that this type of research raises not only on the border between science, philosophy and theology but also between what is considered affirmed science and what some might consider science fiction. The book addresses some questions from the academic perspective of the specialized knowledge of its authors: astronomy, biology, philosophy and theology, and attempts to think about the search for extraterrestrial intelligent life from the application of a rational epistemological method that allows progress on solid bases.

The book is available in different ebook formats.



One word to summarize the activities of this year is "connections". I tried to establish connections with researchers attending several conferences, connections with students and visitors, connections between those with different expertise in science, and connections between science and faith. I think this is a nice way to continue the mission of the Specola, demonstrating the Church's support today for "true and solid science, whether human or divine" (Leo XIII, *Motu Proprio Ut Mysticam*, 1891).

In particular, here in Castel Gandolfo, I continued the research projects with Gabriele GIONTI on the Hamiltonian canonical equivalence between "Jordan" and "Einstein" frames. One new preprint was recently submitted, and we have several ideas for new developments.

The collaboration with Fabio Finelli and Daniela Paoletti (INAF-OAS Bologna) led to the publication of a paper

in the journal *Physical Review D*, "Redshift evolution of cosmic birefringence in CMB anisotropies". Cosmic microwave background (CMB) linear polarization is an important probe to study the energy content of the universe (e.g. axion-like dark matter or quintessence).

The summer was quite busy. I helped with the organization of the Vatican Observatory Summer School. Having a Summer School after a five-year hiatus owing to the pandemic was not easy, but luckily there was a very good group of students. I also attended several conferences in Bologna, Trento, Bari and Rijeka (Croatia).

Together with Gabriele GIONTI we hosted at Castel Gandolfo professor Günter Sigl (Universität Hamburg). I have known him since the time of my PhD thesis (he was my co-supervisor). We have some ideas for future projects; we hope to put them in concrete form in the coming years.

There are always a lot of requests for outreach talks. With Giuseppe KOCH, I gave a presentation on the first vice-director of the Specola, "Fr. Giuseppe Lais, Oratorian" at the Congregation of the Oratory of St. Philip Neri (Santa Maria in Valicella). With Gabriele GIONTI, I provided the seminar "From the Astronomical Observatory of the Roman College (Collegio Romano) to the Vatican Observatory (Specola Vaticana)" at the IAPS-INAF Institute here in Rome. I also gave several presentations in my Diocese of Reggio Emilia – Guastalla, in several schools and parishes, at Catholic University (Piacenza) and at Sapienza University.



Galaverni lecturing in Santa Margherita Ligure, July 18



“I love it when a plan comes together!” This was the stock phrase of George Peppard’s cigar-chomping character Col. “Hannibal” Smith in the old television show “The A-Team”. This year many interesting things came together, and I love that they did, although the coming together was not always planned.

My work focuses on the science of those astronomers in history who opposed the “Copernican Revolution”. To some, this subject might be arcane. I find it fascinating.

Br. Guy CONSOLMAGNO and I came together to publish two in-depth discussions of the long history of Jesuit astronomers and the Coriolis Effect. Jesuits envisioned this hurricane-spawning effect long before Mr. Coriolis. Recognizing that such an effect must exist if Earth rotates (as Copernicus said), yet observing no such effect, they saw it as an argument against Copernicus. Once the effect was in fact observed, later Jesuits took an interest in it. Consolmagno and I produced a full scholarly discussion of this history for the *Catholic Historical Review*, and a popular discussion for our new book *When Science Goes Wrong: The Desire and Search for Truth*. This history matters — it counters the common presumption that those who opposed Copernicus did so reflexively, on the authority of scripture, conspiring to cast aside science and the search for truth.

It is also commonly presumed that science in the Copernican Revolution made our Earth merely one of many planets, orbiting (according to Bruno) one of myriad suns, thus giving us the modern universe. My research, however, has shown that early Copernicans like Johannes Kepler argued that stars were not other suns. Kepler, addressing Bruno, said our Sun was a unique body within a universe that reflected both God’s power to create on an immense scale and God’s care for the littlest created things (like us). Moreover, Kepler had powerful scientific arguments supporting his views.

These arguments were eventually undermined by advances in the understanding of optics and star images. Nevertheless, during the time when the idea of myriad other earths became popular, Kepler’s science had not been undermined. That’s challenging, since we think of that idea as being a product of science. Looking for when science really did support the idea yields more challenges. What do these challenges mean for the idea of other earths, still so popular today?

This year I finally succeeded in publishing my research on Kepler and other earths, which brought together science, history and even religion — in an astrobiology journal! I owe this success in large part to the Vatican Observatory community, who gave me feedback (CONSOLMAGNO especially) on what I needed to get this plan to come together. Shortly after the paper appeared, I was invited to give a presentation for NASA-Goddard, hosted by an exoplanet research group. That was nearly-new territory for me. “Nearly” because a few months prior to NASA, I had spoken on Kepler and touched on the other earths subject; I had been invited to be part of the 25th Seven Pines Symposium, a small gathering that included a Nobel laureate in cosmology and the head of the Event Horizon Telescope project — very much new territory for me, and unplanned.

In both cases, however, the audiences were receptive and the talks went well. I am thrilled to be able to successfully connect my arcane research specialty with something so “cool” as the search for other earths and life on them. I am not sure there was really a plan for that, but I certainly do love how it all came together! I am happy and honored to be part of the Vatican Observatory.



Holly McGuire (VOF ACME program 2022 alumna) and Louisville Archbishop Shelton J. Fabre, at the Archdiocese of Louisville Gold Mass for Science, November 27. McGuire and Chris GRANEY serve on the Archdiocese’s Faith and Science Dialogue Group that organizes the Gold Mass. Photo courtesy of Ruby Thomas



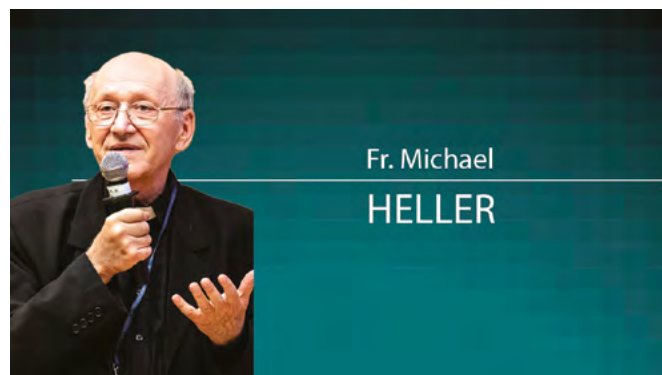
A public viewing of the Moon at Bellarmine University in Louisville, Kentucky, through a telescope that once belonged to Msgr. Michael Bouchet, rector of the Louisville Cathedral during the late 19th century. Chris GRANEY (left) restored it to operation after over a century in storage.



The Bouchet telescope in action under the stars at St. Gregory the Great Church in Samuels, Kentucky



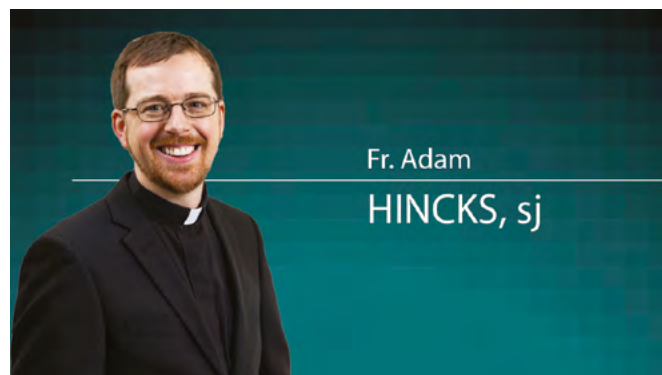
Christina Graney (who contributed to the Bouchet telescope restoration) and Archdiocese of Louisville Archivist Tim Tomes observe Venus at the restored Bouchet telescope’s “first light” outside the Archdiocese of Louisville History Center



My scientific activity this year was dominated by the celebration of the 550th anniversary of the birth of Nicolaus Copernicus. Preparations for this anniversary have been going on for a long time. Many works devoted to Copernicus and his times have been published.

I also wrote a book entitled *Nicolaus Copernicus' Theory of Relativity*. I tried to show the importance of the Copernican Revolution in the evolution of the idea of relativity from antiquity to the latest theories of modern physics. The culminating point of the celebrations was a trio of scientific symposia in cities related to Copernicus' life: Toruń, Kraków, and Olsztyn. I took part in two of them: in Kraków and Toruń. Apart from them, many other meetings, symposia and discussions were also held.

These celebrations (especially the symposium in Kraków) had a personal touch for me. I was one of the few participants in this year's celebrations who also took an active part in similar celebrations fifty years ago, in 1973, when the entire scientific world celebrated the 500th anniversary of Copernicus' birth. At that time, the highlight of the ceremony was a trio of symposia of the International Astronomical Union, which were held in Warsaw, Toruń, and Kraków. The symposium in Kraków was devoted to the confrontation of cosmological theories with observational data. I had the honor of presenting the opening paper at that symposium. It was my first ever scientific paper presented before an international body. Since then, cosmology has made gigantic progress. I have been very lucky to be its eyewitness.



This year has been exciting on the research front as the Simons Observatory (SO), a new multi-telescope facility that I am involved with, is currently being installed in Chile. SO will do a wide-area, high-sensitivity survey of the cosmic microwave background (CMB), the oldest light in the universe, in order to search for the faint signal of inflation that set the initial conditions of the cosmos — if indeed inflation, the putative superluminous expansion of the universe within the first second after the big bang, did occur. If we do not detect the inflation signal that will also be an important result! Furthermore, SO will tell us more about dark matter and dark energy, about the mass of neutrinos (currently unknown), about galaxy evolution, and much more.

My group in Toronto, led by a postdoc and a PhD student (who is about to defend!), is contributing to the software stack that controls the observatory and collects and organizes data. It is an exciting time because of the excellent wide-area CMB data that SO will give us over the next decade. Currently, I am serving as the chair of the Membership Panel that reviews applications of scientists who want to join the SO collaboration, and it is rewarding to see the amazing variety of talent among my colleagues.

I have been getting more involved in time domain astronomy, where we look for giant explosions in distant galaxies that suddenly cause a new source to appear in the sky and fade away, and where we study things whose brightnesses vary in time, like the powerful jets that are spewed out from the discs around some supermassive black holes that live in the centers of galaxies, called active galactic nuclei (AGN). CMB observatories like SO turn out to be great instruments for doing this time domain astronomy at millimeter (mm) wavelengths. I have been working with one of my PhD students and a former undergraduate to analyze the AGNs that we see in the CMB data from the Atacama Cosmology Telescope (ACT), a predecessor to SO. We work closely with colleagues in ACT and SO on a variety of time domain projects.

I presented our work on mm AGN observations at the European Astronomical Society's Annual Meeting in Kraków in July. It was a wonderful event where I was able to learn much and to do some networking. Fr. Richard D'SOUZA was also at the conference. At the conference banquet, we dined with some alumni of the Vatican Observatory Summer School. It was evident that the school had had a positive impact on them.

My other trip of note this year was an extended stay at the Vatican Observatory headquarters in the spring. It was good to reconnect with my colleagues there. I was also able to meet one of my SO colleagues, Giuseppe Puglisi, for the first time in person. After visiting the Specola he invited me to give a talk at Tor Vergata where he is based. My stay at the Specola overlapped with the beginning of the 2023 Summer School, and I was honored to give a talk to the students before returning to Toronto.

My teaching continues to go well. I have an undergraduate class called "Faith and Physics", and I enjoy our high-quality discussions. The students come from various backgrounds that include engineering, physics, philosophy, and history. In the winter term I taught my undergraduate class on "The Bible and the Big Bang" for the second time and will offer it again in 2024. My final course for this year is Astronomy 101, "The Sun and Its Neighbours", a huge class of non-science majors—over 1,200 undergraduate students. The week before I wrote this report, I was teaching them about the asteroid Bennu and the OSIRIS-REx mission that returned a sample to earth, and was delighted to show them a special video greeting from Br. Bob MACKE who told them about his preparations to analyze the Bennu sample. It was a special moment that crystallized the relationship between my work at the University of Toronto and my affiliation with the Vatican Observatory.

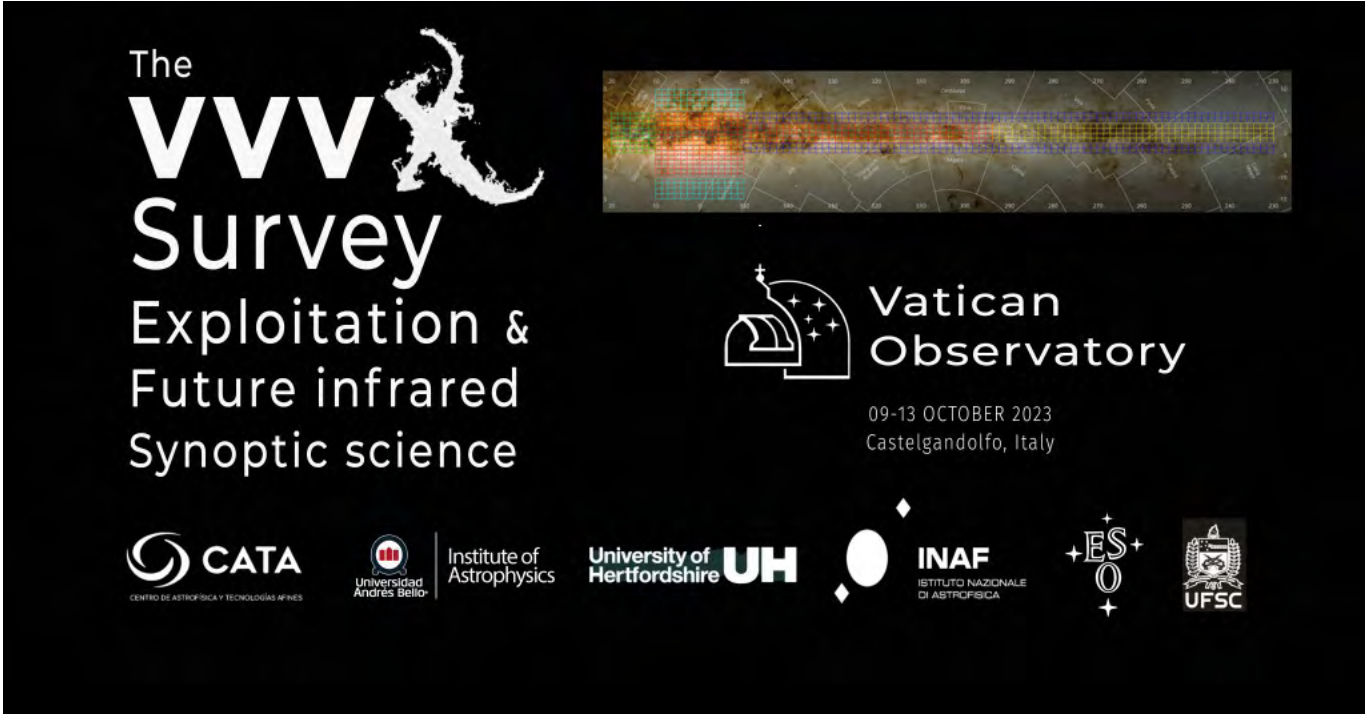


This year, I was very happy to visit the Specola and interact with the staff again, because we organized the workshop on "The VISTA Variables in the Via Lactea Extended Survey (VVVX) Exploitation & Future Infrared Synoptic Science", held October 9-13. Our workshop hosted twenty-two scientists from all over the world, including many former students from recent Vatican Observatory Summer Schools (Dr. Alonso Luna, Dr. Maria Gabriela Navarro, Dr. Sol Alonso, Dr. Fernanda Duplancic, Dr. Roberto Saito, Dr. Matteo GALAVERNI). The invited speakers were mostly members of the VVVX Science Team, and also local Jesuits (Fr. Richard D'SOUZA and Fr. David BROWN). The success of the workshop was ensured thanks to the spotless work of the Organizing Committee that included Phil Lucas, Joyce Pullen, Roberto Saito, Maria Gabriela Navarro, Marina Rejkuba, and Valentin Ivanov. We are also very grateful for the help from Federico BALZONI, Antonio CORETTI, Assunta RODIA and Romano REGGIO from the Specola.

