

THE
VATICAN OBSERVATORY
2008 ANNUAL REPORT

Telling Our Story

VATICAN OBSERVATORY ANNUAL REPORT 2008



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Vatican Observatory Publications

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FROM THE DIRECTOR

"...that everyone might see clearly that the Church and her Pastors are not opposed to true and solid science, whether human or divine, but that they embrace it, encourage it, and promote it with the fullest possible devotion."

– Pope Leo XIII, on the refounding and restructuring of the Vatican Observatory, 14 March 1891

TELLING OUR STORY

Many of you are familiar with the two-fold statement mission of the Vatican Observatory described above by Pope Leo XIII. I would like to take the opportunity here to talk about a special gathering the Observatory staff held to address the second part of our mission statement—to embrace, encourage, and promote science. This was a wonderful occasion to do so, as the Observatory continued preparations for its role in celebrating the International Year of Astronomy 2009.

From June 23-27 eleven members of the Vatican Observatory and three younger Jesuits who are candidates to join the Observatory met at the Jesuit retreat house in the Abruzzi hill country in the town of Calascio, Italy, to discuss the direction and future priorities of the Observatory.

The first priority of the Observatory is, of course, scientific research. Therefore, we began our week together by discussing our astronomical research in the following fields: Planetary Sciences, Stellar Astronomy, Extragalactic Astronomy, Cosmology, and the History of Astronomy. Our major research tool is the Vatican Advanced Technology Telescope (VATT), located on Mt. Graham in the Pinaleno Mountains of southeastern Arizona. Christopher Corbally, S.J., vice director for the Vatican Observatory Research Group in Tucson, reported to the group that the VATT is in excellent shape, with a newly aluminized mirror and a new CCD camera. He said that a small spectrograph is in development and should be on line soon. The VATT team is doing a great job in making this facility one of the most efficient telescopes in Arizona.

William Stoeger, S.J., coordinator for Science and Theology programs, next outlined the efforts of the Observatory in this field. Observatory staff are often called on to contribute to these discussions at different levels. Guy Consolmagno, S.J., coordinator for public relations, reminded the group that the Vatican Observatory was formally established by

Pope Leo XIII “in order that the world may see that the Church supports true science.” He discussed the importance of not only doing good science, but letting the world see it, in terms of education, public outreach, and public relations.

Lastly, we discussed the Observatory’s education and outreach efforts. In this area, we are extremely proud of the highly successful Vatican Observatory Summer Schools. Begun in 1986, the summer schools already have produced 275 alumni from 52 nations. In the same spirit that moved the Observatory staff to start the summer schools, we are planning to dedicate special efforts to astronomy education in Africa. Though the opportunities are enormous, our resources are limited. It is clear that our work could most effectively be done in collaboration with other friends and colleagues.

At the conclusion of this highly fruitful week, on returning to the Observatory in Castel Gandolfo, we were privileged by a visit from the newly-elected Father General of the Jesuits, Adolfo Nicolás, S.J. Father General visited the Observatory’s telescopes, the library, and our offices in the Pontifical Palace. He encouraged us to do good science and to help answer the important questions that people ask regarding science and faith.



Adolfo Nicolás, S.J., Father General of the Jesuits (center), visited with the Vatican Observatory staff in Castel Gandolfo.

The Observatory staff was especially blessed to have the opportunity to explain our work to the Holy Father. On September 4, I was received in private audience by Pope Benedict XVI. I briefed the Holy Father on the staff meeting held at Calascio in June and on the Observatory’s activities in celebration of the International Year of Astronomy 2009. This audience is a concrete manifestation of Benedict XVI’s appreciation of the Observatory’s work.



On 4 September, the Holy Father received Vatican Observatory Director José Funes, S.J., in private audience.

PERSONNEL NEWS

New Staff Member

On 1 October David Brown, S.J., joined the staff of the Observatory. Father Brown obtained his bachelor of science in Physics at Texas A&M University and then, in 1991, he joined the Society of Jesus. After studies in philosophy at Fordham University, New York, and theology at the Weston Jesuit School of Theology in Cambridge, Massachusetts, he was ordained to the priesthood in 2002. He has completed his doctoral studies in astrophysics at the University of Oxford, Oxford, England and continues his work on the synthesis of stellar populations to model the ultraviolet excess in giant elliptical galaxies. Father Brown is a member of the New Orleans Jesuit Province and this year he was assigned by his superiors to the Vatican Observatory.

James Bowes, S.J., received a new destination from his superiors. We thank him for his service as Superior at the Jesuit Community in Tucson.

New Adjunct Scholars

Adjunct Scholars are individuals who have a major collaboration with members of the Observatory's research staff and/or are carrying out a project for the Observatory itself.

On 9 February, Dante Minniti, a long-time collaborator of the Vatican Observatory, was appointed Adjunct Scholar. Minniti is an alumnus of the very first Vatican Observatory Summer School held in 1986. He subsequently received the first Martin F. McCarthy Jesuit Community Scholarship to begin his doctoral studies in astronomy at the University of Arizona. On completion of his doctorate, he pursued several post-doctoral appointments at the European Southern Observatory, whose headquarters are in Munich, Germany, and at the Lawrence Livermore Laboratory in California. Minniti is currently a full professor at the *Pontificia Universidad Catolica in Santiago de Chile*, where he was named Director of Research and Doctorate in May. He also received the 2008 Scopus Prize in the area of Physics and Astronomy from Elsevier and the Chilean *Conicyt*. He was awarded a Research Grant from BASAL Center for Astrophysics and Associated Technologies as Principal Investigator in the area of extrasolar planets and low mass stars.

On 20 June, Dr. Ileana Chinnici was appointed Adjunct Scholar of the Vatican Observatory. Chinnici is the first woman to have such an appointment. She is an astronomer at the Observatory of Palermo and an expert in the history of astronomy. She has published studies on Father Angelo Secchi, S.J., a renowned Jesuit astronomer of the 19th century, and on the *Carte du Ciel* ("Map of the Sky"). The *Specola Vaticana* (Vatican Observatory) was one of the participating observatories in the *Carte du Ciel*, and the historical telescope used for this survey is still in the Vatican Gardens at Castel Gandolfo. Chinnici is also one of the main organizers of the exhibit on antique astronomical instruments to be displayed at the Vatican Museums as part of the International Year of Astronomy 2009 celebrations. The exhibit is scheduled to open in mid-October.

AWARDS AND APPOINTMENTS

On 7 May, in a ceremony at Buckingham Palace, Adjunct Scholar Father Michael Heller was awarded the Templeton Prize for his work. He received the following additional awards: Prize of the Prime Minister of the Polish Republic, Honorary Citizen of the City of Tarnow, Honorary Diploma of the Minister of Foreign Affairs of the Polish Republic, and Prize of the Rector of the Pontifical Academy of Theology in Cracow.

On 6 September, George Coyne, S.J., director emeritus of the Vatican Observatory, was awarded the Gregor Mendel Medal by Villanova University, Philadelphia, for his contributions to the discussion of the religious implications of scientific evolution.

On 3 December, Giuseppe Koch, S.J., Vice-Director of the Observatory for Administration, was honored for his 50 years as a Jesuit with a celebration at Castel Gandolfo.

Guy Consolmagno, S.J., completed his term as chair of the Division of Planetary Sciences of the American Astronomical Society. He continues as Secretary of the International Astronomical Union (IAU) Division III and past president of IAU Commission 16. He began a new appointment on the Mars Nomenclature Working Subgroup, and his appointment to the Working Group on Planetary System Nomenclature of the IAU was approved.

