



VATICAN OBSERVATORY
FOUNDATION

2019 ANNUAL REPORT OF GIVING



President's Report

Writing in Spring of 2020, in the midst of the coronavirus crisis, it is hard to remember what even happened in 2019. Everything is now seen in the light of our current fears and anxieties. But the truth is that the need for a Vatican Observatory is no less, even in these times, and your continued support is as valuable to all of us as it ever has been.

And in fact, 2019 was a wonderful year for the Foundation! Reversing previous deficits, in 2019 our financial bottom line was in the black, thanks to a rising stock market and a number of generous donations, including a thoughtful legacy gift. An increase in total donors, especially subscribers to our Sacred Space Astronomy site, made a big difference.

We “showed the world” how lives of faith and lives of science enrich each other through a number of successful programs:

- The biennial Faith and Astronomy Workshop in January brought educators from around North America to Tucson for a week full of talks, workshops, and field trips; here they learned about the life and work of astronomers, and reflected on how that impacts Catholic life and faith.
- We participated in a number of outreach events in Tucson, providing a prize to a SARSEF science fair winner and exhibiting at the Festival of Books in March.
- April and May found me giving talks and retreats in Australia, New Zealand, and California. (My thanks to those who sponsored my travel and showed such remarkable hospitality, especially Cardinal John Dew of Wellington — who personally drove me to the airport at 4 am!)
- In June we held our annual public seminar at Georgetown University in Washington DC... including a special tour of the historic Heyden Observatory.
- We participated in events celebrating the 50th anniversary of the Apollo 11 moon landing.
- My autumn in Rome included filming for an upcoming documentary on meteorites, interviews for Austrian and Scottish television, and many tours of our Visitor's Center in the Papal Gardens.
- Major addresses during the European half of my year included events in Dublin, York, Scotland, Paris, and the annual Christmas Lecture in Bucharest.

But of course none of this public engagement would have any credibility without evidence of solid science happening at the Vatican Observatory. Thanks to the Foundation's support of the Vatican Advanced Technology Telescope (VATT), a number of research projects made great strides in 2019. Two of these collaborations have whimsical names appropriate for the Vatican's participation: EDEN and HOLiCOW. (Read about them in the Vice Director's Report, below.)

Which brings us back to why we do the work we do. Even — perhaps especially — in a time of social uncertainty, our seemingly abstract work as astronomers is still vital. One insight into that assertion came from Father George Coyne, whom sadly we lost this year.

Father Coyne directed the Vatican Observatory for nearly thirty years and founded the Vatican Observatory Foundation. In his role as fundraiser, gathering the resources that led to the construction of the VATT, he had a profound understanding of both the questions and the needs of our supporters. When people looked at the troubles in the world and wondered why we would spend precious financial and human resources on something esoteric like a telescope, his reply was direct and surprising: “Yes, we need to feed the hungry and cure the blind,” he said. “But if that is all that we do, then we will all be hungry, and we will all be blind.”

Unless we feed the soul — with astronomy, art, music, storytelling — our souls starve. If we do not study and dream about the stars, then our intellects and our imaginations will go blind. Without those qualities that make us more than just grazing animals, we lose sight of the greater purpose for which we were created. Without “HOLiCOW” we'd be no more than cows.

These present troubles will end; that is why we need to be sure to maintain a world with astronomy and other arts and sciences. We need to be ready to direct our spirits to the greater meaning that only a well-nourished soul can reach for.

The creation of the universe was marked by the presence, at the beginning, of the Word. We do not live by bread alone, but by every word uttered by the mouth of the Creator. Only with your support can we be ready to read, to appreciate, and to share those words.

Br. Guy Consolmagno, S.J.
President

Chairman's Report

The Vatican Observatory has lost a great statesman and spiritual driver with the passing of Father George Coyne, S.J. He will be remembered by all who knew him for his wisdom, humility, good humor, and gentle soul. I first heard of Father Coyne when I read an article that he wrote about the Vatican Observatory in the magazine *Sky and Telescope* in the mid-1990s. "What?" I thought, "The Vatican has an Observatory???" As a Catholic and a lifelong amateur astronomer I HAD to reach out to him to learn more.

Thus started an email exchange that resulted in my becoming involved in the Vatican Observatory Foundation. Months later I was surprised to learn that Father Coyne was the Director of the Vatican Observatory. (This was in the days before ubiquitous web sites and so it was not as easy to find organizational details). It was much later that I learned that he is one of a handful of Jesuits to have an asteroid named after him. Vintage George Coyne. He was approachable and personable — humanistic traits not always found in today's brilliant scientists.