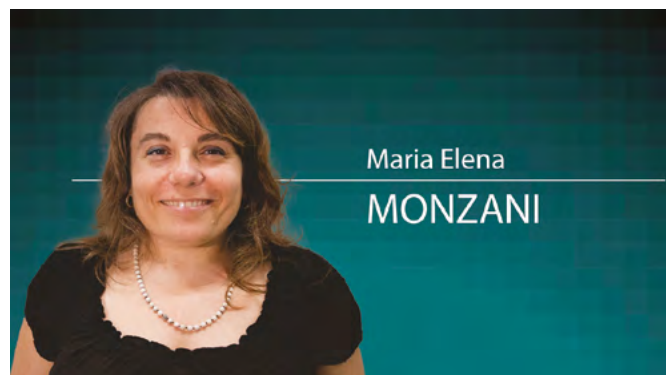
The Vatican press highlighted some of our VVVX discoveries. These included a new catalogue of nearly twenty thousand never-seen-before galaxies just behind the plane of the Milky Way; hyper-velocity stars found at the heart of our galaxy that are moving faster than two million km/hr; a new kind of variable star in the nuclear disk of the Milky Way that we named "dipping giants"; and the measurement of the age of the nuclear disk of the Milky Way using Mira variable stars.

Regarding my normal activities, I continued as the Director of the Institute of Astrophysics at Universidad Andres Bello in Chile, and was also appointed visiting researcher at the Department of Physics of the Universidade Federal de Santa Catarina, in Florianopolis, Brazil, where we collaborate closely with Prof. Roberto Saito (VOSS 2007). Among other activities, I gave public talks and a few interviews for the media (local TV, radio, newspapers, and social media), and also continued as

member of the PhD Board Committee in Astronomy, Astrophysics and Space Science for the Università Roma La Sapienza, Università Roma Tor Vergata and INAF, in Roma, Italy. I attended different international seminars, meetings and workshops, and gave a few invited talks, as listed elsewhere in this Annual Report.



Attendees of the workshop “The VISTA Variables in the Via Lactea Extended Survey (VVVX) Exploitation & Future Infrared Synoptic Science”, held October 9-13, included scientists from all over the world, including many alumni of recent Vatican Observatory Summer Schools.



Last year's scientific highlight was the long-awaited result from the LUX-ZEPLIN (LZ) experiment, which included an announcement of the most sensitive Dark Matter search ever performed. The paper describing this result ended up being "under review" for an entire year, because, not to mince words, our team made a mistake in the statistical treatment of the data.

Our mistake was mercifully caught by a reviewer of *Physical Review Letters*. The anonymous reviewer unearthed a subtle inaccuracy in our work, which we eventually tracked down to a minute inconsistency between two statistical papers discussing an identical algorithm (or

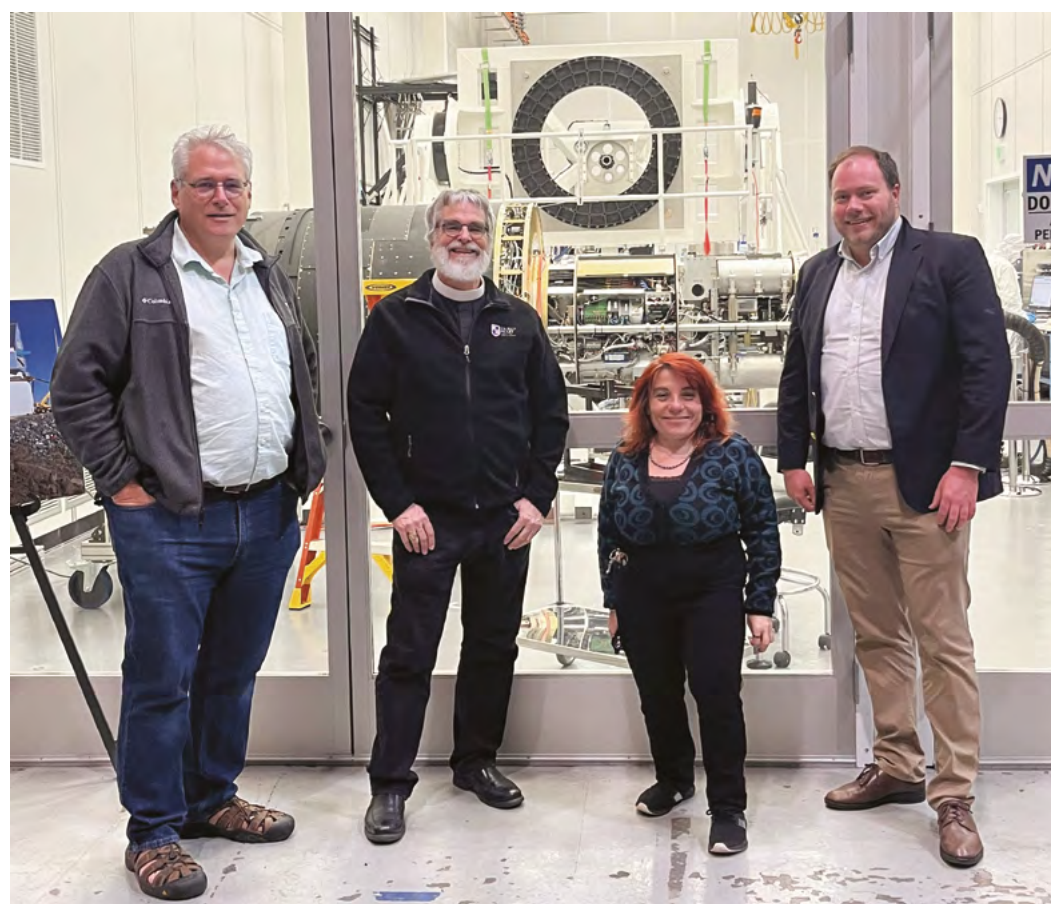
attempting to do so). Several months and three rounds of journal review led to a revised (needless to say, slightly worse) Dark Matter result, which became ready for a public announcement at the largest conference in our field, the UCLA Dark Matter symposium.

I was ultimately selected to present at that conference and announce to the whole field that "we made a mistake last year". Paradoxically, this would be one of the proudest moments in my career: yes, I had to admit that I and 250 of my colleagues had made a mistake; but crucially, I had the privilege of demonstrating, to a room full of experts, "how science really works". It is OK to make a mistake. It is OK if someone else points it out. It is OK to own our mistake publicly. This is how science advances. And the community of our colleagues is there to guarantee that we do, in fact, understand what we are doing and are confident in what we are claiming. I was delighted to learn that Br. Guy and Chris had been writing a book about "mistakes in science", while I had been living the firsthand experience of finding and solving one such mistake.

This year I attended two summer institutes: the Vatican Observatory Summer School (VOSS) in June, and the the SLAC Summer Institute (SSI) in August. Both schools were making their return to in-person instruction, and were devoted to Machine Learning. I lectured on Dark Matter and AI-based Anomaly Detection, and was delighted to meet two very enthusiastic and very energetic groups of students. In August, August, two of my students successfully defended their dissertations: Sojin Han (San Francisco State) and Tyler Anderson (Stanford). Finally, my project on Anomaly Detection was selected for funding by the Department of Energy, supporting my collaboration with the Stanford Institute for Computational and Mathematical Engineering and with the Data To Knowledge Lab at Rice University.

In 2023 I expanded my "science, faith and art" outreach. In March, I was a guest of the Italian Modernities Lecture Series at Stanford, where I discussed the works of one of my favorite poets, Eugenio Montale, with three

literature professors (I started my remarks with: "my only qualification to be on this panel is that I went to high school in Italy"). In June, I attended the conference of the Society of Catholic Scientists (SCS), where I learned that the nature of human beings and the origin of their desires are also, in a way, "Dark Matter" (we observe their effects but don't fully understand their origin and nature). In July, I gave a presentation about "the darkness of creation" to the monks of Holy Transfiguration (an Eastern Catholic monastery of Ukrainian Greek rite in California), during the visitation of their bishop Venedykt. In October, I attended the first Novitate Conference in Washington DC, where I presented a paper on the anthropology of desire of René Girard and Luigi Giussani. And in November, I participated in the "Faith and Science Week" hosted by SCS at the University of Notre Dame, and attended a Gold Mass on the feast of St. Albert the Great.



Aaron Roodman (Deputy Director of Rubin Construction for SLAC and Camera Program Lead), showing the LSST camera under construction to Br. Guy, Maria Elena and Chris Kennedy (VOF)



Among the Vatican Observatory Adjunct Scholars, I am one of the few who work with philosophy and theology. This is due to my primary job as full professor of Fundamental Theology in the Pontifical University of the Holy Cross in Rome, work that I try to put in living dialogue with scientific research. My dual expertise in theology and astronomy allows me to promote activities of interdisciplinary kinds, and to attend conferences which, more and more often, ask theologians and philosophers to face topics at the intersection of science and faith.

In September, for example, I was asked to participate as main lecturer in the XI Latin American Congress of Science and Religion, an international conference organized by the Catholic University of Salta (Argentina) and the Popular Autonomous University of the State of Puebla (Mexico). The subject was “End and finality of the universe: Scientists, philosophers and theologians in search of meaning.” The lecture I was entrusted to give was titled “End of the cosmos and fulfillment of history: reflections on the mutual implications between cosmology and theology.”

Another interdisciplinary activity I usually attend is the yearly Space Festival organized by the first Italian astronaut, Franco Malerba, in Busalla-Genova, in July. I gave a lecture on “Man’s place in the cosmos: Center or periphery?” For the past three years, together with Malerba, I have been organizing a competition for young researchers associated with the main subject matter of the Festival, this year “Moon and beyond”. The award ceremony was chaired by Anthea Comellini, the second Italian woman astronaut selected by NASA/ESA to fly in space, after Samantha Cristoforetti.

I commit much time to working with young graduate students and researchers at the Advanced International School for Interdisciplinary Research (SISRI, Italian acronym, sisri.it), a school I established in 2005. The School’s 2023 general workshop, held in May, was dedicated to the theme, “Goals of research and pursuit of the end: Interdisciplinary reflections on freedom”. I

am also happy to announce that in this year we started a new research project on creativity, a deep and intriguing topic at the intersection of technics, anthropology and philosophy. A first result was the publication of a special issue I edited for the journal of philosophy *Acta Philosophica*, entitled: “Creativity: artificial, animal and human intelligence.” I was also the editor of another special issue for the *Rivista Italiana di Filosofia del Linguaggio* (*Italian Journal of Philosophy of Language*), entitled “The interdisciplinary language of science, philosophy and religious studies.”

Among the events of 2023, one was a bit special for me. I was the recipient of the Expanded Reason Award, a €25,000 prize promoted by the Joseph Ratzinger Foundation and The University Francisco de Vitoria, Madrid. The prize was granted to the web platform for high schools, “DISF Educational” (disf.org/edu), that I directed and implemented in recent years. I was awarded the prize during a ceremony held in Vatican City State, chaired by Cardinal Luis Ladaria, former Prefect of the Congregation for the Doctrine of the Faith. This web platform scores about one million pages read every year. It includes many items on Christian faith and scientific culture. Some of its most read pages: “Does the big bang theory rule out the idea of creation?”; “How did life arise on Earth?”; “The environmental issue: what role can science and religions play?”; “Is the human being different from other animals?”; “Why did the Catholic Church condemn Galileo?”... and many others.

What will 2024 bring us? It will bring new scientific results, of course; but also the need, I guess, to continue to provide well-founded arguments to show the harmony between science and faith.



Card Luis Ladaria presents the Expanded Reason Award to Giuseppe Tanzella-Nitti, October 17, Vatican City State



2023 Space Festival Award.

From left to right: prof. Amalia Ercoli-Finzi, Filippo Tonti, Anthea Comellini, Camilla Reghin, Giuseppe Tanzella-Nitti

Learning the Universe

Data Science Tools for Astronomical Surveys

CHAPTER FOUR

SUMMER

SCHOOL 2023

The 18th Vatican Observatory Summer School (VOSS) took place this year from June 4 to June 30, restarting the VOSS following the Covid-19 pandemic.

Ever since our Summer Schools began in 1986, these (usually) biennial events have offered groups of twenty-five students from all over the world the opportunity to participate in a unique educational experience.

The Vatican Observatory Summer Schools differ from other schools by virtue of both their four-week duration and the close living and intense collaboration among the students, the school faculty, and the staff of the Observatory.

The topic was chosen by the Director of the Observatory, Guy Consolmagno, through a competition among four different groups of astronomers. Each group proposed a different topic for the school, and the chosen group became the VOSS 2023 faculty.

The winning topic for VOSS 2023, entrusted to the VOSS 2023 Dean, Alessandro Omizzolo, was “Learning the Universe: Data Science Tools for Astronomical Surveys”. Recent cosmological surveys, like the Gaia mission, have collected enormous amounts of data; with new instruments coming online, and with an ever-growing number of objects being observed, “Big Data” will likely become the norm in astronomy, and astronomers will need new ways to analyze these data sets.