I. RESEARCH HIGHLIGHTS

During 2008, Vatican Observatory astronomers reported on studies covering a broad range of topics, from the discovery of two planets in other star systems to the development of a classification system that puts the enormous amount of accumulated star data at astronomers' fingertips. Below we offer popular descriptions of some of this work.

PLANETARY SCIENCES

Discovery of Two Extrasolar Planets

The original aim of the Optical Gravitational Lensing Experiment (OGLE), a long-term project of the University of Warsaw, was to look for "dark matter" in our galaxy. But as it happens, this project has also led to the discovery of two new planets by a team of astronomers led by Vatican Observatory Adjunct Scholar Dante MINNITI.

OGLE was designed to detect the mysterious "dark matter" thought to be responsible for the unusual motions of stars in galaxies by looking at how star brightness changes over time. In 2002 a dedicated OGLE telescope was built in Chile, equipped with a sensitive camera and computer software to track the brightness of each star in the field of view.

Hunting through the OGLE telescope data, however, Minniti, who is also an astronomer at the *Pontificia Universidad Catolica de Chile*, and his colleagues found another kind of fluctuation in the star brightness data: sudden decreases that could only be caused by the transit of planets across the face of these stars. And finally, after several years' effort, in 2008, they were able to confirm their suspicions and publish the discovery of two extrasolar planets.



Dante Minniti

The team members start their search by re-examining the OGLE database to check old candidates, determine when they were likely to have transits by a planet, and run the OGLE software to select new candidates. The team then puts together spectroscopic and photometric databases to select the most promising candidates. To date, they have analyzed about 100 OGLE candidates.

Once a candidate star has been found in the OGLE data, Minniti and his team aim a much larger telescope also located in Chile—the European Southern Observatory's 8-meter VLT ("Very Large Telescope")—at each candidate to measure its radial velocity to see how much the star is pulled by the planet, which reveals the plan-

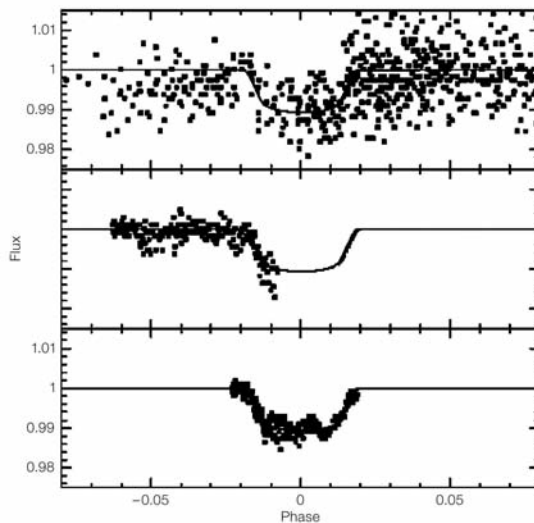
et's mass. They then measure very precisely when the light dips from a transit, and how deeply it dips. The period of the dipping reveals the characteristics of the planet's orbit, while the amount of light blocked tells them the physical size of the planet. This information yields the planet's density, which reveals if it is a gas planet like Jupiter, an ice planet like Neptune, or a rocky planet like Earth.

The candidate planets found in the OGLE data were not confirmed as real planets until the team could clear up discrepancies in their calculations. A large part of the work they did in 2006 was dedicated to eliminating non-planetary candidates from the OGLE selection. After the first year, they had tentative orbits for three possible planets.

The main effort in 2007 was devoted to the difficult task of defining the objects' orbits well enough to be able to predict when transits should occur. Finally, on 19 June 2007, the team observed a full transit of the object known as OGLE-TR-182-b, and determined that it was a Jupiter-like gas giant. Even then, another year's work remained before the report of their discovery was published this past year.

The second planet, known as OGLE-TR-211-b, was no easier to confirm, but the astronomers managed to conclude that it is also a planet, with a planetary mass close to that of Jupiter. Additionally, slight variations of transit times for this planet lead the team to suspect that there may be another massive planet in the system that may be perturbing the orbit, but only future observations can confirm if this is real or due to an instrumental artifact.

This program and the observations carried out prior to it have helped the team gain the experience needed to interpret data that are already coming from spacecraft such as the French COROT mission. Their new insight from working with the OGLE data has led to a more-realistic prediction of the space mission yields and taught the team how to efficiently identify the spectroscopic signatures of planetary impostors.



The dip in each light curve is the telltale sign of a planet passing in front of the star known as OGLE-TR-182. The top curve, from the original OGLE data, only hints at the planet's transit. The dips are unmistakable in data from the Very Large Telescope in Chile, showing the beginning of the transit (middle) and full transit (bottom).

About this study: A popular account of these discoveries can be found in Minniti et al., 2008, *Messenger*, 133, 21. Additionally, this work was reported in the following journal articles: Lopez-Moralez et al. 2008, *Astronomical Journal*, 136, 1901; Pont et al. 2008, *Astronomy & Astrophysics*, 487, 749; and Udalski et al. 2008, *Astronomy & Astrophysics*, 482, 299.

Solar System Stratigraphy



Guy Consolmagno, S.J.

Astronomers have long known that the rocky asteroids dominate in the inner asteroid belt between Mars and Jupiter, while the darker and possibly water rich C-class asteroids are more likely found in the outer belt; ice-rich objects (D types) mostly occur at Jupiter’s distance and beyond. New work by Vatican Observatory astronomer Guy Consolmagno, S.J. and his colleague Dan Britt with the University of Central Florida shows that these different types of asteroids are also systematically more and more porous as one moves from the inner to the outer part of the asteroid belt; material toward Jupiter and beyond is up to 80% empty space. This finding shows that the solar nebula out of which the planets formed was not only chemically zoned – just like rock layers on Earth – but its physical state also varies with proximity to the nascent Sun. This is an important new clue into how the planets themselves were formed.

About this study: This work was reported at the 10th *Asteroids, Comets, Meteors* meeting held 14-18 July 2008 in Baltimore, MD, hosted by the Johns Hopkins University Applied Physics Laboratory.

STELLAR ASTRONOMY

Searching for a Stellar “Needle” in a Haystack of Data

What happens to the enormous amount of star data that astronomers from around the world collect at their telescopes? In recent years, as this information has become available in digital form, it has been archived in large computer databases accessible to any other astronomer who may have an interest in those star images or spectra for their research.

But astronomers are challenged to find the actual stellar data they need in the terabytes of data already archived. They face a classic case of finding a needle in a haystack. Computer searches are, of course, the answer—the “magnet” that can pull out the needle. But a simple Google-like search will not work with complicated stellar data. In order to make the right stars “stick” to the “magnet” for any given search, the data

have to be organized in a way that is simple and makes sense both to the computer and to the astronomers using the computer. Up to now, searching stellar databases for groups of stars with common properties has been difficult and with limited capabilities. To solve this problem, Vatican Observatory astronomer Christopher Corbally, S.J. and his colleagues devised a classification encoding system for stellar spectra that are stored in archival databases. Their system is currently being tested on the Space Telescope Science Institute's Multi-Mission Archive (MAST), which contains spectra of more than 10,000 stars and galaxies obtained from NASA space missions, such as the Hubble Space Telescope.

This team of database gurus and experts in the classification of stars put considerable effort into making their search system easy and comprehensive, despite all the many varieties of stars and their attendant peculiarities. With this system, spectral classes are encoded into a digital format listing each star's spectral type and sub-type, luminosity class, and possible spectral peculiarities. The experience that Corbally and team member Richard Gray, professor of astronomy at Appalachian State University, gained in writing their book *Stellar Spectral Classification* (Princeton University Press, in press for 2009) proved invaluable to being able to schematize all the classification possibilities. The other team members are: project coordinator Myron Smith, database expert Randall Thompson, and European Space Agency researcher Inga Kamp.

