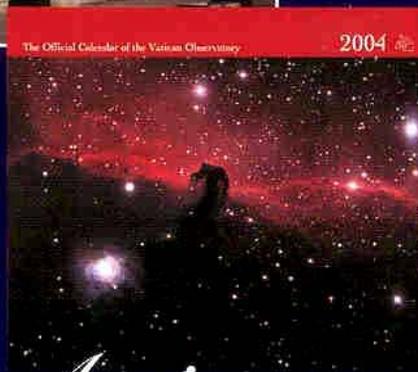
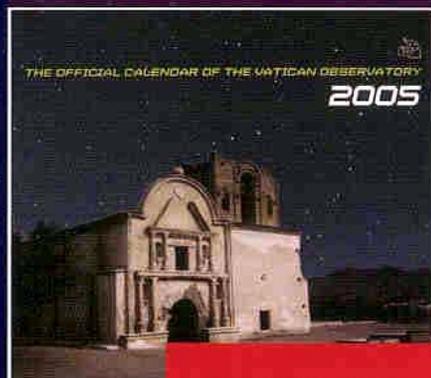
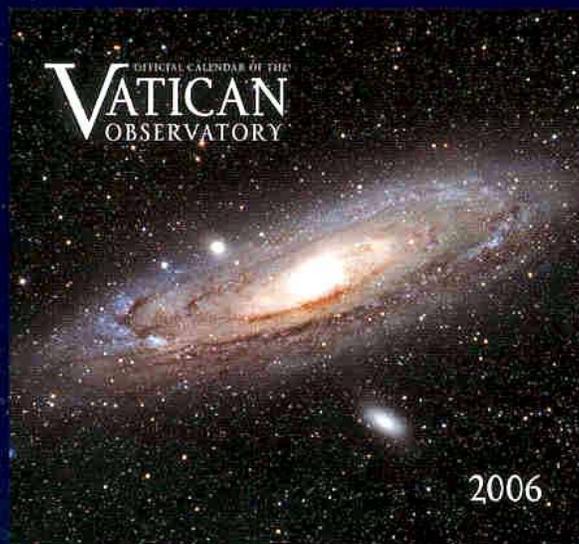


THE VATICAN OBSERVATORY

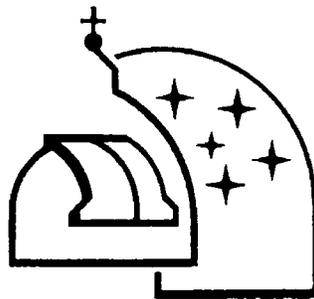
2005 ANNUAL REPORT



*The
20th Anniversary
of the
Vatican Observatory
Foundation*



Vatican Observatory Annual Report 2005



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FRONT AND BACK COVERS *Collage of Vatican Observatory calendars produced by the Vatican Observatory Foundation in support of its fundraising activities.*

Editor: Elizabeth J. Maggio
Cover Artist: Dave Fischer

From the Director

Celebrations

In the 2005 Annual Report, we look back on the year's accomplishments at the Vatican Observatory. But I also would like to take the opportunity here to look forward to three very special celebrations for the Observatory that will occur in 2006. The first celebration is the 100th anniversary of the assignment by Pope Pius X in 1906 of the Vatican Observatory to the Jesuits. This milestone event came 15 years after Pope Leo XIII established the Vatican Observatory, or *Specola Vaticana* as it is known in Italy, which formalized the Holy See's long history of supporting astronomical research that began in the late 1500s with the reform of the calendar.

The second and third celebrations, which are featured here, mark the 20th anniversary of the founding in 1986 of both the Vatican Observatory Summer Schools and the establishment of the Vatican Observatory Foundation .