I recently listened to the interview with Father Coyne and Brother Consolmagno in the *On Being* podcast (Feb 20, 2020 – find the link at vofoundation.org). Father Coyne states that his scientific knowledge of the Universe allowed him to reflect upon and inform his understanding of this "magnificent God ... that made a universe that has a dynamism to it and thus is not completely determined."

One of his scientific interests was the life and death of stars. "My knowledge of the life and death of stars," he says, "leads me to know that there's a unity in the whole Universe with respect to life and death. If stars were not being born and dying, we would not be here. The Sun is a third generation star. It was only after three generations of stars that we had the chemical abundance to make primitive life forms ... and then through that to come to ourselves." Finding God in all things, indeed.

Thank you, Father Coyne, for sharing your travels on this inexorable and ineffable journey around the Sun and among the stars. You will be sorely missed.



Rich Friedrich and Father Coyne visiting VATT on Mount Graham, AZ. February 2003

Rich Friedrich
Chairman

Our Mission

The Vatican Observatory has a double-edged mission: scientific research into the knowledge of the universe, including our place in it, and the education of the public based upon the knowledge derived from that research.

RESEARCH. In the early 1990s the marvels of technology and the commitment of a few visionary philanthropists made possible the creation of the Vatican Advanced Technology Telescope (VATT), which empowered scientists to look with more acute "eyes" into the universe. Today, the VATT continues to provide stunning access to the heavens for researchers from around the globe. Combined with other technologies and the continued commitment of Vatican Observatory scientists, our work is literally pushing the boundaries of what we know and how we know it.

EDUCATION. Each year members of the Observatory staff share their expertise by making educational presentations to groups all over the world, both in person and through teleconferences and publications. In recent times Vatican Observatory scientists have played an increasingly important role in the dialogue between science and faith.

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The VOF has established a memorial page and fundraiser to honor Fr. Coyne. Go to www.vofoundation.org/fr-george-coyne/



Vice Director of the Research Group's Report

We astronomers of the Vatican Observatory Research Group (VORG) are skywatchers. We keep our eyes raised to the heavens like the kids we were when we first wished upon a star. But as researchers we must rely on some pretty high technology up on Mount Graham! And keeping up with all the technology has become a huge challenge in itself.

The principal function of a research telescope like our Alice P. Lennon Telescope – also known as the Vatican Advanced Technology Telescope (VATT) - is to gather light, so that instruments (filters, cameras, spectrographs, etc.) attached to the telescope can process and record the light. This takes time. The Earth is spinning, and so the telescope must spin in the opposite direction to compensate. The automated mechanical drives of telescopes are designed to track the star or other target and keep it in the “crosshairs.” Fluctuations or drifts cause blurring in the image or loss of light in a spectrum. An additional system can help. An auxiliary camera watches a guide star. When the guide star's position in the field of view drifts, guiding software nudges the telescope to keep the guide star on its mark, and consequently to eliminate any drifts of the whole field of view.

For example, the guiding system of VATT typically nudges the telescope every 3 seconds to tweak the tracking by fractions of an arc second, i.e., by angles subtending the thickness of a sheet of paper at 100 yards.

VATT has a guider box whose primary purpose is to allow telescope guiding - hence the name. It is, in fact, an aluminum box mounted below the telescope's primary mirror. Scientific instruments (the VATT4k CCD Imager, the VATT-Spectrograph, etc.) are attached to the bottom of the guider box. Guide cameras are attached to the sides of the box, each on a stack of mechanical stages for adjusting focus and scanning the field of view. Inside, the box contains a translation stage



bearing a U-shaped mirror for off-axis guiding and a pick-off mirror, as well as two rotating stages for optical filters, which transmit or block light of given wavelengths before it reaches the imaging cameras.

In 2017, new and more sensitive guide cameras were acquired and installed at VATT. But until last year the eight actuators for the guider box's mechanical degrees of freedom depended on obsolete, twenty-year-old electronics. In 2019 we replaced them with Moog Inc. SM2316 Class 5 D-Style smart motors commanded via Ethernet. The mechanical aspects of the project were supervised by Michael Franz and the software aspects by Scott Swindell. Other contributors were Christopher Johnson, Jeff Rill, Paul Arbo, and Dan Avner. The center mirror (both sides) and the U-mirror (one side) were re-aluminized by Composite Mirror Applications Inc.