After the team's Spectral Class Encoding System completes the test phase on MAST, it will be reviewed to become an approved tool of MAST within the International Virtual Observatory Alliance, whose stated mission is "to make it possible for astronomical researchers to find, retrieve, and analyze astronomical data from ground- and space-based telescopes worldwide."

About this study: This work can be found in Smith et al., 2008, IVOA Note, at www.ivoa.net/Documents/latest/SpectClasses.html

MAST

MAST STScI Tools Mission Search Tutorial Site Search
About MAST Getting Started Suggestion Box

Spectral Classes Search

Sp. Types	Subtypes	Lum. Class	Peculiarities
O	all	all	none
B	0	V	comp.
A	1	IV-V	Sp
F	2	III	high
	3	II	SiC
	4	I	Eu
			Cr
			met-wk
			met-str
			Am

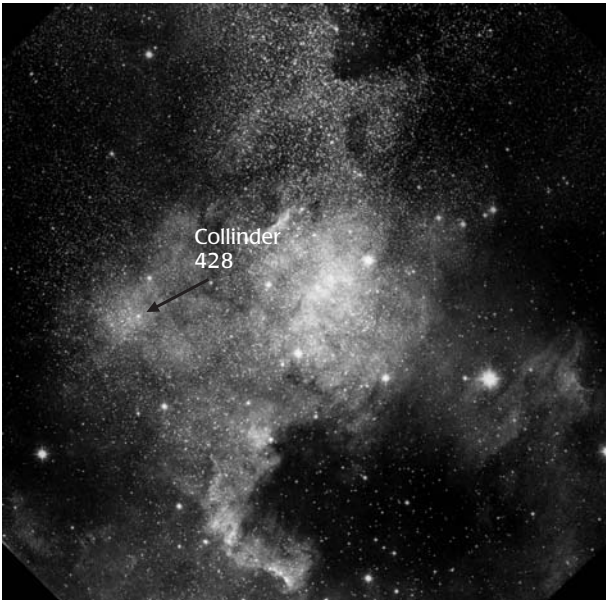
Search Reset Clear Form

Spectral class:
(TT.tt.LL.PPPP)

This deceptively simple web form is part of a new search system that is being tested as a way for astronomers to sift through the massive amount of data in the Space Telescope Science Institute's Multi-Mission Archive (MAST), and quickly find the data they need for their research.



Christopher Corbally, S.J.



Arrow locates a star group known as Collinder 428 in the North America Nebula, in this Vatican Observatory archive photo.

Cluster or Coincidence?

In the accompanying photo of the North America Nebula, taken nearly fifty years ago with the Vatican Observatory's Schmidt camera in Castel Gandolfo, an arrow points to a feature known as Collinder 428.

When this feature was first identified in the 1930s, astronomers thought that Collinder 428 was a star cluster embedded in the gaseous nebula. A cluster is a group of stars held together by gravitational attraction. Astronomers, though, had their doubts about Collinder 428. Now new analysis reveals that this feature is merely unrelated background stars peeping through a hole in the dark nebula, making them look like a star



Richard Boyle, S.J.

cluster. The detective work was done by astronomers at the Institute for Theoretical Physics and Astronomy in Vilnius, Lithuania, in collaboration with Vatican Observatory astronomer Richard Boyle, S.J., and his colleagues Frederick Vrba of the US Naval Observatory, Flagstaff, Arizona, and A. G. Davis Philip of Union College, Schenectady, New York. Future work planned by the researchers include analyzing the other groups of stars visible near this nebula to see if they are real clusters or not.

About this study: The work on Collinder 428 was reported in Laugalys V. et al., 2007, *Baltic Astronomy*, 16, 349-382.

EXTRAGALACTIC ASTRONOMY

Elliptical Galaxy Radiation Mystery

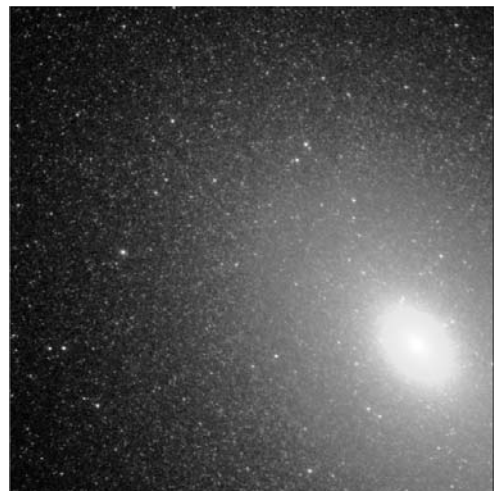
In general, old stars in elliptical galaxies emit light primarily in the longer-wavelength region of the spectrum. We can see visible light coming from them, but you don't expect to see energetic ultraviolet (UV) radiation, since such UV radiation is the signature of young, very active stars. Yet, in some elderly elliptical galaxies, such as M32 pictured here, we do see excess UV radiation. Where is it coming from?

The reason most older stars don't emit such energetic radiation is that the UV rays produced in the cores of these older stars are absorbed by the thick layers of hydrogen surrounding the active cores. If somehow those hydrogen layers could be stripped away, then the UV could reach space (and, eventually, our telescopes.) And in fact, in our own galaxy we do see such "stripped stars" both in globular clusters, and among the regular stars of the galaxy, where they are called "subdwarf B" (sdB) stars since they shine like young active B stars but are much smaller than them.

In the case of such stars in our own galaxy, how do we think this hydrogen stripping occurred? One possibility is that sdB stars were actually formed in a double (binary) star system. When the pair's more-massive star reaches the end stage of its evolution and "puffs out" into its red giant phase, most of its outer hydrogen layer gets close enough to the second star that the second star's gravity could possibly pull off the outer hydrogen layers of its companion, leaving behind an sdB star.

While this process might work with stars in our own galaxy, could this model be applied to stars in elliptical galaxies? One important difference is chemical composition. The stripped stars in the globular clusters of our Milky Way galaxy are very much depleted in metals, that is, in elements heavier than hydrogen and helium. But stars in the elliptical galaxies are very much enriched in these elements. Will this different chemistry make a difference in how such stars evolve?

To find an answer to this question, Vatican Observatory astronomer David Brown, S.J., has been using and adapting a series of very complex computer models that calculate how a star evolves over the course of its lifetime. With these programs he was able to perform a series of calculations for single and binary stars with different metal contents. He found that the abundance of these heavy elements does not directly affect the mass transfer process between stars in binaries. This is good news for applying the binary stripping model to elliptical galaxies, but the rest of Brown's findings aren't necessarily as encouraging. His calculations show that the heavy elements do



Elliptical galaxy M32 imaged by the Hubble Space Telescope

NASA, SPACE TELESCOPE SCIENCE INSTITUTE



David Brown, S.J.

affect the rate at which stars in binary pairs evolve to produce sdBs. Furthermore, the composition of the stars also determines when sdBs appear from the different evolutionary scenarios that produce them, and the epoch during which particular sdBs will dominate the population. These results put certain constraints on using the binary stripping model to explain the UV radiation coming from the elliptical galaxies.

Brown's results were able to reproduce reasonably well the star populations actually observed in the globular clusters NGC 6791 and NGC 6752 in our Milky Way galaxy. However, his findings still do not explain why the number of sdB stars in binary systems is different for stars that do and do not belong to globular clusters within our own galaxy. The mystery remains unsolved!