Learning the Universe
Data Science Tools for Astronomical Surveys

18th Vatican Observatory Summer School
04-30 June 2023
Castel Gandolfo, Italy

Faculty
Viviana Acquaviva (Co-Chair)
CUNY / Flatiron Institute
Željko Ivezić (Co-Chair)
University of Washington / Rubin Observatory
Guy Consolmagno, S.J. (Director)
Vatican Observatory
Alessandro Omizzolo (Dean)
Vatican Observatory
Dalya Baron
Carnegie Observatories
Marc Huertas-Company
Instituto de Astrofísica de Canarias / Observatoire de Paris
Francisco Antonio Villaescusa Navarro
Flatiron Institute / Princeton University

As detectors become more sensitive, telescopes grow larger, and computers become ever more powerful, astronomical data has entered the petabyte domain. Major surveys have already measured billions of celestial sources; new surveys will produce astronomical catalogs of tens of billions of stars and galaxies, millions of AGN, and trillions of diverse precise measurements. We will explore the science behind these surveys, present the concepts of Big Data and Machine Learning, and provide a hands-on data analysis experience to enable students to use these data for their astronomical projects.

Scientific Organizing Committee (SOC)
Guy Consolmagno, director Vatican Observatory - Alessandro Omizzolo, Vatican Observatory & INAF-Padova - Stefano Cristiani, INAF-Trieste - Andrea Grazian, INAF-Padova - Viviana Acquaviva, CUNY/Flatiron Institute - Željko Ivezić, University of Washington / Rubin Observatory - Dalya Baron, Tel Aviv University / Carnegie Observatories - Marc Huertas-Company, Instituto de Astrofísica de Canarias / Observatoire de Paris - Francisco Antonio Villaescusa Navarro, Flatiron Institute / Princeton University

CONTACT: Guy Consolmagno, S.J. (Director)
Specola Vaticana
V-00120 Vatican City State - Rome, Italy
Tel.: +39 06 69885266 FAX: +39 06 69884671
e-mail: school@specola.va

Complete the application form at vaticanobservatory.va by **31 October 2022**

Modern astrophysics is enjoying a “golden age” in terms of the amount of data it has available — so much data that, not so long ago, fully exploiting its content would have required hours and hours of work. Today that data can be explored in less time, using modern software tools.

Thus the 2023 VOSS focused on learning the new data analysis techniques that computer science has developed, and applying them specifically to astrophysical research. A lot of computing power and a good knowledge of how

to use that power allows young astrophysicists to rapidly get the best out of large quantities of the most recent data.

The VOSS 2023 faculty consisted of some of the best experts in the world in this field: Viviana Acquaviva (Co-Chair, CUNY/Flatiron Institute), Željko Ivezić (Co-Chair, University of Washington, Rubin Observatory), Dalya Baron (Carnegie Observatories), Marc-Huertas Company (Instituto de Astrofísica de Canarias, Observatoire de Paris) and Francisco Antonio Villaescusa

Navarro (Flatiron Institute, Princeton University). These were joined during the school's sessions by other invited speakers from various universities and research institutes: Giorgio Calderone (INAF-Trieste), Christopher Corbally (Vatican Observatory), Stefano Cristiani (INAF-Trieste), Richard D'Souza (Vatican Observatory), Gabriele Gionti (Vatican Observatory), Andrea Grazian (INAF-

Padua), Adam Hincks (University of Toronto & Vatican Observatory), Robert Macke (Vatican Observatory), Enrique Marquez (Centro de Astrobiologia, Madrid), Maria Elena Monzani (SLAC National Accelerator Laboratory & Vatican Observatory), Dovi Poznanski (Tel Aviv University), Vernesa Smolicic (University of Zagreb).

The VOSS students were chosen from a pool of over two hundred applicants. The large number of applications made it easier to find, but harder to choose, graduate and advanced undergraduate students who best reflected the selection criteria: academic excellence, economic need, and a desire to work together and cultivate inclusive relationships. The students came from twenty different countries, from Australia to Canada, from China to Argentina. In addition, three young Jesuits with an advanced background in astronomy and physics joined the school; they came from Australia, China, and Congo.



This year's school featured days of intense work and experimentation on the main topics of the VOSS, but there were also times set aside for enrichment and leisure. There was a meeting with the ambassadors to the Holy See of the students' various countries of origin. There was a weekend in Arcetri and Florence, a visit to the monastery of Subiaco, a day at the beach and all the things that the students organized independently among themselves. There was to have been an audience with the Pope, but unfortunately this was cancelled owing to the health problems of Pope Francis, who instead wrote a letter to all the participants.

Many evenings featured shows organized by the students and dinners in which they prepared dishes from their countries of origin. The atmosphere at the Summer Schools has always been one that makes being and working together a positive experience.

While at VOSS, the students engaged in research projects proposed by the faculty. Students gave presentations about themselves, their places of origin, and their fields of research. They also produced group presentations about their VOSS research projects; in these, each student group illustrated how they had applied the knowledge they acquired at VOSS to their fields of research.

VOSS 2023 ended with a graduation ceremony and a final dinner. Once again the Summer School achieved its goals, both scientific and human. One of the school's participants, Rafael Bertolotto from Uruguay, won the McCarthy-Stoeger Fellowship to support his further studies at the Steward Observatory of the University of Arizona in Tucson. And all the students established bonds of collaboration and friendship among themselves and with the faculty and the Vatican Observatory that they will carry with them for the rest of their scientific careers, and even beyond.





*Message of His Holiness Pope Francis
to Participants in the Summer School of Astrophysics
of the Vatican Observatory*

Dear brothers and sisters,

I greet you all and offer you my cordial good wishes as you take part in the Vatican Observatory Summer School. I also express my gratitude to the distinguished faculty who are guiding you in this experience.

All of us are fascinated by the great discoveries about the universe that astronomers are offering us in these days. We are amazed at the marvelous images sent from the new James Webb space telescope, and once the Vera Rubin Observatory becomes operative we expect to see how the universe continues to expand and change before our eyes. Above all, we are struck by the vastness of the universe, its enormous extent and the astonishing number of galaxies, stars and planets that have been identified.

Over two millennia ago, the Psalmist wrote, “When I see the heavens, the work of your hands, the moon and the stars which you arranged, what is man that you should keep him in mind, mortal man that you care for him?” (Ps 8:5). The immensity of the universe has always been a source of wonder for humanity. Its sheer size can be overwhelming, even frightening. As young scholars at the dawn of the 21st century, you seek in the course of this Summer School to grasp something of that vast expanse and to develop methods capable of better digesting and understanding the constant flow of new data.



You are in the process, then, of acquiring tools that can help you understand the universe. Yet all of us know that, even with the best of tools, the quality of their results depends on the wisdom and expertise of those who employ them. In science and in philosophy alike, we can be tempted to obtain only those responses that we already expected, and not to let ourselves be surprised by new and unforeseen discoveries. My hope is that you will not remain content with the results of your research until you have also had the experience of being surprised. And even though you are looking at reality through the window of astronomy, be sure not to neglect the other windows that can show you other important realities, like compassion and love, realities that you are no doubt encountering also in the friendships that you are forming in these days.

Perhaps the most amazing thing about this universe is that it contains creatures like us, men and women who possess the ability to observe it with wonder and to “interrogate” it. Indeed, when the Psalmist asks, “What is man that you should keep him in mind, mortal man that you care for him”, he immediately goes on to say, “Yet you have made him little less than a God; with glory and honor you crowned him” (Ps 8:5-6).

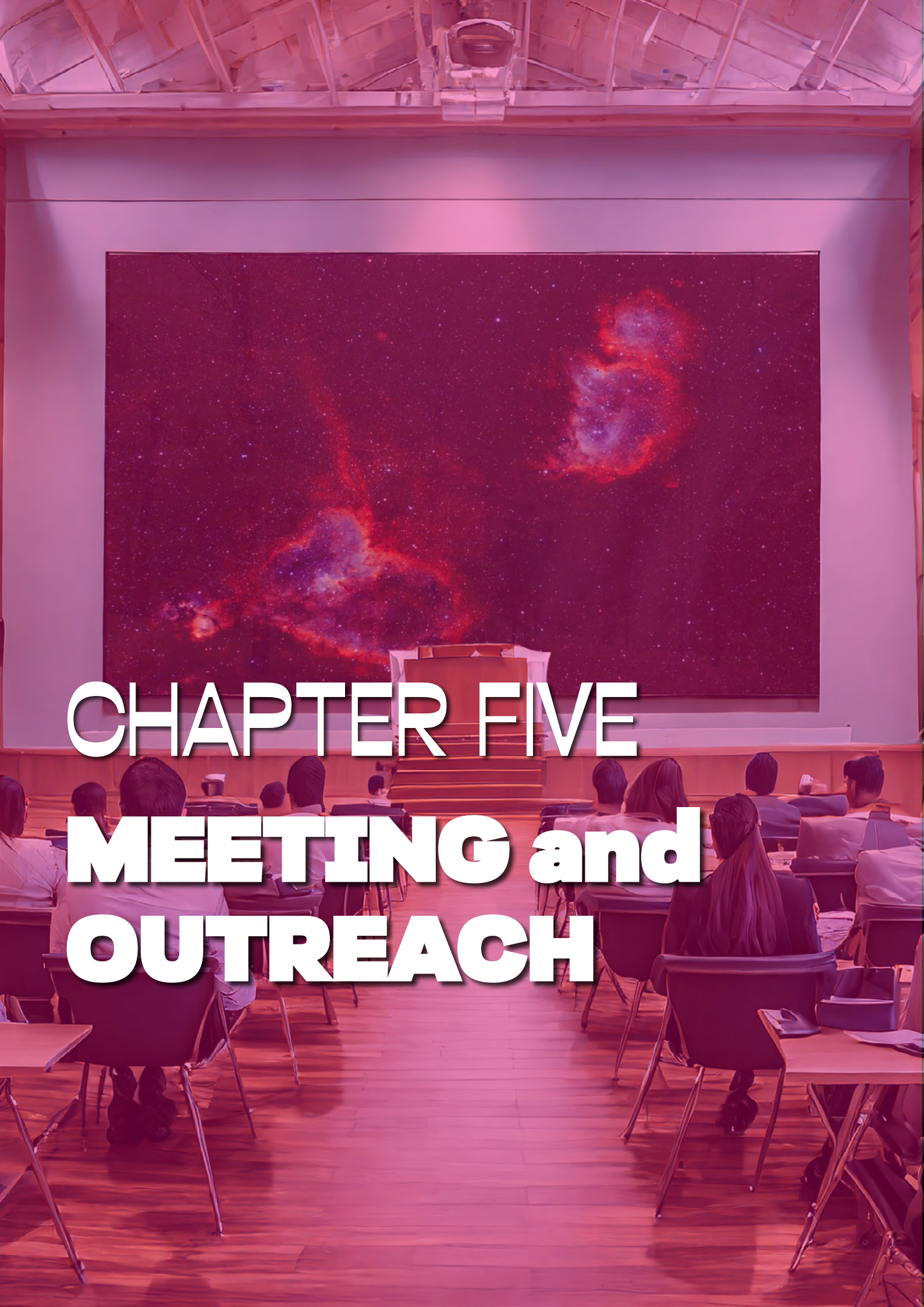
May you never lose this sense of wonder, in your research and in your lives. May you be inspired always by the love for truth and awestruck by all that each fragment of the universe sets before you.

I offer you my best wishes for pleasant and fruitful days of study and friendship. I cordially bless you in whatever paths your work leads you, and I ask you, please, to pray for me.

Rome, Gemelli Hospital, 15 June 2023

Francis





CHAPTER FIVE

MEETING and OUTREACH

SCIENTIFIC PRESENTATIONS and CONFERENCES

BROWN

- “The VVVX Survey: Exploration and Future Infrared Synoptic Science” conference at the Specola, October 9-13; presented “PEPSI Survey of TESS Stars in the NEP”, October 10.

CHINNICI

- Scientific Instrument Society Study Tour 2023, New England, USA, May 13-21.
- XLII Scientific Instrument Symposium, “*Through Ages, Cultures, Concepts: Instruments in Collections, Books, Archives*”, Palermo, September 18-22; presented “The Ramsden Circle: some iconographic representations” (poster, with M. Coniglio); presented “Observatories across the miles: how astronomers at Palermo and Greenwich worked together through the 19th century to share knowledge, data and instruments” (poster, with L. E. Devoy).
- Segundas Jornadas de Epistemología e Historia de la Astronomía, JEHA - II, Córdoba, Argentina, November 23-24; presented “The Carte du Ciel, an early global cooperation project” (talk, via zoom).

CONSOLMAGNO

- Annual meeting of the Astronomical League, Baton Rouge, LA, July 27-29; co-presented an invited talk with Dan M. Davis; panel discussion on science communication.
- Annual meeting of the Meteoritical Society, August 13-18, UCLA, Los Angeles, CA; presented a paper.

CORBALLY

- Vatican Observatory Summer School, Learning the Universe, in June; gave an invited talk on “ML and More in Stellar Spectral Classification”; also joined CONSOLMAGNO to talk about “George Coyne and the Vatican Observatory School”.

D’SOUZA

- FiatLux: Lighting up dark halos with galaxies, Castel Gandolfo, June 19-23.
- EAS Meeting, Krakow, July 10-14.
- SIC Symposium, Palermo, September 18-22.
- Gaia Unlimited Workshop, Torino, October 3-6.
- VVVX Survey Meeting, Castel Gandolfo, October 9-13.

GABOR

- Fourth assembly of the Alliance of Historic Observatories at Yerkes Observatory, October 5-7.
- EDEN collaboration workshop, March 2-3; gave a talk.
- AstroRob VII conference in Malaga (Spain), October 16-20; presented a poster on the VATT’s automation.

GALAVERNI

- “Cosmic Magnetism in Voids and Filaments” conference, Bologna, January 23-27.
- Cosmology meeting “UniVersum 2019”, Trento, February 1-3.
- Istituto Nazionale di Astrofisica – Istituto di Astrofisica e Planetologia Spaziali, Roma, March 29; presented “From the Astronomical Observatory of the Roman College (Collegio Romano) to the Vatican Observatory (Specola Vaticana)” (with Fr. Gabriele GIONTI).
- Vatican Observatory Summer School, “Learning the universe. Data science tools for astronomical surveys”, Castel Gandolfo, June 4-30.
- 18th Patras Workshop on Axions, WIMPs and WISPs, Rijeka, Croatia, July 3-7; presented “Birefringence in CMB anisotropies due to cosmological pseudoscalar fields”, July 3.
- 1st General Meeting of COST Action COSMIC WISPs, Bari, September 5-8; presented “Birefringence in CMB anisotropies”, September 5.