Vatican Observatory Summer Schools

In 1985 Father Martin F. McCarthy, S.J., now retired from the Observatory, shared with me an interesting observation: The Observatory was at that time a research institution and not a teaching one. He rightly pointed out that this situation deprives us of regular contact with young scholars in our fields of research. We had contact with them only occasionally, and yet they are not only the promise for the future but are usually among the most active and imaginative of researchers. Father McCarthy then asked: Considering the long history of the Observatory, and its definition as a research center according to the wishes of the Holy See, how would it be possible to insert a program of regular contact with the young scientists? Shortly thereafter the idea surfaced of organizing a month-long school to be held at the Observatory at Castel Gandolfo on some special topic of modern astrophysics to which 25 advanced astronomy students from around the world would be invited. Immediately from the beginning, we decided that the school would be a mixture of students from both industrialized and developing countries. A year after Father McCarthy shared his vision with me, the Vatican Observatory Summer Schools (VOSS) was born. We did not know at that time what a wise step we were taking.

We have now held ten VOSS, producing around 250 alumni plus faculty members. We typically receive about 200 applications to each school. Around 70% are excellent, so that the selection of 25 students is intensive and results in a high quality group of young scholars. I must say that VOSS alumni, although a relatively large group, are a real family. When the members of this family later encounter each other at research centers and at international meetings, there is always a celebration of wonderful VOSS memories. In brief, the summer schools not only provide a platform to launch professional careers in astrophysics, but they generate many friendships across international borders.

Of the ten schools' 250 alumni, 45% have been young ladies and 55% young lads. Of these students, 62% came from developing countries and 38% from industrialized ones—in all, 56 nations from every continent, excluding the Arctic and Antarctic (!), have been represented at VOSS. In many ways, however, the most significant statistic is that about 85% of the alumni are still active in research and/or teaching astrophysics, many of them concentrated at major centers throughout the world. For instance, 13 alumni are located in or near Munich, Germany, where they work at the headquarters of the European Southern Observatory, the Max Planck Institute for Astrophysics (*Max Planck Institut für Astrophysik*), and the Institute for Astronomy and Astrophysics (*Institute für Astronomie und Astrophysik*) of the Ludwig-Maximilian University; 10 alumni are located in Tucson, Arizona, at the University of Arizona and the National Optical Astronomy Observatories; 8 alumni call La Plata, Argentina, home where they are members of the Faculty of Astronomical Sciences and Geophysics at the National University of La Plata (*Universidad Nacional de La Plata*); another 7 alumni are at the Center for Astronomical Research (*Centro de Investigaciones de Astronomía*) in Merida, Venezuela; and so on. Knowing personally these young astronomers, I imagine that the VOSS alumni groupings in such centers provides the opportunity for some partying! The point that I am trying to make is that VOSS has succeeded eminently in the goal that we persistently emphasize—to cultivate research in astrophysics among young scholars so that they might influence developments in their own specialties. Many of them are doing a faster dance than their former teachers! And so we have much to celebrate in what they have accomplished.



VOSS 2005 students take a break from classes to learn about the sundial from faculty member Woodruff T. Sullivan, University of Washington, Seattle. (Photo by VOSS student Siramas Komonjinda, Thailand)

Vatican Observatory Foundation

Featured on the cover of this year's annual report are some of the Vatican Observatory calendars produced by the Vatican Observatory Foundation as part of its fundraising efforts. As you can see, these calendars are astronomical works of art, made possible through the efforts of Foundation Board member Brendan D. Thomson.

Why does the Vatican Observatory need a Foundation? It came into being because of the Vatican Advanced Technology Telescope (VATT) at the Mt. Graham International Observatory in Arizona. When the University of Arizona initially approached the Observatory for this joint venture, it was

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easy to see how the VATT would meet the Observatory's needs for an advanced telescope. At the same time the Observatory realized that it could contribute to the technological advancements needed to build even larger telescopes by being the first instrument to use the new spin-cast mirrors developed at the University of Arizona.