About this study: This work will be published in Brown's doctoral thesis, "The Applications of Binary Population Synthesis Methods at Different Metallicities to Sub-Dwarf B Stars," which he successfully defended at Oxford on December 8, 2008.

Filling the Gaps in Galaxy Data



José Funes, S.J.

The growth of galaxies is shaped by star formation and its interaction with the interstellar medium, but astronomers only have a sketchy picture of what's happening. To fill in the data gaps, Vatican Observatory director José Funes, S.J., has been working with a team of scientists led by Robert Kennicutt of the Institute of Astronomy, University of Cambridge, UK, and Janice Lee of Carnegie Observatories, Pasadena, California, to survey a suite of galaxies lying relatively nearby to our own Milky Way galaxy, close enough that they can map out the regions within these galaxies where stars are formed. The team aims to look at a wide range of different galaxy types, to discover the effects that their traits have on the way stars are formed and interact with their environment within their galaxies.

The project is called the Local Volume Legacy, which looks through data already collected by the Spitzer Space Telescope for a sample of 258 galaxies located within 11 megaparsecs (about 36 million light years) from Earth. This survey includes all known galaxies within the closest 3.5 megaparsecs, and a sampling of spiral and irregular galaxies from the larger and more representative region.

The project goal is to produce a census of the local Galactic neighborhood, with data in many different colors, including even the faintest galaxies, taking advantage of Spitzer's high resolution and ability to measure wavelengths of light that cannot be seen from the

surface of the Earth. These data will then be compared with data for the same objects obtained from a number of other surveys that are using both large Earth-based telescopes, such as the Very Large Array radio telescope in New Mexico and the Giant Metre-Wave Telescope in India, and other orbiting telescopes such as the Hubble Space Telescope.

By filling in critical data gaps, the Local Volume Legacy project provide the astronomical community with a core set of data on the Galactic neighborhood.

About this study: This work is described in *Formation and Evolution of Galaxy Disks*, eds. J.G. Funes and E.M. Corsini (San Francisco: ASP Conference Series, Vol. 396). This book is the proceedings of an international conference held by the Vatican Observatory 1-5 October 2007 at the *Centro Convegni Matteo Ricci*, Rome, Italy.

COSMOLOGY

Other Ways to Look at the Big Bang

The “Big Bang” is the popular name given for our current understanding of the origin and early evolution of the Universe. It encompasses a mathematical description of how space and time evolve, constrained by our understanding of the basic physics of matter and our observations of how the universe looks.

But for those working in the field of cosmology, there is more than one “Big Bang” model—any number of possible assumptions exist on which mathematical models can be based. Thus the work of the cosmologist is to test these alternative models, to see which ones are consistent with observations, and to suggest new observations or measurements that, in turn, may be able to provide definitive tests for the different Big Bang models. Some of this work is being carried out at the Vatican Observatory by cosmologist William Stoeger, S.J., in collaboration with cosmologists around the world.



William Stoeger, S.J.

The simplest, and thus in many ways most elegant, variations of the Big Bang model are based on assumptions about the mathematical shape of the universe first developed by four scientists—Alexander Friedmann, Georges Lemaître, Howard Percy Robertson, and Arthur Geoffrey Walker—in the early 20th century. In these models, referred to as “FLRW” for the scientists, the universe is presumed to be perfectly smooth (homogeneous) on the largest scales. Stoeger and Marcelo Araújo (Universidade Federal do Rio de Janeiro, Brazil) have been working for several years to develop a framework for observationally testing cosmological models that do not presume large-

scale homogeneity and thus go beyond an FLRW interpretation of cosmological data. Using this approach one can determine whether or not the universe is indeed close to FLRW on the largest scales, instead of simply assuming that it is.

Mathematical models for the evolution of the universe after the Big Bang must always simplify the complexities of nature. What Stoeger and Araújo have been doing is to gradually add more and more complexities into previous models, bringing them a little closer to reality while seeing just how important those added wrinkles are to our understanding of how the universe evolved.

Over the past year, the researchers have been extending and improving their approach developed in previous studies. They looked into what happens if, while still assuming the universe is the same in every direction (“spherically symmetric”), it is filled with vacuum energy—the most likely type of “dark energy”—in a uniform way. This would explain the apparent acceleration of cosmic expansion, for which there is increasing strong evidence. They then constrained these models to match the data for that part of the universe that can be causally connected to our local neighborhood. Apart from being interesting in its own right—showing how that kind of data can control how the models behave—this work also illustrates how such data controls the evolution of a universe that follows the FLRW assumptions; and how to treat the general equations that control such a universe even in the non-FLRW case.

About this study: This work is reported in Araújo et al., Phys. Rev. D., 78, Issue 6, id. 063513.

THEOLOGY, PHILOSOPHY, AND SCIENCE

Where Science and Theology Meet

In light of our scientific understanding of reality, how can we speak about God’s universal creative action in nature and God’s special action in history, as invoked by major religious traditions? Vatican Observatory cosmologist William Stoeger, S.J., has been exploring the places where science and theology meet, and in a chapter of a book published in 2008 he explores ways in which we can think about God’s action in the Universe.

Three hundred years ago the famous German philosopher and mathematician Leibniz (who, with Newton, invented Calculus) gave a piquant expression to an old philosophical mystery: “why is there ‘something’ instead of ‘nothing’? Not just, “why does the universe exist,” but indeed, “why does existence itself exist?”

A principle common to Jewish, Christian, and Islamic philosophical traditions is the idea that God created the universe “from nothing”—*creatio ex nihilo*, as the philosophers put it. Stoeger points out that there is a great difference between the “nothing” that the philosophers are talking about here, and the physicists’ idea of a vacuum. Even where there is no material substance present, as you might find in deep space far from any galaxy that this space still has “space” and “time” and the laws of physics that allow physics to operate in these places. By contrast, the philosophers are referring not to empty space, but to the very reason that space and time itself exist. Indeed, in the theological tradition, the fact that existence continues to exist from moment to moment is tied up in the same mystery. And so they speak not only of *creatio ex nihilo* (creation from nothing), but also *creatio continua*: the fact that at every instant, the continued existence of the universe itself is deliberately willed by God, who in this way is continually causing the universe to remain created.

We can never completely understand how God creates. But, as Stoeger puts it, a compelling case can be made that this *creatio ex nihilo/creatio continua* primary causality model provides “the least inadequate” account of God’s creative action.

What the natural sciences investigate are the “secondary causes” (everything that happens besides this creative action of the Creator); it is through these secondary causes that the universe unfolds in all its richness. God continues to act as Creator in and through them, sustaining them in their existence and their efficacy. In fact, Stoeger argues, there are strong indications that God’s particular actions in human history are an ongoing manifestation and mode of God’s universal creative action, properly understood as multi-faceted and highly differentiated.

However, there are two key aspects that are critical for accepting this approach. The first is to realize that the character of our description of divine creative action, and indeed of our language about God, can only be seen as a poetic analogy for the reality. God, as the reason for why everything exists, is not just another entity alongside the entities of reality—just another law of physics. And along with this, it is essential to remember that God’s action is radically different than other actions and causes. It enables and empowers and gives existence to the rest of the actions of the universe, but does not substitute or intervene among them. Nor does it bring about change—it is never experienced as a completely separate cause that effects change; rather it is what makes change possible.

The second aspect has to do with the causes that the natural sciences investigate. None of those laws of nature in themselves provide the ultimate source of either order or existence. Physics is incapable of doing that. It always has to start with something—a field

potential, energy—and well-defined states of that “something.” These must possess some dynamical regularities or order; and then physics can describe how you get from one state of such a system to subsequent states, or what had to precede a given state—presupposing the existence of time. Thus, physics and the other natural sciences are simply, in principle, not capable of providing the level of ultimate grounding and explanation that Creation does.