Continued from page 4, before Center Spread Extra, Discovered at the VATT

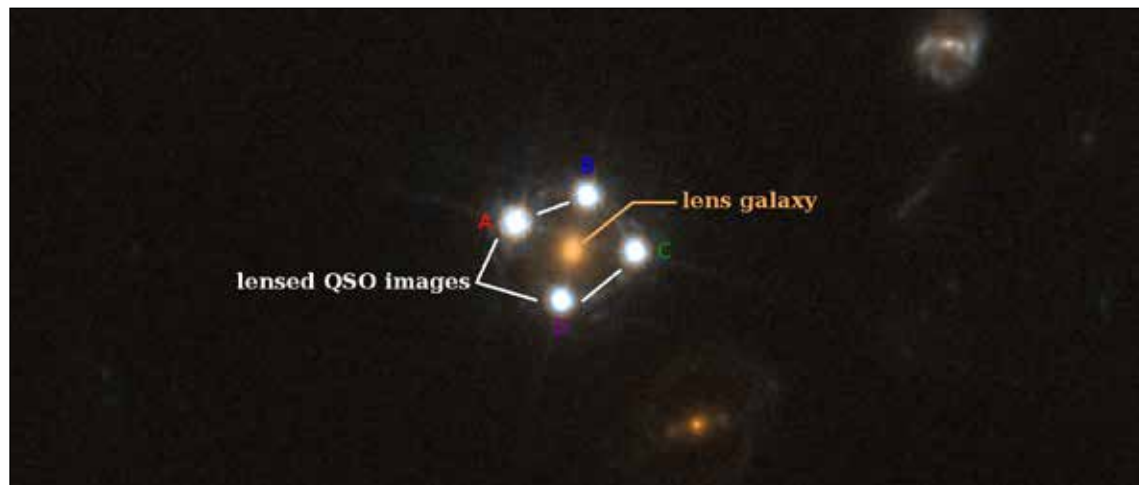
The new hardware should last a decade. Moreover, VATT's upgraded guiding system allows us to conduct cutting-edge research programs. Two programs we are engaged in that require the new capabilities are EDEN and Cosmograil/H0LiCOW.

EDEN (Exo-Earth Discovery and Exploration Network; <project-eden.space>) aims to examine all M stars (red dwarfs) within fifty light years and conclusively determine whether there are any Earth-sized planets in their habitable zones. The EDEN transit survey is a multinational collaboration, created by Daniel Apai of the University of Arizona. Fathers Boyle and Gabor represent the Vatican

Observatory. VORG was the first to join forces with Daniel's team of students, committing considerable time on the 72-inch Lennon Telescope. Steward Observatory is dedicating observing time on the 90-inch Bok, the 61-inch Kuiper, and the 32-inch Schulman telescopes. Max Planck Institute for Astronomy in Heidelberg is contributing observing time on two Calar Alto telescopes, and the National Central University of Taiwan is committing astronomical resources in Lulin. EDEN is a part of the official follow-up program for NASA's TESS space telescope, as well as an independent M-star survey. It has a great potential for discovering exciting Earth-sized planets. VATT is EDEN's most sensitive facility, and it is also recognized as one of the best among the whole TESS follow-up community. The stable guiding is a major contributing factor.

With COSMOGRAIL/H0LiCOW, VATT rejoins the cosmological fray (after the MACHO survey). There are currently two values of the Hubble constant, a key cosmological parameter. The Planck collaboration's value derived from the most sensitive observations and the most detailed analysis of the cosmic microwave background is 67.4 ± 0.5 km/s/Mpc (2018).

The latest result obtained from supernova and Cepheid surveys SH0ES (Riess et al. 2019) is 74.0 ± 1.4 km/s/Mpc. This difference appears to be irreconcilable. The COSMOGRAIL/H0LiCOW collaboration (<cosmograil.org>, <h0licow.org>) pursues a third, independent approach. It monitors strongly lensed quasars (figure below), measuring time delays between the luminosity variations of the lensed images.



The COSMOGRAIL project has been running for more than 13 years in the Southern hemisphere, using the 1.2m Swiss Leonard Euler telescope located at La Silla in Chile. Their latest result is $73.3 \pm 1.7 - 1.8$ km/s/Mpc, i.e., with an uncertainty of 2.4%. In 2019 the VATT became a part of this project, as its observatory in the Northern hemisphere. Accumulating data will reduce the uncertainty even further. Again, solid guiding was one of the reasons why the collaboration chose the VATT, putting the Vatican's telescope on the forefront of cosmological research.

Up-to-date technology is what makes the VATT relevant, attracting exciting collaborations and cutting-edge research. And keeping the Vatican ADVANCED TECHNOLOGY Telescope true to its name is made possible thanks to your support.

Paul Gabor, S.J., Ph.D.
Vice Director, Vatican Observatory

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 to ensure that all information is
 correct. If any errors or omissions
 are noted, we offer our apologies
 and ask that you notify us.*

2019 Circles of Giving Awards

The Vatican Observatory Foundation honors individuals and organizations whose generosity over time has been vital to our mission. Each Circle of Giving is named for an individual notable in the history of Astronomy, the Society of Jesus and the Vatican Observatory. Our thanks and prayers go to all those who support our mission but especially to the following being recognized this year.