GIONTI

- FLAG (INFN) meeting, Department of Physics University of Bologna, December 21-22, 2022.
- “The search for Quantum Gravity, CDT and Friends, Jubilee edition” conference, Neijmegen (Netherlands), Radboud University, January 25-27.
- 18th Vatican Observatory Summer School; presented “A popular introduction to Quantum Gravity”, June 27.
- International School “Einstein equations and the dark side of the universe”, Mellerio-Rosmini College of Domodossola, Domodossola (Italy), July 17-21.
- “New Heavens and a New Earth: Scientific and Theological Eschatology” conference, Angelicum Thomistic Institute, Rome (Italy), March 10-11; presented “The Universe as described by the standard model of cosmology: from the Big-Bang to the end of the Universe”.
- “Quantum Gravity 2023” conference, Neijmegen (Netherlands), Radboud University, July 11-14; presented “On the canonical equivalence of Jordan and Einstein frames”.
- XXV SIGRAV Conference on General Relativity and Gravitational physics, SISSA Miramare Campus, Trieste, Italy, September 4-8; presented “On the canonical equivalence of Jordan and Einstein frames”.
- Presented “Jordan and Einstein frames”, Steward Observatory, The University of Arizona, Tucson, USA, October 4.

GRANEY

- “New Heavens and a New Earth: Scientific and Theological Eschatology” conference, Angelicum Thomistic Institute, Rome, March 10-11; presented “A New-Old Heaven and Earth: St. Thomas, Kepler, and the scientific reception of Copernicus” (invited talk), March 10, <https://www.youtube.com/watch?v=Y4uY3YsJWkw>.
- Seven Pines Symposium XXV, “Windows on the Universe: from Galileo to LIGO and beyond”, Stillwater, Minnesota, May 10-14; presented “A Cloudy Window: On early telescopes showing stars as disks, and why that matters” (invited talk), May 12.

- NASA-Goddard Sellers Exoplanet Environments Collaboration, Technosignature seminar series, September 27; presented “The Challenging History of Other Earths” (invited talk – online), https://seec.gsfc.nasa.gov/News_and_Events/technosignatureSeminars.html.
- “Fides et Ratio: Copernicus between Faith and Reason, Yesterday and Today” conference, Pontifical University of John Paul II, Kraków, Poland, November 7; presented “Copernicus and the Universe of Stars” (invited talk), <https://www.youtube.com/watch?v=crlK4mPWKXE&t=5945s>.

HELLER

- World Copernican Congress, Kraków, May 24-26; presented “Nicolaus Copernicus’ Theory of Relativity”, May 24.
- World Copernican Congress, Toruń, September 12-15; presented “Copernicus as a relativist”, September 15.
- International Conference “Copernicus: Between Faith and Reason, Yesterday and Today”, Kraków, November 7; presented “A Copernican Question in Theology: Does Theology Have to Be Geocentric?”
- Symposium “Faith and Reason”, Kraków, November 16; presented “Third crisis in the dialogue faith and reason”.

HINCKS

- 18th Vatican Observatory Summer School, Vatican Observatory; presented “How to Measure the Oldest Light in the Universe and What It Tells Us” (seminar talk), June 12.
- European Astronomical Society Annual Meeting, Kraków, Poland, July 10-14; presented “Measuring Point Source Variability in a Wide-Area Cosmic Microwave Background Survey”, July 13.

MINNITI

- Astrobiology Workshop, Universidad de Concepción, Concepción, Chile, January (online); presented “Caracterización de Planetas Errantes” (invited talk).
- ESO Workshop “Peer Review Under Review”, Garching, Germany, February (online).
- CAPOS Workshop, Universidad de Concepcion, Concepcion, Chile, February 7 (online).
- IAU Symposium 377 on “Early Disk Galaxy Formation: From JWST to the Milky Way”, Kuala Lumpur, Malaysia, February (virtual); presented “The Galactic Extinction Horizon with Present and Future Surveys”.
- SOCHIAS Annual Meeting, Temuco, March; presented “Amazing secrets to succeed in Astronomy” (invited talk).
- VVV Grad Student Workshop (Organizer and speaker), UNAB, Santiago, March.
- ESO Workshop, “Coordinated Surveys of the Southern Sky”, Garching, Germany, March (online).
- Presented “Rediscovering the Milky Way: New Galactic Globular Clusters” (invited seminar), Department of Physics, Universidade Federal de Santa Catarina, Florianopolis, Brazil, June.
- Chilean CCAT Workshop, Santiago, Chile, September (online); presented “CCAT-VVVX Synergy” (invited talk).
- 65th Annual Meeting of the Asociacion Argentina de Astronomia, San Juan, Argentina, September; presented “Rediscovering the Milky Way” (invited talk).
- ESO Workshop “Wide field imaging surveys”, ESO Garching, Germany, October; presented “What Is This? WIT Objects and Other VVVX Survey Discoveries”.
- “The VVVX Survey Exploitation & Future Infrared Synoptic Science” workshop, Vatican Observatory, Vatican City State, October; presented “The Galactic Extinction Horizon”.
- Annual Editor’s Meeting Astronomy & Astrophysics, Observatorio Astronómico Nacional, Madrid, Spain, October (online).

- XXIII Congreso Internacional de Astronomos Aficionados, Santo Domingo, Chile, November; presented “What is this? New Discoveries in the Milky Way” (invited talk).
- XVII Latin American Regional IAU Meeting, Montevideo, Uruguay, November; presented “What is this? WIT objects and serendipity in the VVV/VVVX survey”.
- Extragalactic Meeting on 60 Years of Sersic’s Law, Observatorio de Cordoba, Cordoba, Argentina, December; presented “But we do not know anything about the Milky Way” (invited talk).

MONZANI

- Presented “Direct Dark Matter Detection with the LUX-ZEPLIN Experiment”, Physics Colloquium, the University of California at Santa Cruz, February 1.
- New York Encounter: “Who am I that you care for me?”, New York, February 17-19; moderated “For me?!? A presentation on the James Webb Telescope”, with Stefanie Milam and Massimo Robberto, February 18.
- Women in Data Science (WiDS) conference, Stanford University, March 8; presented “A Sparkle in the Dark: The Outlandish Quest for Dark Matter”, (science keynote).
- 2023 UCLA Dark Matter Symposium and XLZD Consortium Meeting, University of California Los Angeles, March 29 – April 5; presented “Dark Matter search results from the LUX-ZEPLIN (LZ) Experiment” (plenary talk), March 31.
- Third NSDF All-Hands Meeting, University of California San Diego, April 11-13; presented “Data-Intensive search for Dark Matter with the LUX-ZEPLIN experiment” (keynote talk), April 12.
- 26th International Conference on Computing in High Energy and Nuclear Physics (CHEP), Jefferson Lab, Norfolk, Virginia, May 9-12; presented “Data-Intensive search for Dark Matter with LUX-ZEPLIN” (invited plenary talk), May 11.
- Sixth Annual Conference of the Society of Catholic Scientists (SCS), Seton Hall University, South Orange, New Jersey, June 2-4; presented “A Sparkle in the Dark: The Outlandish Quest for Dark Matter”, June 3.

- Vatican Observatory Summer School (VOSS): Learning the Universe, Data Science Tools for Astronomical Surveys, Castelgandolfo, Vatican City State, June 9-30.
- 51st SLAC Summer Institute: Machine Learning across the Frontiers, SLAC National Accelerator Laboratory, California, August 7-18; presented “Anomaly Detection Applications II” (invited lecture), August 14.
- KIPAC Astrophysics Colloquium at Stanford (joint Colloquium with Tianji Cai and Kazu Terao), November 9; presented “Anomaly Detection For Rare Event Searches”.
- Physics & Astronomy Colloquium, University of Notre Dame (South Bend, Indiana), November 15; presented “A sparkle in the dark: data intensive searches for Dark Matter with LUX-ZEPLIN”.

TANZELLA-NITTI

- Department of Physics of the University of Rome Tor Vergata and the INFN (National Institute of Nuclear Physics) conference, January 9; presented “Life in the cosmos: a Theological Perspective”.

VISITS to OTHER INSTITUTIONS

BROWN

- Fordham University, New York, to confer with Fr. John Cunningham, S.J. with regard to a mutual project using the Vatican’s Lennon Telescope (VATT), March 27-29.
- Leibniz Institute for Astrophysics in Potsdam, Germany, to confer about next steps next step in PEPSI project, September 25-29.

GABOR

- Took part in the 40th Ebicycle, a 7-day, 350-mile cycling tour of observatories and astronomical sites, each year alternately in Bohemia, Moravia, and Slovakia, July 17-25. This was the 13th time joining the group of 50 professional and amateur astronomers for the event.

- Visited the observatory and planetarium in Ždánice (in Moravia, the eastern third of the Czech Republic).
- In connection with the work of the VATT Imager Science Advisory Committee, visited Spectral Instruments (November 23, 2022) and Teledyne Photometrics (November 3, 2023), both in Tucson.
- In connection with VATT’s automation, visited Projectsoft in Hradec Kralove, Czech Republic (August 2-3 and September 20).
- Visited the Ondřejov Observatory of the Astronomical Institute of the Academy of Sciences of the Czech Republic, August 7.

GRANEY

- Angelicum Thomistic Institute, Rome, March 10-11.
- Pontifical University of John Paul II, Kraków (Poland), November 7.

HINCKS

- Specola Vaticana, April 20 – June 13 (with a couple of periods away on other trips).

MACKE

- University of Arizona Lunar and Planetary Laboratory (January-March and September onward) for OSIRIS-REx.
- NASA Johnson Space Center (Houston, TX) for OSIRIS-REx (March and October/November).

AWARDS and GRANTS

HELLER

- “Ratio et Spes”, Prize of the Ratzinger Foundation and University of Toruń, November 13.

MONZANI

- *Reaching a New Energy Sciences Workforce*, DOE Office of Science, High Energy Physics (HEP).
- *Artificial Intelligence Research in High Energy Physics*, DOE Office of Science, HEP Computing.
- *Facility Operations Support to LUX-ZEPLIN*, DOE Office of Science, HEP Cosmic Frontier.
- *Laboratory Directed Research and Development*, SLAC National Accelerator Laboratory.
- *Machine Learning and Artificial Intelligence Research*, DOE HEP, Cosmic Frontier via SLAC.
- *Mission Science allocation to LZ*, National Energy Research Scientific Computing Center.

BOARDS and SERVICE

BROWN

- Serving on the board of the Vatican Observatory Foundation in the capacity as Treasurer. Member of the Development Committee and the Finance Committee. Previously served on the Board of Advisors.

CONSOLMAGNO

- Science Advisory Board, SETI Institute
- Member, IAU Working Group on Planetary System nomenclature; chair, Mars Task Group
- Vice President, Meteoritical Society and various ex-officio boards of that society

FRANCL-DONNAY

- Board, Institute for Religion and Science.
- Chair, Parish Council of Our Mother of Good Counsel Parish.
- Board, University of California, Irvine Graduate Alumni.

GABOR

- Elected to serve on the board of the Alliance of Historic Observatories.

GRANEY

- Co-Chair, Archdiocese of Louisville Faith and Science Dialogue Group.
- Board Member, Louisville chapter of the Society of Catholic Scientists.

HINCKS

- Governing Council, Regis College, Toronto.
- Literary Trustee, Estate of Bernard Lonergan.
- Membership Committee (chair), Simons Observatory Collaboration.
- Board Member, Toronto chapter of the Society of Catholic Scientists.

- Committees in the Dept. of Astronomy & Astrophysics, University of Toronto: Colloquium Committee (chair starting in July); Community Climate Committee (chair starting in July); Academic Appeals Committee.

MINNITI

- Scientific Organizing Committee, IAU Symposium 377 on “Early Disk Galaxy Formation: From JWST to the Milky Way”.
- Scientific Organizing Committee, ESO Workshop “Wide field imaging surveys”.
- Scientific Organizing Committee, Vatican Observatory Workshop on “The VVVX Survey Exploitation & Future Infrared Synoptic Science”.

PUBLIC PRESENTATIONS

BROWN

- “*Relación entre ciencia y cristianismo*”, Pontifical Catholic University of Puerto Rico in Ponce, Puerto Rico, February 17, at congress “The Christian Proposal in the Face of the Challenges of a Changing World”.
- “The Chemical Elements and Cosmic Order” (with Heather Foucault-Camm) as part of the The St. Albert Initiative on Science and the Catholic Faith, sponsored by The Society Of Catholic Scientists, The McGrath Institute for Church Life and The Collegium Institute, for Catholic schools of the Archdiocese of Philadelphia, at St. Joseph’s Preparatory School, Philadelphia, PA, March 25.
- Day of reflection to the major theologians at Kenrick-Glennon Seminary, St. Louis, MO, April 19.
- Talk for the 8th grade class at Santa Cruz middle school in Tucson, AZ on May 1.
- Commencement address at Regina Coeli Hybrid School at Corpus Christi Parish in Phoenix, AZ, May 13.
- Led a retreat at Cloisters-on-the-Platte retreat house in Gretna, NE, November 30 - December 3.

CHINNICI

- “I libri raccontano ... la scoperta di Cerere Ferdinanda”, Palermo, Museo Pitre (for “Il maggio dei libri 2023”), May 30.
- “Scientific cooperation and international diplomacy: the role of the astronomical community from the 19th century to the First World War”, INAF Osservatorio Astronomico di Roma, Monte Porzio Catone (RM), (for *Under the same sky*, invited by the ’Hellenic Institute of Cultural Diplomacy in Rome), November 10.

CONSOLMAGNO

- Conducted the monthly Full Moon Meetups for the Vatican Observatory Foundation and numerous on-line presentations to institutions from California to India.
- UK, February 5 - 12: Two presentations at Heriot-Watt University, one at St. Andrews University, one at Stonyhurst College, one at St Mary’s Church, Hampstead (also an online presentation to India).
- Midwest US, March 8 - 12: Talks at Lyon College, Batesville, AR; Chicago Theological Union, Chicago.
- Northern California: Presented a retreat at the El Retiro Jesuit Retreat Center, Los Altos, March 17 - 19; three presentations at Stanford/SLAC, March 20-21; talk at St. Ignatius Church, San Francisco, March 23.
- Montreal, Canada: Three presentations at McGill University, March 26-27.
- Boston, MA: Talk at MIT, April 3.
- Milwaukee, WI: Annual Coyne Lecture, Marquette University, April 12.
- Minnesota: Eight presentations at the Bell Museum, St. Thomas University, the University of Minnesota main campus, the University of Minnesota Duluth, and the College of St. Scholastica, April 14-20.
- Seattle, WA: Presentation at St. Joseph’s School, April 24.
- Rome, presentation at the Biblioteca dell’Accademia dei XL, June 8.
- Brooklyn, NY; presentation at the Fontbonne Hall Academy, July 25.
- Lake Tahoe, CA: presentation at the UC Davis Tahoe Environmental Research Center, August 10.