Stoeger argues that, with proper understanding of these two aspects, a deep compatibility and complementarity can be seen between the natural sciences and Jewish, Christian, and Islamic philosophical/theological accounts of creation.

About this study: This work was published in *Scientific Perspectives on Divine Action: Twenty Year of Challenge and Progress*, eds. R.J. Russell, N. Murphy and W.R. Stoeger (Vatican City State: Vatican Observatory Publications, 2008).

II. INSTRUMENTATION AND TECHNICAL SERVICES

Vatican Advanced Technology Telescope (VATT)

Working with Bob Peterson as the University of Arizona Steward Observatory’s mountain operations manager and Ken Duffek as the VATT manager, Christopher Corbally, S.J., remains director for the VATT, while Richard Boyle, S.J., is the telescope scientist and scheduler. Ned Franz, Dave Harvey, Chris Johnson, and Gary Gray comprise the rest of the VATT’s regular engineering team.

This year has seen a change in personnel. Chris Tardif, our electronic engineer, left the department and is now perusing a graduate degree at the University of Arizona. We at the VATT wish him the best in his future endeavors.

Telescope Upgrades

A major computer and network upgrade was performed in the summer of 2008. Important highlights include:

- A 1 gigabit fiber isolated network with a 10 gigabit backbone for the entire observatory. Harvey and Johnson worked diligently on porting current control software over to the new Hewlett Packard (HP) computers. This is the first gigabit network to be installed on Mt. Graham.
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- A cooling system for the HP computer racks was also designed and integrated for maintaining proper operating temperatures of the new computers and networking equipment.
- Harvey also upgraded the NTP server as well as converted all analog video links from the telescope to fiber optics. This method of isolation was completed to minimize lightning damage, increase network robustness, and protect the new computer equipment kindly donated by Hewlett Packard Corporation.
- Harvey and Johnson, with Boyle, have been instrumental in continued observer training and support during the observing season.
- Currently, the VATT computer up-time has been running at 99.8%. With the upgrade, it is anticipated that our computer up-time will increase to 100% reliability.



Chris Johnson at the climate-controlled computer rack, part of the HP upgrade at VATT.

DAVID HARVEY PHOTOGRAPHY

Power Audit

Prior to the summer shutdown, VATT manager Duffek coordinated a power audit for the observatory site. This audit was ordered to determine phase balancing of the observatory's electrical power distribution system and proper grounding of the VATT building ground grid to the microwave communications tower. The report generated from the power audit showed that the building phases were well within 10% of balance. A few electrical code violations were identified as well as excessive UPS ground currents. Franz and Gray took on the task of fixing the code violations, and they rectified all UPS ground problems by isolating building ground from UPS ground.

Microwave Grounding

The microwave communication tower, which stands near to the VATT building, was found with a 56 ohm ground impedance that did not meet the Motorola standard of 25 ohms or less. Our investigation showed the cause of this problem to be that the chemical ground was destroyed, exposing the observatory to a lightning risk. An exten-

sive repair plan was implemented by the VATT, and with the help of MGIO and the LBT group, the microwave tower grounding scheme was repaired and improved to 0.5 ohms. This is well within the Motorola standard. The VATT team on this project consisted of Franz, Gray, and Duffek.

Safety Program

In the last year we have implemented a safety program at the VATT. This program involves identifying potential hazards to personnel and telescope equipment. Problems ranging from pinch points on the telescope to fall protection have been addressed. The Steward Observatory safety manager, Dale Web, and mountain operations manager Peterson visit the observatory quarterly for a walk-through to flag any issues. In the last year we identified 24 problems, some related to necessary repairs in a now 15-year-old building. Gray completes these repairs in a timely manner as they arise and are assigned to him.

Gray has done an outstanding job repairing the concrete deck on the east side of the Observatory. In other work, the observatory water heater was replaced, fire exit doors were labeled, and emergency lighting was installed. At this writing we have addressed all issues and continue to work toward a safer work environment.



Gary Rosenbaum prepares to "hard wash" the VATT primary mirror

DAVID HARVEY PHOTOGRAPHY

Telescope Maintenance

The telescope primary mirror had a hard wash this year rather than a complete re-aluminization. Gary Rosenbaum, a mirror coating expert with the Steward Observatory mountain operations group, came up to train Gray on the hard-washing technique. Rosenbaum also advised on a maintenance procedure for keeping the primary mirror clean. Gray is now a licensed protector and keeper of the mirror.

During this period Franz, Rosenbaum, and Joe Hoscheidt, also from the mountain operations group, developed and revised the pump-down procedure for the VATT 4K CCD camera. This procedure set forth a system to check out and train selected personnel for handling our camera and has contributed to our overall instrument reliability of 98.9%.

Engineering Projects and Staff

When the VATT engineering staff was not on the mountain, they were working on the new optical spectrograph. They have optically aligned the instrument and taken its first image (of a nickel). Testing the motor control portion under freezing conditions is under way. The grating stage has been put into a freezer and taken down to -22 degrees Celsius. Once the cold test is passed, the team will progress to software design and integration.

Vatican Observatory Website

At the prompting of Colleen de Keratry of Petrus Development, the Vatican Observatory's web site is being redesigned by its webmaster, Ayvur Peletier, and managed by Christopher Corbally, S.J. The overall goal is to provide a more interesting and easier browsing experience, while maintaining balance between its various interests, those of a research observatory, those of fundraising, and those of outreach. The content management system "Joomla" is being used with the expectation of making the web site easy to update by those responsible for the data in each part.

III. OBSERVATORY AND STAFF ACTIVITIES

International Year of Astronomy Preparations

In 2009 the Observatory will join in celebrating the International Year of Astronomy (IYA2009) being celebrated through the initiative of the International Astronomical Union and UNESCO. It will honor the 400th anniversary of Galileo's first telescopic observations, one of the epoch-making events at the beginning of modern science.

In 2008 the Observatory continued preparations for the following IYA2009 events:

- Together with the Vatican Museums and Italy's National Institute for Astrophysics the Observatory, an exhibit at the Vatican Museums featuring telescopes down through the centuries. The exhibit will open in the autumn of 2009.
 - Together with the Pontifical Academy of Sciences, a Study Week on Astrobiology to be held at the Academy 6-10 November 2009.
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- A meeting 21-26 June 2009 of Vatican Observatory Summer School alumni on the theme of "Astronomy: A Stimulus to Dialogue on Humanity's Common Concerns." The meeting will be held at the *Istituto il Carmelo* Conference Center at Sassone, Italy, near the Observatory headquarters at Castel Gandolfo.

In addition, the Observatory is one of the sponsors of the following IYA2009 international conferences:

- The Galileo Affair: A Historical, Philosophical, and Theological Re-Examination, to be held 26-30 May 2009 at the *Istituto Stenssen* in Florence.
- VI Conference on the Inspiration of Astronomical Phenomena to be held 18-23 October 2009 in Venice.

Observatory Activities

From 23-27 June eleven members of the Observatory and three younger Jesuits who are candidates to join the Observatory met at Calascio (Italy) to discuss the direction and future priorities of the Observatory (see From the Director).

On 30 June staff members of the Observatory with Louis Caruana, S.J., professor of Philosophy at Heythrop College, and Pawel Kapusta, S.J. professor of Theology, at the Pontifical Gregorian University, met to discuss important issues and concerns related to science, philosophy, and theology.