Georges Lemaître Circle - \$5,000

Belgian priest and cosmologist, Lemaître was one of the first to propose what has come to be known as the Big Bang. As president of the Pontifical Academy of Sciences, he had the very difficult task of trying to convince Pope Pius XII of the difference between scientific theories and religious creeds. With such figures as Hubble and Einstein, Lemaître was a principal protagonist in the birth of modern cosmology.

- Dr. Fernando Comeron Tejero
- Professor William E. Kovacic
- Mr. Francis J. Manion, The Manion Family Fund
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Christoph Clavius Circle - \$10,000

Mathematician, confidant of Galileo, and major figure in the reform of the calendar, Clavius suffered the tensions of his day between old worldviews and the challenges of new discoveries. Facing them as a scientist, he confirmed Galileo's observations and established a tradition of true scholarship which contributed to the spirit embodied in the founding of the Vatican Observatory.

- Mr. William Fruchterman
- Dr. and Mrs. Christopher M. Graney
- Ms. Barbara Rom,
- The Davis-Rom Fund of the Community Foundation for Southeast Michigan
- Ms. Christine Wing Shan Tong

Eusebio Kino Circle - \$25,000

Father Eusebio Kino, like the Vatican Observatory itself, is a splendid example of the Jesuits extending their endeavors from the Old World to the New. While studying in Europe he distinguished himself as a mathematician, physicist and astronomer, and he built numerous telescopes and astrolabes. As a missionary in the Sonora region of Mexico where Tucson stands today, he used his astronomy skills to craft accurate maps.

- Ms. Andrea M. Dudek
- Ms. Karen Gardner

Angelo Secchi Circle - \$50,000

Known as the Father of Modern Astrophysics, Secchi was the first to classify stars according to their spectra. His scientific and engineering contributions ranged from the study of sunspots to double stars to irrigation systems while creating an astronomical laboratory on the roof of Sant' Ignazio Church in downtown Rome. He contributed in an exceptional way to the tradition of high quality research at the Vatican Observatory.

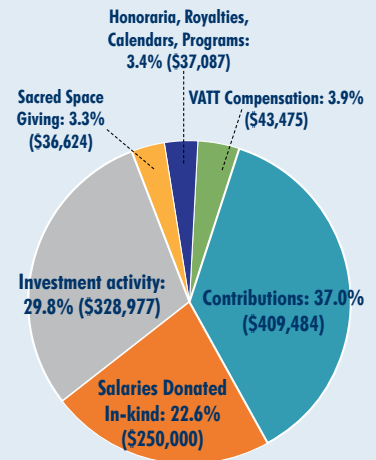
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Gregory XIII Circle - \$250,000

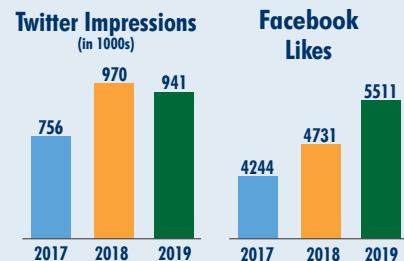
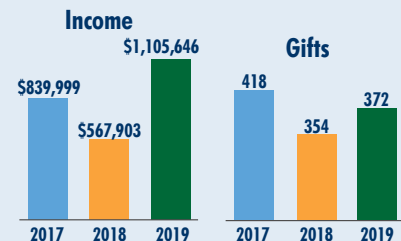
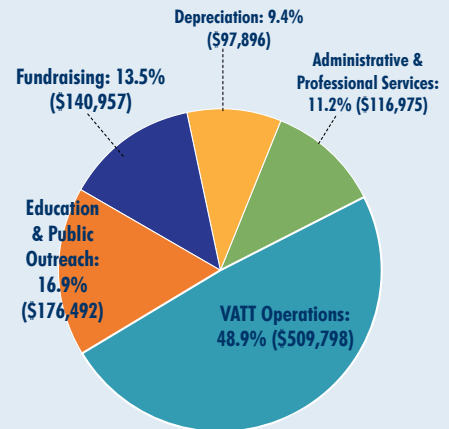
In the famous Tower of the Winds Pope Gregory XIII was shown a beautiful meridian that demonstrated the need to reform the Julian calendar. So he commissioned the Jesuit astronomers at the Roman College to create the new Gregorian calendar, which they did in 1582. Thus began a tradition of Papal interest in astronomy, which over the next centuries was to mature into the modern-day Vatican Observatory.

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Income: \$1,105,646



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