- Los Angeles, CA: two presentations, August 26-27.
- Los Altos, CA: two presentations, September 6.
- Phoenix, AZ: presentation, September 21.
- Honolulu, HI: Chaminade University of Honolulu, two presentations, October 6-8.
- Eastern US: Presentations at Canisius University, Buffalo, October 23; Providence (RI) College, October 25-26; University of Massachusetts Dartmouth, October 27; Deerfield Academy, MA, October 29-30; North Shore Synagogue, Syosset, NY, November 1; St. Joseph University, Philadelphia, November 2; Georgetown University, November 3; St. Edmund’s Retreat Center, Enders Island, CT, November 5.

CORBALLY

- “Machine Learning and More in Stellar Spectral Classification”, East Valley Astronomy Club, Phoenix, April, and Sonora Astronomical Society, Green Valley, September.
- “Stellar Spectral Classification and the Discovery of Astrophysically Interesting Stars”, with Richard Gray, Appalachian State University, Loughton Astronomical Society, England, October (online).
- “Cosmic Expansion”, Sabbatical Groups at the Redemptorist Renewal Center, Tucson, April and November.
- “What was the Star of Bethlehem?”, Marian Club, St. Thomas the Apostle parish, Tucson, November.

FRANCL-DONNAY

- “Extravagant un-busyness”, Saint Genevieve Parish, December 2022.
- “In The Beginning was the Word”, IHM Conference Center, January.
- “The Way of Love”, Holy Cross Parish, March.
- “Impractically Practical: Are Scientists Mystics?”, Thomas Paine Unitarian Church, March.
- Theology on Tap, Holy Cross Parish, April.
- “Women in Science: Opportunities for the Future”, American Philosophical Society, October.
- “The Psalms”, Our Mother of Good Counsel Parish, October.

GABOR

- Taught a tier II general education course on the history and philosophy astronomy, ASTR 320, in the Fall semester at the University of Arizona.
- Presented a paper on Joseph Stepling and the Theresian Enlightenment at a September 21-23 conference celebrating the 400th anniversary of the Province of Bohemia of the Society of Jesus.
- Gave talks at two Rotary Clubs: in Tucson at Westin La Paloma, March 7; in Green Valley, September 12.
- Gave a public lecture at the Malaga Academy of Sciences, October 19.
- Gave talks in Ždánice, Vsetín, Zlín, Ždánice (again), and Čakovice (Czechia).

GALAVERNI

- “P. Giuseppe Lais, C.O. Dall’Osservatorio del Collegio Romano alla Specola Vaticana” (with Fr. Giuseppe KOCH), Santa Maria in Vallicella, February 7.
- “Faith and Science” at the Università Cattolica, Piacenza, March 1.
- “L’amor che move il sole e le altre stelle. Breve viaggio nell’universo”, Santa Margherita Ligure, July 18.
- “Problemi aperti in cosmologia: cosa (non) sappiamo. Il modello cosmologico attuale e le principali domande aperte”, Università La Sapienza, Roma, November 23.

GIONTI

- “The Beginning and the end of the Universe between Science and Faith”, C.I.R.A. (Italian Center for Aerospace Research), Capua, Italy, March 30.
- “The Beginning and the end of the universe”, online seminar, Master in Science and faith, University Regina Apostolorum, Rome, May 9.
- “The scientific work at the Vatican Observatory”, Vanvitelli University-Department of Aeronautical engineering, Aversa, Italy, May 24.
- “The History of the Specola Vaticana (Vatican Observatory)” with Matteo GALAVERNI, IAPS, Frascati, Italy, April 29.
- “The Beginning and the end of the universe”, St Lorenz, Piglio, Italy, May 27.

- “The scientific work at the Vatican Observatory”, Italian Embassy to the Holy See, Rome, June 5.
- “The Big-Bang and the question of God”, San Louis Jesuit Parish, Naples, June 21.
- “The Big-Bang between science and theology”, Domoschool (2023), Domdossola, Italy, July 18.
- “A Journey in the Universe”, S. Lucy convent of the Clarisse Sister of the S. Lucy convent, Foligno, Italy, November 5.

GRANEY

- “Jesuits in a Spin: Society of Jesus, Rotation of the Earth and the Coriolis Effect” (invited talk), ITESO, Universidad Jesuita de Guadalajara, October 24, <https://www.youtube.com/watch?v=wcLsQnZ8O5k>.
- “Jesuit Astronomers, the New Telescope, and the Moon” (invited talk), ITESO, Universidad Jesuita de Guadalajara, October 25.
- “Jesuit Astronomers, the New Telescope, and Jupiter” (invited talk), ITESO, Universidad Jesuita de Guadalajara, October 26.
- “Kentucky’s Oldest Telescope: Born and Bred in Louisville”, four presentations in spring-autumn at the University of Louisville (Kentucky, USA) Public Astronomy Lectures, the Louisville Astronomical Society, Bellarmine University (Louisville), and St. Gregory Church (Samuels, Kentucky).
- “Monsignor Michael Bouchet and His Telescope” (with Tim Tomes, Archivist, Archdiocese of Louisville), Louisville, Kentucky, November 28.

HELLER

- Panel discussion, Literary Festival of Olga Tokarczuk “Góry Literary”, Sarna Castle, Ścinawka Górna (July 5-10), July 9.

HINCKS

- “The Jesuits, Astronomy and the Vatican Observatory” (presented remotely), St. Mary Student Parish, Catholic Campus Ministry at the University of Michigan, February 24.
- “Does a Fine-tuned Universe Tell Us Anything About God?” (invited lecture), University of St. Michael’s College, Toronto, March 2.
- “The Big Bang *Ex Nihilo*?” (keynote talk), conference on Science and Divine Action, St. Patrick’s Pontifical University, Maynooth, Ireland, April 18.
- “Revealing the Cosmic Web with CMB Data”, seminar talk, Dept. of Physics, University of Rome ‘Tor Vergata’, May 25.
- “Entering Their Door and Leaving by Ours: Reclaiming Secularity in the Intellectual Apostolate”, Conference on Jesuit Scholarship in a Secular Age, Loyola University, Chicago, September 1.
- “The Big Bang *Ex Nihilo*?”, Catholic Chaplaincy at the University of Toronto Mississauga, November 9.

KIKWAYA ELUO

- Talk to Jesuit scholastics, August 29, Universite Loyola du Congo (ULC), Kimwenza, Kinshasa, Democratic Republic of Congo.
- Talk to Jesuit high school students, September 5, College Boboto, Gombe, Kinshasa, Democratic Republic of Congo.
- Talk to Jesuit high school students, September 8, College Bonsomi, N’djili, Kinshasa, Democratic Republic of Congo.
- Talk to Sisters of Sacred Heart (Tertians), October 5, Castel Gandolfo, Rome, Italy.

MACKE

- Space Science Club, Regis High School, Denver, Colorado (telepresence), October 31.
- “Meteorites in the Vatican” Astronomical League of the Philippines, Manila, Philippines (telepresence), June 24.

MONZANI

- “Impazzito di luce: A Discussion of Poems by Eugenio Montale”, panel discussion with Robert Harrison, Thomas Harrison and Laura Wittman, Italian Modernities Lecture Series, Stanford University, February 28.
- “Shining Light on Dark Matter with the LUX-ZEPLIN Experiment”, Bishop O’Connell High School, Arlington VA, March 16.
- “Shining Light on Dark Matter with the LUX-ZEPLIN Experiment”, De Marillac Academy (4th through 8th grade), San Francisco, April 24.
- “A Sparkle in the Dark: The Outlandish Quest for Dark Matter”, the Holy Transfiguration Monastery at Mount Tabor, July 23.
- “Beyond Deceit: René Girard and Luigi Giussani on the Meaning of Desire”, panel discussion with Tyler Graham and Thomas Deutsch, moderated by Brandon Vaidyanthan, Novitate Conference, the Catholic University of America, November 3.

TANZELLA-NITTI

- “The problem of the ‘Two Cultures’ and the humanistic dimensions of scientific activity,” Pavia, January 19.
- “Ruggiero Boscovich and the commitment of Jesuits to science,” Rome, November 18, on occasion of the publication of the book by Angelo Gallippi, “R. Boscovich, the Astronomer-Poet” (Venice: Marcianum Press, 2023), to which I contributed a Foreword.

MEDIA EXPOSURE

BROWN

- Participated in a podcast about faith and science with Loyola Press, the series being called “Catequesis Para el Camino”, July 26.

CONSOLMAGNO

- Interviewed for *Life and Work*, the magazine of the Church of Scotland, and Radio Maria in London (while in the UK in February).
- Interviewed with MACKE for an article that appeared in the Toledo *Blade* on March 26.
- Interview published in *La Repubblica* (in Italian) on July 19.
- Interviewed for an article that appeared in *Figaro Magazine* (in French) on August 12.
- Interviewed by *The Irish Catholic* regarding the OSIRIS-Rex mission, published September 28.
- Interview for the Italian magazine *Tempe* in October.

CORBALLY

- Answered questions for “Vatican’s telescope in Southern Arizona charting the stars for 30 years”, an article in the Diocese of Tucson’s New Outlook (October 24), written by Carissa Krautscheid, <https://news.diocesetucson.org/news/vaticans-telescope-in-southern-arizona-charting-the-stars-for-30-years>.

D’SOUZA

- Ken Croswell, “The Drama Next Door [on the Andromeda galaxy’s history of mergers]”, *Sky and Telescope*, December.

FRANCL-DONNAY

- “The Memory of Chemistry” by Sabrina Vourvoulias in Fantasy Magazine, October, <https://www.fantasy-magazine.com/fm/fiction/the-memory-of-chemistry/>.
- *National Geographic* and *Smithsonian* on the use of castoreum to flavor food, November.

GABOR

- Interviewed by Pat Parris of the Tucson local TV station KGUN9 on December 8, 2022, <https://www.kgun9.com/absolutely-az/why-the-popes-telescope-is-in-southern-arizona>. This served as the basis for an *Absolutely Arizona* piece on the Vatican Observatory broadcast in December 2022, as well as, much later, a piece announcing the VATT’s 30th anniversary events.
- Interviewed by Tim Robertson, made available as an *Observers Notebook* podcast from May 15.
- Interviewed by Adam Šindelář, broadcast by the Czech Radio on October 15 (*Vertikála*).

GALAVERNI

Vatican Radio program “Indovina chi viene a Pranzo”, aired on February 6.

GIONTI

- Interviewed by Channel 5 of Chile National television, for the Rebus program, RAI 3, on May 3.
- Interviewed on June 22 by Stefano Girotti Zirotti, RAI Vaticano, for a documentary broadcasted on August 25 on the 2025 Jubilee.
- Interviewed on April 27 by the journalist Guyonne De Montjou for the newspaper Le Figarò.
- Interviewed by Silvia Caracciolo of TV France, October 24.

GRANEY

- Interviewed by CNA for “Catholic astronomers: Newly discovered planet a testament to Earth’s ‘startling uniqueness’”, Peter Pinedo, January 19, <https://www.catholicnewsagency.com/news/253397/catholic-astronomers-newly-discovered-planet-a-testament-to-earth-s-startling-uniqueness>.
- Interviewed by Ruby Thomas of *The Record* (Archdiocese of Louisville, Kentucky, USA) for “Opportunity to stargaze through a 150-year-old telescope”, September 9, <https://therecordnewspaper.org/opportunity-to-stargaze-through-a-150-year-old-telescope/>, pertaining to the Archdiocese’s Msgr. Michael Bouchet telescope (a 100-cm refractor), which I restored to functionality this year and which

Archdiocesan Archivist Tim Tomes and I took to various locations within the Archdiocese for public observations.

- Interviewed on EWTN regarding newly-discovered Fr. Georges Lemaître video, February 9, <https://youtu.be/iZDkDnmPkoc?t=657>.
- Interviewed on EWTN regarding Vatican Observatory Summer School and Coriolis Effect research, June 1, <https://www.youtube.com/watch?v=wDo56pPVOL8>.
- Montserrat Muñoz, “Jesuitas, ávidos astrónomos”, Noticias: ITESO, Universidad Jesuita de Guadalajara, October 30, https://www.iteso.mx/en/web/general/detalle?group_id=2664210.
- Other media exposure through various VO press releases produced as part of my job as Press Officer (Vatican Observatory Foundation).

HINCKS

- Interview on *Tapestry*, a national radio program on the Canadian Broadcasting Corporation: Mary Hines, “Jesuits in Space”, January 20, <https://www.cbc.ca/player/play/2163762243702>.
- Interview on Cosmos From Your Couch, Dunlap Institute: “Can Religion and Astronomy Coexist?”, January 25, https://www.youtube.com/watch?v=dJSji_g2Iuc.
- Interviewed for news story by the Toronto Star: Kevin Jiang, “Scientists create the most detailed map of dark matter yet, confirming Einstein’s theory of general relativity”, April 11, <https://tinyurl.com/2xn4yx6y>.
- Interviewed for news story by the National Post: Joseph Brean, “Most of the universe is invisible dark matter. Scientists used the glow of the Big Bang to map it”, April 11, <https://nationalpost.com/news/world/atacama-cosmology-telescope-big-bang-dark-matter-map>.
- Interviewed for news story by Faculty of Arts & Science, University of Toronto: “Astronomers release the most detailed map of matter in the cosmos, confirming Einstein’s theory of general relativity”, April 11, <https://tinyurl.com/yzevxx3k>.
- Interviewed and featured in Toronto Life: Caitlin Walsh Miller, “‘There’s always more to understand about the universe’: Meet the U ofT scientist

working on a cutting-edge map of dark matter”, April 21, <https://tinyurl.com/43kkb9rk>.

KIKWAYA ELUO

- Anastasia Makunu, “African Jesuits in Science at the Service of the Mission of Christ, 2022”, JCAM (Jesuit Conference Africa Madagascar), Annual Review 2022.
- Elisabetta Povoledo, “Centuries of Stargazing Leave Jesuit Names Written in the Heavens”, *The New York Times*, March 22.
- Mary Lim, “Priest and Scientist Fr. Jean-Baptiste celebrates 25th Jubilee”, *New Outlook*, Diocese of Tucson, June 13.

MACKE

- Interview with David Maciejewski for *El Español* regarding my roles in the Vatican Observatory and the OSIRIS-REx mission.
- Interview on *AMDG* Podcast, hosted by Eric Clayton SJ.
- Javier Martinez-Brocal, “El astrónomo del Vaticano que ayuda a la NASA en la misión Osiris-Rex”, *ABC* (Spain) September 25.
- Peter Pinedo, “Meet the Vatican scientist helping NASA on a historic space mission”, *Catholic News Agency*, September 28.
- Interview on *Quirks & Quarks*, hosted by Bob McDonald; Canadian Broadcasting Company Radio 1, September 23.
- Elisha Sauers, “NASA needed help with a mission. The Vatican came to the rescue”, *Mashable.com*, September 16.
- Carol Glatz, “Vatican Astronomer Macke helps in historic mission to study asteroid.” *Catholic News Service*, September 19.
- Alfredo Carpineti, “This Week a Piece of The Most Dangerous Asteroid Will Land in America”, *IFLScience*, September 19.
- Alfredo Carpineti, “The Countdown to OSIRIS-REx” (YouTube video), *IFLScience*, September 19.
- Alfredo Carpineti, “OSIRIS-REx Mission Success!” (YouTube video), *IFLScience*, September 24.
- Sarah Readdan, “Creator of the Heavens, Faith and science go hand in hand, according to 2 Vatican

astronomers with regional ties”, *The Blade* (Toledo OH), March 26.