The following seminars were held at Castel Gandolfo: "Density of Very Faint Meteoroids" by JEAN-BAPTISTE KIKWAYA, S.J.; "Asteroids and the Stratigraphic Sequence of the Solar Nebula" by GUY CONSOLMAGNO, S.J.; "Laws of Nature and Purpose in the Universe" by GEORGE COYNE, S.J.

A seminar on "Religion and Science in Today's America," sponsored by the Vatican Observatory and the Lumen Christi Institute for Catholic Studies at the University of Chicago, was held 11 October at the Adler Planetarium in Chicago.

Cardinal Lajolo's Visit

Giovanni Cardinal Lajolo, President of the Pontifical Commission for Vatican City State and to whom the Vatican Observatory reports, will visit Tucson, Arizona, 26-28 February

2009 to participate in the Vatican Observatory Foundation Board Meeting and the events surrounding it. He will tour the Vatican Advanced Technology Telescope on Mt. Graham. He will also be honored on 2 March at a reception on behalf of the Foundation to be hosted at the Papal Nunciature in Washington, D.C. by His Excellency Pietro Sambi, Papal Nuncio to the United States.

On 2 June, the council meeting of the directors of the Governorate of the Vatican City State, chaired by Cardinal Lajolo, was held at the Vatican Observatory in Castel Gandolfo.

Staff Presentations and Academic Activities

CARUANA • Delivered a paper on “Evolutionary Ethics and Intentional Content” at the conference on Biological Explanations of Behavior: Philosophical Perspectives held from June 12-15 at Leibniz University, Hannover, Germany.

CHINNICI • Gave a talk prepared in collaboration with S. Maffeo, SJ, on the historical instruments in the Vatican Observatory at the XXVII Scientific Instrument Symposium, held in Lisbon from 16 to 21 September 2008.

CONSOLMAGNO • Spoke on “Meteorite Porosity and Asteroid Structure” to the physics department of Williams College, Massachusetts, on 13 February, and to the physics and astronomy department of the University of Louisville, Kentucky, on 16 April • Presented a seminar on “Meteorites, Asteroids, and the Structure of the Solar Nebula” at the headquarters of the European Southern Observatory in Garching, Germany, on 23 September, and at the department of physics and astronomy of Union College, Schenectady, New York, on 9 October.

CORBALLY • On 18 September gave a talk in the Astronomy Lecture Series at Embry-Riddle Aeronautical University, Prescott Campus, Arizona. He spoke on “Rock Stars and the L & T Dwarfs.” • This was also the topic of his talk on 12 November at Pima Community College East Campus, Tucson, Arizona, in its Lecture Under the Stars series. • Participated regularly in the Star and Planet Formation Discussion Group at Steward Observatory, in which he led on 24 November the topic of “The Context of λ Boötis Stars for HR 8799 and its Exoplanets.”

COYNE • Taught the general astronomy course, Natural Sciences 102, during the Spring semester at the University of Arizona, Tucson. • From 14 to 21 March served as JFK Russell Fellow at the Center for Theology and the Natural Sciences (CTNS), Berkeley,

California. As Fellow, gave a talk on 15 March at the research conference of the CTNS on the topic "Twenty Years After the New View from Rome: Pope John Paul II on Science and Religion." • Gave a keynote address to the XXII Congress of the National Astronomy Society of Mexico at the Universidad Iberoamericana, Mexico City, on 18 April. • Gave an invited lecture on "Emergence in Neo-Darwinian Evolution: A Basis for Ethics in Astrobiology," at the Workshop Astrobiology: Expanding Our Views of Society and Self, held May 7-10 at Biosphere 2, near Oracle, Arizona. • Gave a lecture on "Determining the Age of the Universe" to the Villanova University Chapter of the Sigma XI Society on 5 September at Villanova University, Villanova (Philadelphia), Pennsylvania. • 18-19 September served on the International Selection Committee for the Bower Prize for Achievement in Science at the Franklin Institute, Philadelphia. • At the Catholic University of Leuven, Belgium, on 9 December he chaired a seminar on the traditions of the Church up to today regarding its relationship to science. He also gave a public lecture on "The Evolutionary Universe."

FUNES • Taught a course on Cosmology during the fall semester in the School of Philosophy, Pontifical Gregorian University. • On 20 February gave a Colloquium on "Galaxy Evolution in the Local Universe" at the Department of Physics, Catholic University of America, Washington, DC. • Gave a keynote address to the XXII Congress of the National Astronomy Society of Mexico at the Universidad Iberoamericana, Mexico City, on 18 April. • Gave a Magisterial Lecture for the opening of the academic year at the *Istituto Superiore di Scienze Religiose San Metodio*, Syracuse (Italy).

HELLER • Gave an interview to the Polish Science Voice on "The God Particle and the Scientific Universe." • He made a press statement about our struggles with Chronos at the Templeton Prize News Conference on March 12. • He also gave addresses at Buckingham Palace on the occasion of the Templeton Prize Award and later at the Polish Club. • On May 7 at the Royal Society, London, he gave a paper on "The Existence of Singularities and the Origin of Space-Time" at the research symposium in his honor on the occasion of his receiving the 2008 Templeton Prize. • On 19-20 May he participated in the 12th Cracow Methodological Conference, Science and Mass Culture. • On 3-4 October he gave a paper on "Homo Sapiens in the Copernican Universe" in Cracow at the conference organized by the Department of Physics, Astronomy and Applied Informatics of the Jagiellonian University and Philosophical Faculty of the Pontifical Academy of Theology.

STOEGER • Participated in the Physics of Fisher Information Workshop in the Department of Optical Sciences, University of Arizona, Tucson, from April 6-11. • Was a principal organizer and participant in the workshop "Astrobiology: Expanding Our Views of

Society and Self,” held May 7-10 at Biosphere 2, near Oracle, Arizona. At the workshop, he delivered one of the invited presentations: “Astrobiology and Beyond.” • From May 29-June 1 he participated in the 3rd International Conference on Theological Aesthetics at the Jesuit School of Theology at Berkeley, California. He contributed a presentation on “Relationality and the Interplay of Unity and Diversity in Nature: Beauty, Mystery and Understanding.” • He convened and chaired the Theology and Natural Science Topic Area Program at the Annual Convention of the Catholic Theological Society of America, June 5-8, in Miami, Florida. • From June 12-15 he was the principal speaker at the annual Cosmos and Creation Workshop at Loyola College, Baltimore, Maryland. • On July 3 he lectured on “The Importance of Inhomogeneous Cosmologies” to the Astrophysics Group at the University of Rome La Sapienza. • He delivered a lecture on “Emergence, Top-Down Causality and their Implications for Theology” on July 8 to the philosophy and science research group at the Pontifical Gregorian University in Rome. From August 6 to September 9 he worked with Ellis and Hellaby in the Cosmology Group, University of Cape Town, South Africa. While there he delivered a seminar on “The Evolution and Extent of Local Cosmic Domains.” • December 15-17 he participated in and served on the Scientific Organizing Committee for a workshop on “The Nature of the Laws of Physics,” held at the Beyond Center for Fundamental Concepts in Science at Arizona State University, Tempe, Arizona.

WHITMAN • Attended the 46th annual summer meeting of the Clavius Group of Mathematicians, held at Saint Louis University, St. Louis, Missouri, from June 22 to July 19. The participants this summer consisted of five Jesuits priests, one religious sister, nine married couples, and four other lay persons. Various topics in mathematics were discussed.

Public and Educational Outreach

CARREIRA • Presented papers on Science and Faith at the 2008 Metanexus Institute Annual Meeting held in Madrid in July and at congresses in Bogota, Colombia, and at Oviedo, Valencia, and Tenerife in Spain. • He gave a week of lectures in Arlington, Virginia, for the Spanish-speaking members of the diocese.