- Sarah Readdan, “Vatican supports science” *The Blade* online edition (Toledo OH), March 26.
- Interview on *The Turley Frequency*, hosted by Kevin Turley; Archangel Radio (Mobile AL), March 13.

Macke MakerSpace videos (YouTube):

- * *OSIRIS-Rex Pycnometer Installed at NASA and Ready for Science!* October 28
- * *Zero-Knowledge Clock Part I*, August 21
- * *Lighted Display Shelves for my MakerSpace*, June 20
- * *Metal Earth Time Lapse of Notre Dame de Paris*, May 20
- * *OSIRIS-REx Pycnometer at NASA Johnson Space Center for SA-SOPIE3*, April 21
- * *Ten Rings to Rule Them All – Mash-Up of Shang-Chi and the Lord of the Rings*, March 13
- * *Observatory on a Church – Secchi’s Observatory on the Church of St Ignatius – Full Build*, February 13
- * *Pycnometer for OSIRIS-REx Revisited*, January 16

TANZELLA-NITTI

Interview “Why Theology Should Take Science Seriously? A Conversation with Fr. Giuseppe Tanzella-Nitti,” by John W. Farrell, published on *Commonweal Magazine*, on March 27, 2023, on occasion of the publication of Tanzella-Nitti’s volume *Scientific Perspectives in Fundamental Theology. Understanding Christian Faith in the Age of Scientific Reason* (Claremont CA: Claremont Press, 2022); the interview was also reprinted on April 5, 2023 on *La Croix International*.

VATICAN OBSERVATORY
ON-LINE MEDIA EXPOSURE

- “Why is the Pope’s telescope in the United States and not in the Vatican?”, *EWTN*, December 12, 2022, <https://www.ewtnvatican.com/articles/why-is-the-popes-telescope-in-the-united-states-and-not-in-the-vatican-248>.
- Jonah McKeown, “Newly-discovered asteroids named after Jesuits — and a pope”, *CNA*, February 21, 2023, <https://www.catholicnewsagency.com/news/253705/newly-discovered-asteroids-named-after-jesuits-and-a-pope>.

- Patrick Hudson, “New asteroids named for Jesuits and a Pope”, *The Tablet*, February 25, 2023, <https://www.thetablet.co.uk/news/16699/new-asteroids-named-for-jesuits-and-a-pope>.
- Carol Glatz, “New asteroids named for pope who led calendar reform, Jesuit astronomers”, *USCCB News*, February 28, 2023, <https://www.usccb.org/news/2023/new-asteroids-named-pope-who-led-calendar-reform-jesuit-astronomers>.
- “Asteroidea Janusz, dotąd znana jako 565184. Nazwę dostała na cześć polskiego naukowca jezuitę”, *TVN24*, February 28, 2023, <https://tvn24.pl/tvnmeteo/nauka/asteroidea-janusz-dotad-znana-jako-565184-nazwe-dostala-na-czesc-polskiego-naukowca-jezuity-st6785061>.
- Tiziana Campisi, “New asteroids named after three Jesuits and a Pope”, *Vatican News*, March 1, 2023, <https://www.vaticannews.va/en/church/news/2023-03/new-asteroids-named-after-three-jesuits-pope.html>.
- “Searching for new worlds using Vatican telescope”, *Vatican News*, March 21, 2023, <https://www.vaticannews.va/en/vatican-city/news/2023-03/specola-vaticana-vatican-observatory-foundation-planet-telescope.html> (on the VO and the Institute for Astrophysics Potsdam survey bright stars suspected to host exoplanets).
- Elisabetta Povoledo, “Centuries of Stargazing Leave Jesuit Names Written in the Heavens”, *New York Times* (online), March 22, 2023, <https://www.nytimes.com/2023/03/22/world/europe/asteroid-names-jesuits.html>; *New York Times* (print), March 24, 2023, A1.
- Barb Umberger, “Director of Vatican Observatory: Astronomy research ‘an act of prayer because it’s a place where I encounter God’”, *The Catholic Spirit*, April 18, 2023, <https://thecatholicspirit.com/news/local-news/director-of-vatican-observatory-astronomy-research-an-act-of-prayer-because-its-a-place-where-i-encounter-god/>.
- “Vatican Observatory launches immersive virtual tour”, *l’Osservatore Romano*, May 19, 2023, <https://www.osservatoreromano.va/en/news/2023-05/ing-020/vatican-observatory-launches-immersive-virtual-tour.html>.
- “Interview: Through the Eyes of Vatican Observatory: Where Science meets Faith”, *Indian Catholic Matters*, May 28, 2023, <https://www.indiancatholicmatters.org/>

[interview-through-the-eyes-of-vatican-observatory-where-science-meets-faith/](#).

- Thaddeus Jones, “Vatican Observatory Summer School reopens its doors”, *Vatican News*, May 31, 2023, <https://www.vaticannews.va/en/vatican-city/news/2023-05/vatican-observatory-summer-school-reopens-its-doors.html>.
- Justin McLellan, “Pope tells astronomers to seek surprises in scientific discovery”, *National Catholic Reporter*, June 22, 2023, <https://www.ncronline.org/earthbeat/science/pope-tells-astronomers-seek-surprises-scientific-discovery>.
- Justin McLellan, “Rising stars: Vatican hosts astronomers of tomorrow for summer school”, *USCCB News*, June 27, 2023, <https://www.usccb.org/news/2023/rising-stars-vatican-hosts-astronomers-tomorrow-summer-school>.
- J-P Mauro, “Vatican Observatory provides all the info on Faith and Science”, *Aleteia*, August 6, 2023, <https://aleteia.org/2023/08/06/vatican-observatory-provides-all-the-info-on-faith-and-science/> (on the “Faith and Science Resource Center” at vaticanobservatory.org).
- Christopher White, “Vatican Observatory summer school teaches how ‘you can’t do astronomy alone’”, *National Catholic Reporter*, August 7, 2023, <https://www.ncronline.org/earthbeat/science/vatican-observatory-summer-school-teaches-how-you-cant-do-astronomy-alone>.
- Ary Waldir Ramos, “Are We Alone in the Universe? Vatican Astronomer Answers”, *EWTN*, August 15, 2023, <https://www.ewtnvatican.com/articles/are-we-alone-in-the-universe-vatican-astronomer-answers-1404>.
- Heather Waldman, “Did you know? Tools for tracking Lake Tahoe’s clarity were invented at the Vatican”, *KCRA3TV*, August 18, 2023, <https://www.kcra.com/article/did-you-know-tools-for-tracking-lake-tahoes-clarity-were-invented-at-the-vatican/44844250> (on Br. Guy Consolmagno at Lake Tahoe, and the instrument created by Fr. Angelo Secchi, S.J. that is widely used to measure water clarity)
- Jonah McKeown, “Celebrations Planned for 30th Anniversary of Vatican Observatory’s Arizona Telescope”, *National Catholic Register*, September 29, 2023, <https://www.ncregister.com/cna/celebrations-planned-for-30th-anniversary-of-vatican-observatory-s-arizona-telescope>.

- Daniel Payne, “At Vatican Observatory, astronomers reveal thousands of newly discovered galaxies”, *CNA*, October 20, 2023, <https://www.catholicnewsagency.com/news/255761/at-vatican-observatory-astronomers-reveal-thousands-of-newly-discovered-galaxies> (on the VO and the VVVX Survey).

VISITORS HOSTED

BROWN

- Hosted a group of seminarians from the Pontifical North American College for a tour of the domes of the papal palace and of the papal gardens, October 14.
- Hosted the Archbishop of Southwark (Most Rev. John Wilson), England, UK for a tour of the domes at the Papal Palace and of the Papal Gardens, also of the offices of the Observatory, October 27.

CONSOLMAGNO

- Hosted the artist Katie Broussard from June 26 - July 9, to allow her to work on a proposed children’s book about the Vatican Observatory.

CORBALLY

- Hosted in Tucson: Allan Deck, S.J.; Cyril Opeil, S.J.; Michael Ryan, NUI Galway.

GALAVERNI

- Hosted at Castel Gandolfo Prof. Günter Sigl (Universität Hamburg).
- Together with Br. Bob MACKE hosted Cristian Carli and other researchers from the Istituto di Astrofisica e Planetologia Spaziali (IAPS) – INAF Roma.

GIONTI

- December 4 (2022): students of the University chapel of the University of Malta.
- December 5 (2022): students of the High School “Villa Sora” in Frascati guided by Prof. Saccoccioni.

- January 7: St. Peter Church parishioners in Capua guided by Fr. Marco Pascarella.
- February 5-6: Albert and Anuta Petrov, Department of Physics, University Federal de Paraíba, Brasil (Albert delivered also, on February 6, a seminar at the Specola).
- March 3: students, guided by Prof. Dall’Acqua, of the High School-Liceo Scientifico-Pesaro (IT).
- March 31: students of Drexel University (USA) guided by Prof. Fraser Fleming.
- April 20: parishioners from Paris who had also a talk on Science and Theology.
- April 29: seminarians and fathers of the Legionary of Christ attending the Master in Science and Theology of the Pontifical University “Regina Apostolorum” in Rome.
- May 2: students of the middle school in Ariccia.
- May 20: students of the Lay Center in Rome.
- July 8: persons from EWTN (USA) television.
- August 31: Netherland Ambassadress to the Holy See and her husband, accompanied by the father delegate of the father general of the Jesuits for the international house in Rome.
- September 15: David Levine and his friends.
- November 17: students of the High School “Villa Sora” in Frascati guided by Prof. Saccoccioni.

HINCKS

- Dr. Giuseppe Puglisi, from the University Rome ‘Tor Vergata’, May 19.
- Rev. Dr. Albert Trudel, O.P. and Rev. Dr. Thomas Davenport, O.P., from the Angelicum, May 21.

MONZANI

- Robert Harrison (Rosina Pierotti Professor of Italian Literature at Stanford University) and Thomas Harrison (Professor of Italian Literature, University of California Los Angeles), Castelgandolfo, June 20.

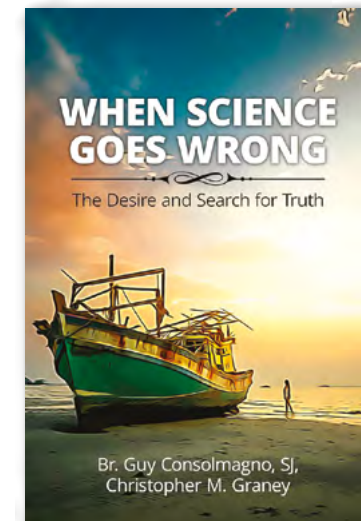
CHAPTER SIX

PUBLICATIONS

BOOKS

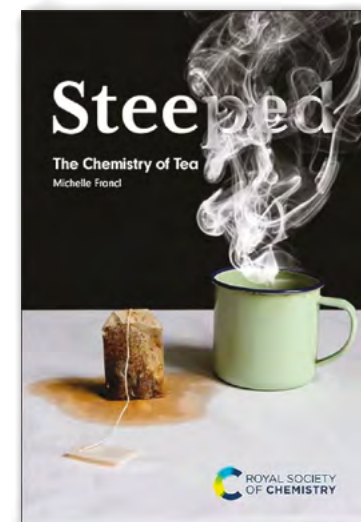
CONSOLMAGNO, GRANEY

CONSOLMAGNO, G. J., GRANEY C.M., 2023 *When Science Goes Wrong: The Desire and Search for Truth*, Paulist Press



FRANCL-DONNAY

FRANCL-DONNAY, M., 2024 *Steeped: The Chemistry of Tea*, Royal Society of Chemistry



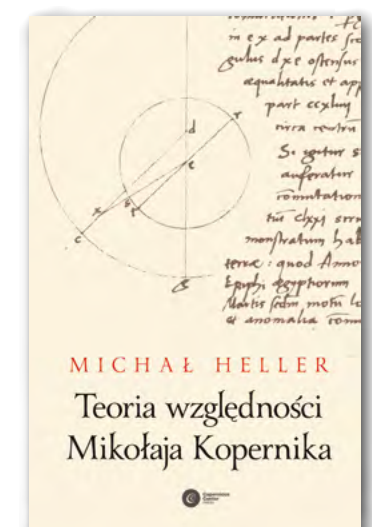
FUNES

FUNES, J. G. (ed.), Lares M., Abrevaya X., Asla M., Florio L. 2023. *La búsqueda de vida extraterrestre inteligente: Un enfoque interdisciplinario*. Universidad Católica de Córdoba.



HELLER

HELLER, M., 2024. *Teoria względności Mikołaja Kopernika*, Copernicus Center Press.



ALTAMORE

Poppi F., Faccini M., ALTAMORE A. 2021. Lorenzo Respighi, cofondatore della Società degli Spettroscopisti Italiani. *Giornale di Astronomia* 48:3, 55, Fabrizio Serra Editore.

ALTAMORE A., GALAVERNI M., CORBALLY C.J. 2021. An Introduction to Angelo Secchi and his Collegio Romano Observatory. In *Angelo Secchi and Nineteenth Century Science*, Ileana CHINNICI and Guy CONSOLMAGNO Editors, Springer.

BOYLE

Dietrich J. et al. [multiple co-authors including BOYLE R. P.]. 2023. EDEN Survey: Small Transiting Planet Detection Limits and Constraints on the Occurrence Rates of Planets around Late-M Dwarfs within 15 pc. *Astronomical Journal*, 165, 149.

Fernandez-Valenzuela E. et al. [multiple co-authors including BOYLE R. P.]. 2023. Weywot: the Darkest Known Satellite in the Trans-Neptunian Region. 55th DPS Meeting, San Antonio, Texas 1-6 October, 2023, #202.04.

KIKWAYA ELUO J.-B., Hergenrother C., BOYLE R. P. 2022. Physical Characterization of 52 Near-Earth Objects with Absolute Magnitudes > 22. *Bulletin of the AAS*, 54(8), <https://baas.aas.org/pub/2022n8i514p04>.

Maskoliūnas M. et al. [multiple co-authors including BOYLE R. P.]. 2023. Lens Mass Estimate in the Galactic Disk Extreme Parallax Microlensing Event Gaia19dke, <https://arxiv.org/pdf/2309.03324.pdf>.

Pozuelos, F. J. et al. [multiple co-authors including BOYLE R. P.]. 2023. A Super-Earth and a Mini-Neptune Near the 2:1 MMR Straddling the Radius Valley around the Nearby Mid-M Dwarf TOI-2096. *Astronomy & Astrophysics*, 672, A70.

BROWN

K. G. Strassmeier et al. [multiple coauthors including BROWN D.]. 2023. VPNEP: Detailed characterization of TESS targets around the Northern Ecliptic Pole I. Survey design, pilot analysis, and initial data release. *Astronomy & Astrophysics*, Vol. 671, A7, 37.

CARUANA

CARUANA L. 2023. Review of *A World Without Work: Technology, Automation, and How We Should Respond*, by Daniel Susskind, in *Heythrop Journal* 64/3, 441-442.

CHINNICI

CHINNICI I. 2022/2023. *Appunti di un gesuita scienziato. I diari di viaggio di Angelo Secchi SJ 1860-1875*. Biblioteca di Nuncius. Studi e Testi, LXXX, Olschki, Firenze.

CHINNICI I. 2023. A travelling chronometer. *Science Museum Group Journal*, issue 20 (online), <https://dx.doi.org/10.15180/232005/001>.

CHINNICI I. 2023. 150 anni fa nasceva la Società degli Spettroscopisti Italiani (1871). *Giornale di Fisica* 64, 1, 77-92.

Coniglio M., CHINNICI I. 2023. Cerere Ferdinanda: il grande affresco dimenticato. *Giornale di Astronomia* 49, 2, 23-28.

CONSOLMAGNO

CONSOLMAGNO G. J. 2023. AI: Skepticism and Hope. *Pax Lumina* 4, January, 48.

CONSOLMAGNO G. J. (with GRANEY C. M. or Redazione). 2023. A Riveder le Stelle: Dalla “prima luce” al VATT [30 Maggio 2023]; A scuola di Astrofisica per misurare le sorgenti celesti [8 Giugno 2023]; La fusione delle galassie e la cronistoria della Via Lattea [6 Luglio 2023]; Alla ricerca della prima materia oscura [3 Agosto 2023]; L’effetto Coriolis e gli scienziati gesuiti [7 Settembre 2023]; I primi 30 anni del VATT sul Monte Graham [12 Ottobre 2023]; Perché il gesuita Bob Macke ha misurato l’asteroide Bennu? [9 Novembre 2023]. *La Civiltà Cattolica*, <https://www.laciviltacattolica.it/osservatorio/>.

CONSOLMAGNO G. J. 2023. To the Moon [January 7, 40]; Blue sky thinking [February 4, 32]; Rocks of ages [March 4, 32]; Turn, turn, turn [April 1, 32]; A Europa moment [May 6, 32]; Webb of mystery [June 3, 32]; Powers of perception [July 1, 30]; A round trip back to Earth [August 5, 30]; A stellar cast of colleagues [September 2, 30]; Touching the face of God [October 5, 30]; Missions accomplished — more or less [November 2, 30]. *The Tablet*, 277.

CONSOLMAGNO G. J., MACKE R. J., Opeil C. P., Britt D. T. 2023. Thermal and physical properties of lunar meteorites at low temperatures. *Meteoritical Society annual meeting abstract* #6092.

GRANEY C. M., CONSOLMAGNO G. J. 2023. Vatican astronomers on the surprises from the Webb telescope. *Aleteia*, <https://aleteia.org/2023/04/04/vatican-astronomers-on-the-surprises-from-the-telescope/>.

GRANEY C. M., CONSOLMAGNO G. J. 2023. Spin off: the surprising history of the Coriolis effect and the Jesuits who investigated it. *Catholic Historical Review*, 109, 302-320.

Graney C. M., CONSOLMAGNO G. J. 2023. Reject the Cult of “Intelligence”. *America*, 229 (July/August), 44-47.

CORBALLY

CORBALLY C. J. 2023. On Militarization of the Moon. Letter to *The Observatory*, 143, 1292, 35.

CORBALLY C. J. 2023. MG1-688432 Project Spectroscopy. *GNAT Monthly Report* vol. 7(2), 2-4.

CORBALLY C. J., Gray R. O., Karmo T. 2023. Spectroscopy of Stars. In *Observer’s Handbook 2023*, ed. James S. Edgar. Toronto, Canada: Royal Astron. Soc. Canada, 282.

Gray R. O. et al. [multiple co-authors including CORBALLY C. J.]. 2023. TU Tau B: The Peculiar “Eclipse” of a possible proto-Barium Giant. *Astrophysical Journal* 166, 161-170. DOI: 10.3847/1538-3881/acf1fe.

Karmo T., CORBALLY C. J., Gray R. O. 2023. The Brightest Stars. In *Observer’s Handbook 2023*, ed. James S. Edgar. Toronto, Canada: Royal Astron. Soc. Canada, 273-281.

Rappaport M. B., CORBALLY C. J. 2023. What Will It Be Like to Live on the Moon? *Nature Volve*, 13, 4-9, https://issuu.com/naturevolve/docs/issue_13_naturevolve.

Rappaport M. B., CORBALLY C. J. 2023. An Ecotheology for Human Settlement of the Inner Planets; Dominion, Despoilment, and a Chance for Re-Dedication. *Theology and Science*, 21(1), 44-66. DOI: 10.1080/14746700.2022.2155910.

Rappaport M. B., CORBALLY C. J. 2023. An Ecotheology for Human Settlement of the Outer Planets: Roles for Religion Beyond the Warmth of the Sun. *Theology and Science*, 21(2), 209-228. DOI: 10.1080/14746700.2023.2188368.

Rappaport M. B., CORBALLY C. J. 2023. Toward an Etiology of Spaceflight neuroplastic Syndrome: Evolutionary Science Leads to New Hypotheses and Program Priorities. *NeuroSci* 4(4), 247-262. DOI: 10.3390/neurosci4040021.

Rappaport M. B., CORBALLY C. J., Campa R. 2023. Rescue and Recovery as a Theological Principle, and a Key to Morality in Extraterrestrial Species. *Zygon*, 58, 636-655. DOI: 10.1111/zygo.12879.

Strassmeier K. G. et al. [multiple co-authors including CORBALLY C.]. 2023. VPNEP: a detailed characterization of TESS targets around the Northern Ecliptic Pole I. Survey design, pilot analysis, and initial data release. *Astronomy & Astrophysics* 671, A7. DOI: 10.1051/0004-6361/202245255.

D’SOUZA

Harmsen B. et al. [multiple co-authors including D’SOUZA R.]. 2023. Constraining the assembly time of the stellar haloes of nearby Milky Way-mass galaxies through AGB populations. *Monthly Notices of the Royal Astronomical Society*, 525, 4497. doi:10.1093/mnras/stad2480.

Smircina A. et al. [multiple co-authors including D’SOUZA R.]. 2023. Origins of the Evil Eye: M64’s Stellar Halo Reveals the Recent Accretion of an SMC-mass Satellite. *Astrophysical Journal Letters*, 949, L37. doi:10.3847/2041-8213/acd5d1.

Gozman K. et al. [multiple co-authors including D’SOUZA R.]. 2023. Saying Hallo to M94’s Stellar Halo: Investigating the Accretion History of the Largest Pseudobulge Host in the Local Universe. *Astrophysical Journal*, 947, 21. doi:10.3847/1538-4357/acbe3a.

FRANCL-DONNAY

FRANCL M. M. 2023. Decentring the Central Science. *Nature Chemistry*, 15, 1319-1320.

FRANCL M. M. 2023. Folding up the questions. *Program for Research on Religion & Urban Civil Society Journal*, 3, 129-133.

FRANCL M. M. 2023. ChatGPT saves the day. *Nature Chemistry*, 15, 890-891.

FRANCL M. M. 2023. Poster children. *Nature Chemistry*, 15, 1-2.

FRANCL-DONNAY M. M. 2023. The Weight of Light. *Give Us This Day*, March.

FRANCL-DONNAY M. M. 2023. In Torrents of Light. *Give Us This Day*, August.

GABOR

GABOR, P. 2023. Timekeeping and the need for astronomical conformity. *ITU News Magazine*, 02, 54-56.

Strassmeier K. G. et al. [multiple co-authors including GABOR P.]. 2023. VPNEP: Detailed characterization of TESS targets around the Northern Ecliptic Pole. I. Survey design, pilot analysis, and initial data release. *Astronomy & Astrophysics*, 671, id. A7, 37 pp.

Pozuelos F. J. et al. [multiple co-authors including GABOR P.]. 2023. A super-Earth and a mini-Neptune near the 2:1 MMR straddling the radius valley around the nearby mid-M dwarf TOI-2096. *Astronomy & Astrophysics*, 672, id. A70, 25 pp.

Dietrich J. et al. [multiple co-authors including GABOR P.]. 2023. EDEN Survey: Small Transiting Planet Detection Limits and Constraints on the Occurrence Rates of Planets around Late-M Dwarfs within 15 pc. *The Astronomical Journal*, 165, 4, id. 149, 18 pp.

Peterson M. S. et al. [multiple co-authors including GABOR P.]. 2023. A temperate Earth-sized planet with tidal heating transiting an M6 star. *Nature*, 617, 7962, 701-705.

GALAVERNI

GALAVERNI M. 2022. Redshift dependent cosmic birefringence from axion-like dark matter. 41st International Conference on High Energy physics (ICHEP2022) – Astroparticle Physics and Cosmology, *Proceedings of Science* 2022.

MACKE R. J., GALAVERNI M. 2022. Sempre nuove ricerche sempre nuove domande. Mezzo secolo dall’ultimo uomo sulla Luna. *L’Osservatore Romano*, 12 dicembre, 8.

GALAVERNI M. 2023. Padre G. Coyne: la Specola Vaticana tra Castel Gandolfo e l’Arizona. *Emmeciquadro* 83, gennaio 2023.

GALAVERNI M., Finelli F., Paoletti D. 2023. Redshift evolution of cosmic birefringence in CMB anisotropies. *Physical Review D*, 107, 8, 083529 [arXiv:2301.07971].

GIONTI

GIONTI G. 2023. What caused the Big-Bang? In *The Philosophers’ Daughters*, ed. by Peter Vardy. Darton, Longman and Todd Ltd, London (UK), 22-23.

GIONTI G. 2023. Assuming the Big-Bang occurred, how did it eventually create such complex human beings as we are? In *The Philosophers’ Daughters*, 27-29.

GRANEY

CONSOLMAGNO G., GRANEY C. M. 2023. *When Science Goes Wrong: The Desire and Search for Truth*. New York: Paulist Press.

GRANEY C. M. 2023. Review of *The Incomparable Monsignor: Francesco Bianchini’s world of science, history, and court intrigue*, by John L. Heilbron. *Catholic Historical Review*, 109:1, 208-209.

GRANEY C. M. 2023. In the Beginning: Nearly a century after a Belgian priest proposed the “Big Bang” theory, astronomers peer back in time to the first galaxies. *Columbia* [Knights of Columbus], 103:3, 21-22.

CONSOLMAGNO G., GRANEY C. M. 2023. Spin Off: The Surprising History of the Coriolis Effect and the Jesuits Who Investigated It. *Catholic Historical Review*, 109:2, 302-320.

CONSOLMAGNO G., GRANEY C. M. 2023. Reject the Cult of “Intelligence”. *America*, 229:1 (July/August), 44-47.

GRANEY C. M. 2023. The Challenging History of Other Earths. *International Journal of Astrobiology*, 22:6 (December), 729-738.

GRANEY C. M. 2023. Astronomers at Vatican Observatory make book list for science-loving kids. *Aleteia*, <https://aleteia.org/2023/02/28/astronomers-at-vatican-observatory-make-book-list-for-science-loving-kids/>.

CONSOLMAGNO G., GRANEY C. M. 2023. Vatican astronomers on the surprises from the telescope. *Aleteia*, <https://aleteia.org/2023/04/04/vatican-astronomers-on-the-surprises-from-the-telescope/>.

GRANEY C. M. 2023. Blaise Pascal, Jimmy Buffett, and a solution if you hate math. *Aleteia*, <https://aleteia.org/2023/06/19/blaise-pascal-jimmy-buffett-and-a-solution-if-you-hate-math/>.

GRANEY C. M. 2023. Jesuit priests were 1st to figure out hurricanes: Why that matters. *Aleteia*, <https://aleteia.org/2023/06/27/jesuit-priests-were-1st-to-figure-out-hurricanes-why-that-matters/>.

GRANEY C. M. 2022/2023. Science in the Bluegrass: The longest Advent possible [December 14, 2022]; Art, science and history in St. Rose Church [February 17]; Flowers of Kentucky [April 18]; Artificial Intelligence? [June 16]; Busy times at the Vatican Observatory [October 18]. *The Record* (Archdiocese of Louisville, Kentucky, USA).

GRANEY C. M. (with CONSOLMAGNO G. or Redazione). 2023. A Riveder le Stelle: Dalla “prima luce” al VATT [30 Maggio 2023]; A scuola di Astrofisica per misurare le sorgenti celesti [8 Giugno 2023]; La fusione delle galassie e la cronistoria della Via Lattea [6 Luglio 2023]; Alla ricerca della prima materia oscura [3 Agosto 2023]; L’effetto Coriolis e gli scienziati gesuiti [7 Settembre 2023]; I primi 30 anni del VATT sul Monte Graham [12 Ottobre 2023]; Perché il gesuita Bob Macke ha misurato l’asteroide Bennu? [9 Novembre 2023]. *La Civiltà Cattolica*, <https://www.laciviltacattolica.it/osservatorio/>.

HELLER

HELLER M. 2023. Teoria względności Mikołaja Kopernika (Nicolaus Copernicus’ Theory of Relativity), CCPress, Kraków.

Brożek B., HELLER M., Stelmach J. 2023. Ciekawość (Curiosity), CCPress, Kraków.

HINCKS

HINCKS A. D. 2023. Integrating the Inquirer: A Jesuit Approach to Interdisciplinarity. *Nexus: Conversations on the Catholic Intellectual Tradition* 2:3.

Isopi G. et al. [multiple coauthors including HINCKS A. D.]. 2023. Compact Sources in the A401–A399 Galaxy Cluster System Observed at 90 GHz with the MUSTANG-2 Camera. *Research Notes of the American Astronomical Society*, 7(4):79.

Li Y. et al. [multiple coauthors including HINCKS A. D.]. 2023. The Atacama Cosmology Telescope: Systematic Transient Search of 3 Day Maps. *Astrophysical Journal*, 956(1):36.

Li Z. et al. [multiple coauthors including HINCKS A. D.]. 2023. The Atacama Cosmology Telescope: limits on dark matter-baryon interactions from DR4 power spectra. *Journal of Cosmology and Astroparticle Physics*, 2023(2):046.