CONSOLMAGNO • On March 2 discussed his book “God’s Mechanics” at the Forum of Grace Episcopal Cathedral in San Francisco. A video of the presentation can be found at: http://fora.tv/2008/03/02/Brother_Guy_Consolmagno_God_s_Mechanics • March 25-28, he was the lead speaker at the biennial Jesuit Theology School, a gathering of British Jesuits. Over a period of four days he delivered talks on the theme of Encountering the Creator, including “Astronomy, God, and the Search for Elegance: How Science Actually Works”; “The Creator of Heaven and Earth: Challenges to our

Understanding of God”; “The Supernatural in Nature: Finding God in the Universe”; and “Heaven or Heat Death? The End of Everything”. Versions of these presentations were later published on the British Jesuit website: www.thinkingfaith.org. • On April 8 he presented a lecture in the Shulman Lecture Series on Science and the Humanities at Yale University. His topic was “Heaven or Heat Death?” • August 8-10 he participated in the annual SciFoo camp at the world headquarters of Google in California, and presented a history of the Vatican Observatory. This unusual conference brings together two hundred notable scientists by invitation only from all fields to speak about their interests in an informal setting.

CORBALLY • Spoke August 15 to the Huachuca Astronomy Club of Southeastern Arizona on “The Vatican and Astronomy.” • On 18 September presented “Would Organized Religion Survive an Encounter with Extraterrestrials?” in the Star Talks series at Prescott Public Library, Arizona. • Visited Our Lady of the Mountains Middle School, Sierra Vista, Arizona, on 7 November and spoke on “The Vatican and Astronomy.” • Hosted groups from Holy Trinity Monastery, St. David, Arizona, and from the Diocese of Tucson Chancery for a visit to the Mount Graham International Observatory and the VATT. • Regularly helped lead by videoconference the monthly discussions of the St. Agatha Catholic Church Faith/Astronomy Dialogue, Portland, Oregon.

COYNE • On 25 January attended a dinner reception in Los Angeles with prospective donors to the Vatican Observatory Foundation (VOF). • Organized and gave a talk at a reception hosted on 20 February by His Eminence Francis Cardinal George at his Chicago residence for friends and benefactors of the VOF. • As President of the VOF, hosted the semi-annual board meetings of the VOF in Tucson on 29 February and in Chicago on 10 October. • Gave a talk on “How Old is the Universe?” at the seminar for friends and benefactors of the VOF held on 28 February in Tucson. • On 18 March he also gave a public lecture at the Jesuit School of Theology, Berkeley, California on “The Dance of the Fertile Universe.” • On 28 March gave a talk at Amherst College, Amherst, Massachusetts on “The Origins of Life in the Universe.” • Gave a talk on 8 April to the Sonoran Astronomy Society, Green Valley (Tucson), Arizona on “The Evolutionary Universe.” • At the University of North Carolina, Charlotte, on 14 April gave a talk on “The Implications of Scientific Evolution for the Science-Religion Dialogue.” In addition to the university, the talk was sponsored by the Piedmont Liberal Forum. He also gave a talk on 13 April at the Charlotte Universal Unitarian Church on “Science and Religion. Can We Talk?” • On 28 May, as President of the VOF, signed a contract with Petrus Development, Ltd. for the organization of fundraising for the VOF. • On 4 September gave two lectures at the

College of New Jersey: to the Physics and Astronomy Club on the “Age of the Universe” and to the public on “Scientific Evolution and Intelligent Design.” • Met on 5 September with His Eminence Justin Cardinal Rigali, Archbishop of Philadelphia, Pennsylvania; on 8 October with His Excellency Martin J. Amos, Bishop of Davenport, Iowa; and on 4 November with His Excellency Robert J. McManus, Bishop of Worcester, Massachusetts, to promote the work of the Vatican Observatory. • Organized a seminar on “Religion and Science in Today’s America,” sponsored by the Vatican Observatory and the Lumen Christi Institute for Catholic Studies at the University of Chicago and held on 11 October at the Adler Planetarium in Chicago. He gave a talk at that seminar on “Did God Design the Universe? A Catholic Scientist Looks at Evolution.” • On 17 October met with the President of the Ahmanson Foundation in Los Angeles, California to seek funds for the VOF. • On 30 October talked to the Pinnacle Presbyterian Church, Scottsdale, Arizona on “The Heavens Declare the Glory of God.” • On 8 October at St. Ambrose University, Davenport, Iowa he gave The Chair of Catholic Studies Lecture on “Creation and Evolution.” • On 3 November he gave the Deitchman Family Lecture at the Center for Religion, Ethics and Culture of the College of the Holy Cross on “Modern Cosmology and Life’s Meaning.” • On 9 November at a reception hosted by VOF Board member James McGee, at his Glendale (Phoenix) residence, spoke to prospective donors to the VOF on the work of the Vatican Observatory. • Gave a lecture on 12 November to the Chair of Catholic Studies at the Newman Center of the University of Toronto, Canada on “Life in the Universe.” • On 25 November lectured to the Sun City Astronomy Club, Tucson, Arizona on the “Age of the Universe.” • Served on the panel for the Rome seminar of 28 November on “Science 400 Years After Galileo Galilei,” sponsored by *Finmeccanica* of Italy and the Vatican Pontifical Council for Culture. He gave an invited lecture on “The Laws of Nature and Purpose in the Universe: An Historical Overview.” • Met on 29 November in Rome with the Scientific Organizing Committee (SOC) for the next meeting of the Science-Faith Series of *Las Salvadoras* of Buenos Aires, Argentina and on 30 November with the SOC of the Italian Science-Faith Series to plan a joint meeting of the Northern and Southern Sections to be held in the environs of Castel Gandolfo 12-14 June 2009 on *Modelli cosmologici e concezione del mondo*.

FUNES • Participated as moderator in the discussion on “The Scientific Formation” organized by the *Cappella Universitaria “La Sapienza”*, Rome, on 23 May. • Spoke on “Astronomy and Faith” at the *Cappella Universitaria* in L’Aquila (Italy) on 28 January; at the *Centro Culturale Mons. Lorenzo Bellomi*, Trieste (Italy), on 31 March; at the San Giovanni Battista Parish, Parabita (Italy), on 17 May. • Gave a lecture at the Jesuit High School, Wimbledon (United Kingdom) on 7 May.

MINNITI • Gave a series of astronomy talks for children at various schools in Santiago, Chile: Wenlock School, *Colegio San Francisco*, Dagoberto Godoy School. • Talked to the general public at the Santiago Planetarium, at University of Chile Sede Villarrica and to the Faculty of Medicine there; also to the Faculties of Medicine at the *Universidad del Desarrollo* and at *Universidad de Concepcion*. • Gave a talk for the blind at the *Biblioteca Central para Ciegos de Santiago*.

News Media Coverage

CARREIRA • Contributed to 14 radio programs aimed at Spanish speaking listeners of Spain and America.

CONSOLMAGNO • Appeared on the nationally syndicated radio show Coast to Coast the night of April 1. • He was among those featured in an extensive article about the Vatican and Science, "Holy Alliance," which ran in the September issue of *Discover* magazine.