JANUSZ

Gilbert i czyste formy Akwinaty: magnetyzm i matematyka (Gilbert and the Pure Forms of Aquinas: Magnetism and Mathematics). [In:] *Zrozumieć postrzeganie i pojmowanie człowieka oraz świata. Prace dedykowane Profesorowi Józefowi Bremerowi SJ z okazji 70-lecia urodzin* (To Understand Perception and Comprehension of the Human and the World. Papers Dedicated to Prossersor Józef Bremer S.J. on the Occasion of His 70th Birthday). [Eds.:]

Adam Jonkisz, Jacek Poznański SJ, Jolanta Koszteyn. Wydawnictwo Naukowe Akademii Ignatianum w Krakowie, Kraków 2023, 181-195.

Potrzeba pokory w odkrywaniu Prawdy. Z Robertem Januszem SJ, pracownikiem naukowym Watykańskiego Obserwatorium Astronomicznego, rozmawia Stanisław Łucarz SJ (The need for humility in discovering the Truth. Robert Janusz SJ, a researcher at the Vatican Astronomical Observatory, is interviewed by Stanisław Łucarz SJ). “Życie Duchowe” 115 (2023), 169-181.

KIKWAYA ELUO

Tóth J. et al. [multiple co-authors including KIKWAYA ELUO J.-B.]. 2022. Tau Herculis 2022 from air and ground, *Proceedings of the IMC*, Hortobagy, Hungary.

Moskovitz N. et al. [multiple co-authors including KIKWAYA ELUO J.-B.]. 2023. Photometry of the Didymos system across the DART impact apparition. ArXiv:2311.01971.

KIKWAYA ELUO J.-B., Hergenrother C. W. 2023. Lightcurves and Colors of Four Small Near-Earth Asteroids: 2020 BV14, 2023 HH3, 2023 HT3, 2023 KQ. *The Minor Planet Bulletin*, 50-4, 300-303.

Gontcho A Gontcho S., KIKWAYA ELUO J.-B., GABOR P. 2023. Resurfaced 1964 VRT video interview of Georges Lemaitre, ArXiv:2301.07198.

KIKWAYA ELUO J.-B., Hergenrother C.; BOYLE R. P. 2022. Physical Characterization of 52 Near-Earth Objects with Absolute Magnitudes > 22, *Bulletin of the American Astronomical Society*, 54:8 e-id 2022n8i514p04.

KIKWAYA ELUO J.-B. 2022. Astronomie au Congo, est-il possible de faire de l’astronomie au Congo. *Actes des Journées scientifiques de la faculté de Physique de l’Universite de Kinshasa*, Universite de Kinshasa, Kinshasa.

KIKWAYA ELUO, J.-B. 2023. Narrowing Down the Physical Characteristics of Optical Fast Rotating Neos from Spectrophotometry. *Proceedings of the First Symposium of African Jesuits in Science, Nairobi, Kenya, 2022*.

KIKWAYA ELUO, J.-B. 2022. Pondering the Handiwork of God’s Creation Through the Lens of a Telescope. *JCAM (Jesuit Conference Africa Madagascar), Annual Review 2022*, <https://relayto.com/jcam/jesuits-africa-annual-review-2022-i6zibk9x0pau4/2AyUf0Ju1>.

MACKE

MACKE R., Tóth J. 2023. Aliens in the Vatican – Research on Meteorites and the Role of the Vatican Observatory. In *The Image of Man in the Universe: Interdisciplinary Perspectives and Challenges*, ed. by Zlatica Plašienková. Bratislava: Comenius University Bratislava, 28-48.

Anderson S. L. et al. [multiple co-authors including MACKE R.]. 2023. The Combined History of the Arpu Kuilpu (H5) Meteorite from a Jupiter Family Comet orbit. *Meteoritical Society Meeting 2023* August 13-18, UCLA.

CONSOLMAGNO G. J., MACKE R. J., Opeil C. P., Britt D. T. 2023. Thermal and Physical Properties of Lunar Meteorites at Low Temperatures. *Meteoritical Society Meeting 2023* August 13-18, UCLA. Abstract #6092.

Flynn G. J. et al. [multiple co-authors including MACKE R.]. 2023. Effects of Porosity on Cratering and Disruption of 3 L-Type Ordinary Chondrites. *Meteoritical Society Meeting 2023* August 13-18, UCLA.

Flynn G. J. et al. [multiple co-authors including MACKE R.]. 2023. Hypervelocity Cratering and Disruption of Three L-type Ordinary Chondrites: Effects of Porosity. 2023 ACM.

Hoover C. G., Ryan A. J., Sánchez P., Biele J., Ballouz R.-L., Lauretta D. S., Connolly H. C. Jr, and The OSIRIS-REx Sample Analysis Team [multiple co-authors including MACKE R. JJ]. 2023. A Comprehensive Nano and Micro-Mechanical Testing Plan for Bennu Sample Return. LPSC 2023.

Flynn G. J., Strait M., Willman H., Rolling A., MACKE R., Durda D. 2023. Response to Hypervelocity Impacts and Physical Properties of the Abu Panu L3 Ordinary Chondrite. LPSC 2023.

MINNITI

Saito R. K. et al. [multiple co-authors including MINNITI D.]. 2023. VVV-WIT-12 and its fashionable nebula: a four year long period Young Stellar Object with a light echo? *The Astrophysical Journal Letters*, 958, L1 (arXiv:2311.01593S).

Gonzalez-Diaz D. et al. [multiple co-authors including MINNITI D.]. 2023. CAPOS: The bulge Cluster APOgee Survey IV. Elemental Abundances of the old globular cluster NGC 6558. *Monthly Notices of the Royal Astronomical Society*, 526, 6274G (arXiv:2310.13054G).

Barbuy B. et al. [multiple co-authors including MINNITI D.]. 2023. Light elements Na and Al in 58 bulge spheroid stars from APOGEE. *Monthly Notices of the Royal Astronomical Society*, 526, 2365B.

Luna A., Marchetti T., Rejkuba M., MINNITI D. 2023. Astrometry in crowded fields towards the Galactic Bulge. *Astronomy & Astrophysics*, 667A, 185L (arXiv:2307.13719).

Ortigoza-Urdaneta M. et al. [multiple co-authors including MINNITI D.]. 2023. Galactic ArchaeoLogIcaL ExcavatiOns (GALILEO). II. t-SNE Portrait of the Local Fossil Relics and Structures. *Astronomy & Astrophysics*, 676A, 140 (arXiv:2306.08677O).

Daza-Perilla I. V. et al. [multiple co-authors including MINNITI D.]. 2023. The VVV near-IR galaxy catalogue in a Northern part of the Galactic disc. *Monthly Notices of the Royal Astronomical Society*, 524, 678D (arXiv:2306.07141).

Saroon S. et al. [multiple co-authors including MINNITI D.]. 2023. The VISCACHA survey – VIII. Chemical evolution history of SMC West Halo clusters. *Astronomy & Astrophysics*, 677, A35 (arXiv:2307.08709).

Oliveira R. A. P. et al. [multiple co-authors including MINNITI D.]. 2023. The VISCACHA survey – VII. Assembly history of the Magellanic Bridge and SMC Wing from star clusters. *Monthly Notices of the Royal Astronomical Society*, 524, 2244O (arXiv:2306.05503O).

Wanderley F. C. et al. [multiple co-authors including MINNITI D.]. 2023. Stellar Characterization and Radius Inflation of Hyades M dwarf stars from the APOGEE Survey. *The Astrophysical Journal*, 951, 90W (arXiv:2305.07065W).

Navarro M. G., Capuzzo Dolcetta R., Arca-Sedda M., MINNITI D. 2023. Globular Clusters in the Galactic Centre Region: expected behavior in the infalling and merger scenario. *Astronomy & Astrophysics*, 674A, 148N (arXiv:2303.18123).

Cruz P., Cortés-Contreras M., Solano E., Rodrigo C., MINNITI D., Alonso-Garcia J., Saito R. K. 2023. M-dwarf stars in tile b294 from the VISTA Variables in the Via Lactea (VVV). *Monthly Notices of the Royal Astronomical Society*, 520, 4730C (arXiv:2301.13491).

Baravalle L. D. et al. [multiple co-authors including MINNITI D.]. 2023. AGN candidates in the VVV near-IR galaxy catalogue. *Monthly Notices of the Royal Astronomical Society*, 520, 5950B (arXiv:2302.05595).

Horta Darrington D. et al. [multiple co-authors including MINNITI D.]. 2023. The chemical characterisation of

halo substructure in the Milky Way based on APOGEE. *Monthly Notices of the Royal Astronomical Society*, 520, 5671H (arXiv:2204.04233H).

Obasi C. et al. [multiple co-authors including MINNITI D.]. 2023. The globular cluster system of the nearest Seyfert II galaxy Circinus. *Astronomy & Astrophysics*, 670A, 18O (arXiv:221205482O).

Daza-Perilla I. V., Gramajo L. V., Lares M., Palma T., Ferreira Lopes C. E., MINNITI D., & Clariá J. J. 2023. Automated classification of eclipsing binary systems in the VVV Survey. *Monthly Notices of the Royal Astronomical Society*, 520, 828D (arXiv:2302.01200P).

Garro E. R. et al. [multiple co-authors including MINNITI D.]. 2023. Gaia-IGRINS synergy: Orbits of newly identified Milky Way star clusters. *Astronomy & Astrophysics*, 669A, 136G (arXiv:221202337G).

Geisler D. et al. [multiple co-authors including MINNITI D.]. 2023. Ca Triplet Metallicities and Velocities for twelve Globular Clusters towards the Galactic Bulge. *Astronomy & Astrophysics*, 669A, 115G (arXiv:221002193G).

Rodríguez M. J. et al. [multiple co-authors including MINNITI D.]. 2023. The VISCACHA survey - VI. Dimensional study of the structure of 82 star clusters in the Magellanic Clouds. *Monthly Notices of the Royal Astronomical Society*, 519, 3357R (arXiv:2212.09685J).

Roman-Zuñiga C. G. et al. [multiple co-authors including MINNITI D.]. 2022. Stellar Properties and Accretion Measures for a Comprehensive Collection of Star Forming Regions in the SDSS APOGEE-2 Survey. *The Astronomical Journal*, 165, 51R (arXiv:221109217R).

Fernandes L. et al. [multiple co-authors including MINNITI D.]. 2023. A Comparative Analysis of the Chemical Compositions of Gaia-Enceladus/Sausage and Milky Way Satellites using APOGEE. *Monthly Notices of the Royal Astronomical Society*, 519, 3611F (arXiv:2301.01302F).

Galdeano D., Ferrero G. A., Coldwell G., Duplancic F., Alonso S., Riffel R., MINNITI D. 2023. Unveiling a new structure behind the Milky Way. *Astronomy & Astrophysics*, 669A, 7G (arXiv:2210.16332).

de Oliveira Salim Jose L., Saito R. K., Kanaan R., MINNITI D., Gramajo L., Botan E. 2023. VVV-VIVACE ID 533558 (= OGLE RRLYR-09505): the half-day period as a challenge for the automatic searches for variable stars. *Research Notes of the American Astronomical Society*, 7, p. 140.

MONZANI

Smith D. A. et al. [the Fermi-LAT collaboration, including MONZANI M. E.]. 2023. The Third Fermi Large Area Telescope Catalog of Gamma-ray Pulsars. *Astrophysical Journal*, 958, 191.

Aalbers J. et al. [the LUX-ZEPLIN collaboration, including MONZANI M. E.]. 2023. Search for new physics in low-energy electron recoils from the first LZ exposure. *Physical Review D*, 108, 072006.

Lesage S. et al. [the Fermi-GBM and Fermi-LAT collaborations, including MONZANI M. E.]. 2023. Fermi-GBM Discovery of GRB 221009A: An Extraordinarily Bright GRB from Onset to Afterglow. *Astrophysical Journal Letters*, 952, L42.

Aalbers J. et al. [the LUX-ZEPLIN collaboration, including MONZANI M. E.]. 2023. Background Determination for the LUX-ZEPLIN (LZ) Dark Matter Experiment. *Physical Review D*, 108, 012010.

Aalbers J. et al. [the LUX-ZEPLIN collaboration, including MONZANI M. E.]. 2023. First Dark Matter Search Results from the LUX-ZEPLIN (LZ) Experiment. *Physical Review Letters*, 131, 041002.

Abdollahi S. et al. [the Fermi-LAT collaboration, including MONZANI M. E.]. 2023. The Fermi-LAT Lightcurve Repository. *Astrophysical Journal Supplement Series*, 265, 31.

Buuck M., Mishra A., Charles E., Di Lalla N., Hitchcock O. A., MONZANI M.E., Omodei N., Shutt T. 2023. Low-energy Electron-track Imaging for a Liquid Argon Time-projection-chamber Telescope Concept Using Probabilistic Deep Learning. *Astrophysical Journal*, 942, 77

Aalbers J. et al. [the LUX-ZEPLIN and XENON collaborations, including MONZANI M. E.]. 2023. A next-generation liquid xenon observatory for dark matter and neutrino physics. *Journal of Physics G: Nuclear and Particle Physics*, 50 013001.

OMIZZOLO

Vulcani B. et al. [multiple co-authors including OMIZZOLO A.]. 2023. Clustercentric distance or local density? It depends on galaxy morphology. arXiv:2302.02376 (in press with *Astrophysical Journal*).

Gullieuszik M. et al. [multiple co-authors including OMIZZOLO A.]. 2023. UV and H α HST observations of 6 GASP jellyfish galaxies. arXiv:2301.08279 (in press with *Astrophysical Journal*).

George K. et al. [multiple co-authors including OMIZZOLO A.]. 2023. Ultraviolet imaging observations of three jellyfish galaxies: Star formation suppression in the centre and ongoing star formation in stripped tails. arXiv:2212.02423 (in press with *Monthly Notices of the Royal Astronomical Society*).

TANZELLA-NITTI

TANZELLA-NITTI G. 2023. Creativity: Artificial, Animal, and Human Intelligence, quaderno monografico, Presentation. *Acta Philosophica*, 32, 11-16.

TANZELLA-NITTI G. 2023. Foreword to the volume A. Gallippi, *L'astronomo poeta.Vicende, scoperte e intuizioni di Ruggero Boscovich*, Marcianum Press, Venezia, 15-20.

TANZELLA-NITTI G. 2023. *Tommaso d’Aquino e il pensiero scientifico contemporaneo, in Vetera Novis Augere. Le risorse della tradizione tomista nel contesto attuale*. I. Bilancio e prospettive, a cura di S.-T. Bonino e L. Tuninetti, Urbaniana University Press, Roma, 151-179.

TANZELLA-NITTI G. 2023. *La dimensione religiosa dell’attività scientifica*, in F. Bisio (ed.), “Intelligenza e spiritualità,” Atti del Convegno dell’Associazione Teilhard de Chardin, Vicenza 12-13.11.2022, Quaderni dell’Associazione P. Teilhard de Chardin.