CORBALLY • Was interviewed and answered questions from the public for various episodes of the Drew Mariani Show on Relevant Radio. On 21 December 2007, the topic was "Creation in Six Days," and on 15 January, "The Vatican Observatory's Planned Move." • He was featured on April 18 in a story by Anne Minard, *National Geographic News*, on the "Pope's Views on Science," a topic prompted by the Papal visit to the United States. • He was interviewed on 16 January by Rob Asterino and Father Dave Dwyer for The Catholic Channel, Sirius Satellite Radio, Busted Halo Show, on UFOs and the Vatican Observatory, following the sighting in Stephenville, Texas. • The topic of what the Church teaches on believing in aliens was also his interview subject on 16 May for Rex Huppke, *Chicago Tribune*; on 19 May for the Drew Mariani Show, Relevant Radio; and on 20 May for Brad Hirschfield and Irwin Kula, Intelligent Talk Radio, KXL in Portland, Oregon. All this interest was sparked by an interview by FUNES that had appeared in *L'Osservatore Romano*. • On 6 June he was interviewed by Ian and Colin Cheney, of Wicked Delicate Films, for "The City Dark," a documentary film on the implications for science, health, and philosophy of the disappearance of the night sky in cities. • Was interviewed on 17 June by Mary Woods for the Archbishop's Hour, Catholic Radio, Archdiocese of Santa Fe, about why the Vatican has an observatory. • On 25 August he gave a video interview in Tucson to Mac Tonnie of Ocean Entertainment, Halifax, Nova Scotia, for a documentary on "Life on Other Planets." • He was also interviewed at the VATT, Mount Graham, Arizona, on 5 September by Kris Koenig, Interstellar Studios, for the "400 Years of the Telescope" documentary, for which he continues to advise, and on 1 October by Matthew McGrath, BBC World Service, for the Heart and Soul program on "Aliens," in which STOEGER was also featured. • In preparation for his lecture "Under the Stars," he

gave an interview on 12 November to Jim Parisi, for News Talk, KNST-790, Tucson, on the Vatican Observatory in Arizona. • He answered questions on 22 September from Tim Drake, National Catholic Reporter, on the Church and Space Exploration, for an article on NASA's 50th anniversary.

COYNE • On 21 January gave an interview to Debora Pezzo of the *Corriere della Sera*, Milan, Italy on the role of the Vatican Observatory in the dialogue on science and religious faith. • Interviewed with *Discover* magazine on 18 February. • Appeared on the History Channel on 16 June with a discussion on our scientific knowledge of the beginnings of life on the earth and the implications for religious belief. • Gave an interview on 14 November organized by David J. Lampe, Department of Biological Sciences, Duquesne University for the program, Darwin2009: A Pittsburgh Partnership. • Gave an interview on 25 November to the Vatican Radio on Galileo and the International Year of Astronomy. • Interviewed on 9 December with Lucette Verboven of the Catholic Television Station of Belgium on Galileo.

KOCH • Gave a video interview to *Rome Reports TV News Agency* about the Star of Bethlehem.

Conference Participation

3-8 January: Waianae, Oahu, Hawaii. The Evolutionary Epic: Science's Story and Humanity's Response. CHRISTOPHER CORBALLY, S.J., gave an invited talk.

7-11 January: Austin, Texas. 211th Meeting of the American Astronomical Society. RICHARD P. BOYLE, S.J. presented a paper.

9-14 March: Houston Texas. Annual Lunar and Planetary Science Conferences. GUY CONSOLMAGNO, S.J. co-authored two papers.

16-18 April: Mexico City, Mexico. JOSÉ FUNES, S.J. and GEORGE COYNE, S.J. gave keynote addresses.

1-5 June: St. Louis, Missouri. The 212th Meeting of the American Astronomical Society. CHRISTOPHER CORBALLY, S.J., presented a paper.

8-10 June: Tucson, Arizona. Annual General Meeting of the International Dark-Sky Association. CHRISTOPHER CORBALLY, S.J., participated.

13-17 July: Baltimore, Maryland. Asteroids, Comets, and Meteors. GUY CONSOLMAGNO, S.J. gave a paper.

26 July-1 August: Star Island, New Hampshire. Annual Conference of the Institute on Religion in an Age of Science. CHRISTOPHER CORBALLY, S.J., participated as a Council member.

27 July-1 August: Matsue, Japan. Meteoritical Society Annual Meeting. GUY CONSOLMAGNO, S.J. co-authored two papers.

21-22 August: Pasadena, California. Meeting of Local Volume Legacy Survey team. JOSÉ FUNES, S.J. participated.

8-12 September: Cracow, Poland. Workshop on Photometry–Vatican Observatory and Ignatianum 2008. RICHARD BOYLE, S.J. and ROBERT JANUSZ, S.J. organized and gave papers.

16-21 September: Lisbon, Portugal. XXVII Scientific Instrument Symposium. ILEANA CHINNICI participated and gave a paper in collaboration with SABINO MAFFEO, S.J.

10-15 October: Ithaca, New York. Division for Planetary Sciences of the AAS Annual Meeting. GUY CONSOLMAGNO, S.J. co-authored two papers.

11 October: Chicago, Illinois. Public Symposium on Religion and Science in Today's America. CHRISTOPHER CORBALLY, S.J., GEORGE COYNE, S.J., and WILLIAM STOEGER, S.J. gave invited papers; JOSÉ FUNES, S.J. chaired a session, and JOHN HOLLYWOOD, S.J. served on the organizing committee.

13-17 October: Baltimore, Maryland. International Astronomical Union Symposium 258 on The Ages of Stars. CHRISTOPHER CORBALLY, S.J., participated.

31 October-4 November: Plenary Session of the Pontifical Academy of Sciences. JOSÉ FUNES, S.J. gave a paper.

IV. PUBLICATIONS

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V. OBSERVATORY VISITORS

The Observatory at Castel Gandolfo received the following visitors:

Mons. Alfred Xuerev, private secretary of the Holy Father; H.E. Mr. Rrok Logu, Ambassador of Albania to the Holy See; Members of the Pontifical Academy of Sciences; the participants of the conference "Cosmic Cataclysms and Life" organized by the European Space Agency; members of the Scientific Organizing Committee of ICRAnet.

The following paid working visits to the Vatican Observatory, Castel Gandolfo:

DAVID ARNETT, Steward Observatory, University of Arizona, USA

ILEANA CHINNICI, Palermo Observatory, Italy

STEFANO COLLONA, University of Milan, Italy

ERNESTO DI MAURO, University of Rome "La Sapienza", Rome, Italy

FERNANDO COMERON, European Southern Observatory, Munich, Germany

ENRICO MARIA CORSINI, University of Padua, Italy

NATE LUST, University of Central Florida, Orlando, Florida, USA

ARMANDO REALE, Emeritus Professor, University of L'Aquila. Aquila, Italy

GIORGIO SALVINI, Emeritus Professor, University of Rome "La Sapienza", Rome, Italy

BARBARA VILLANI, Istituto di Fisica dello Spazio Interplanetario, Turin, Italy

The following paid brief visits to the Vatican Observatory, Castel Gandolfo:

KEVIN BAINES, Jet Propulsion Laboratory, Pasadena, California, USA

ARTHUR CHENG, Cambridge Geoscience, Cambridge, Massachusetts, USA

CANDICE HANSEN, Jet Propulsion Laboratory, Pasadena, California, USA

DENNIS MATSON and members of the Cassini-Huygens Imaging Team, Jet Propulsion Laboratory, Pasadena, California, USA

MARK SHOWALTER, SETI Institute, Mountain View, California, USA

ANNE VERBISCHER, University of Virginia, Charlottesville, Virginia, USA

The following paid working visits to the Vatican Observatory Research Group, Tucson, Arizona:

RUGGERO FERRO, Department of Mathematics, University of Verona, Verona, Italy

A. G. DAVIS PHILIP, Union College and Institute for Space Observations, Schenectady, New York, USA

OLGA I. PINTADO, Instituto Superior de Correlacion Geologica, Tucuman, Argentina