While authorities of the Holy See were clearly proud of the role to be played by the Observatory in this world-renowned project, they were not prepared to finance it at a cost estimated to be about five times the annual operating budget of the Observatory. But they were prepared to help us raise the funds, and for this the Vatican Observatory Foundation, a tax exempt scientific research foundation incorporated in the State of Arizona, was founded in 1986.

We had the good fortune in the first several years of the Foundation's existence to raise the funds required for the construction of the VATT and for its short-term maintenance and operation. This "good fortune" was the generosity of ten founding members of the Foundation and, in particular, to the substantial gifts of Thomas J. Bannan of Palm Springs, California, and of Fred A. Lennon of Solon (Cleveland), Ohio.

In its first six years, the Foundation raised approximately \$4.5 million (including the Bannan and Lennon gifts), which was used for the construction and initial operation and maintenance costs of the VATT. Each year since then the Foundation has raised around \$300,000 to continue meeting the operation and maintenance needs of the telescope, with the aim of building an endowment sufficient to cover these costs in perpetuity.

As a result of these activities, the Foundation has attracted a circle of true friends who through their generosity genuinely encourage us in our research. They are, in fact, an important force in that research. Witness to this is the initiative taken by the Foundation to ask staff astronomers to present their research in a popular way during a seminar each year on the occasion of the Foundation's annual meeting of its Board of Directors. Much discussion about science takes place during these seminars, and there is a true sharing in the mission of the Observatory.

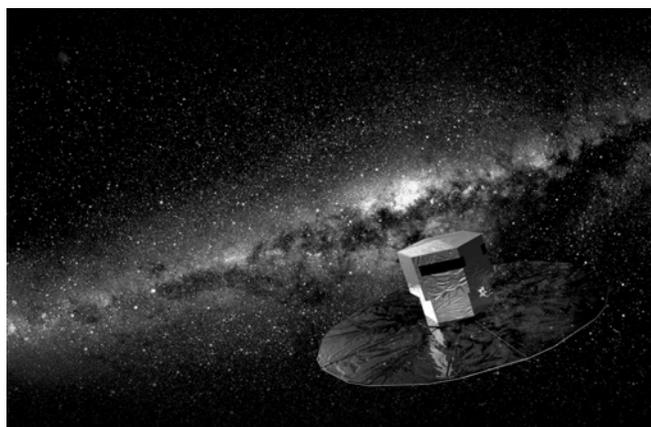
Our Foundation friends come from a wide spectrum of professional backgrounds and geographical locations. The 24 current Board members include men and women in the sciences, financial management, engineering, and medicine. They reside in far-flung cities in the United States: Baltimore, Chicago, Cleveland, Houston, Los Angeles, New York, Philadelphia, Phoenix, Salt Lake City, San Jose, Signal Mountain (Tennessee), and Tucson. Vatican City is even represented!

We are proud of the Foundation's Board members and of all our friends who are associated with the Foundation. We celebrate them as we celebrate the 20th anniversary of the Vatican Observatory Foundation.

Research Highlights

VATT and the Billion-Star Space Mission

In 2012, the European Space Agency (ESA) will launch Gaia, a space mission to measure one billion stars for a census of stellar population in our Milky Way galaxy. The spacecraft, pictured here, will chart the location and motions of the stars and look at them through a variety of filters to record their brightness and colors, all with unprecedented accuracy. This information is needed to clarify the origin and subsequent history of the Milky Way and to get a better picture of its three-dimensional structure.



Artist conception of the Gaia spacecraft mapping the stars of the Milky Way. (Credit: Medialab)

In 2005, after about five years of studying which filters to use on Gaia, ESA announced its top choices. The winners include a set of seven filters based on the Strömvil Photometric System. The announcement was welcome news to Vatican Observatory astronomers Richard Boyle and Christopher Corbally. For many years Boyle and his collaborators have been using the Strömvil filters on the VATT to study the colors of hundreds of stars and to document the system's performance. The researchers classify the stars based on the color data. Corbally then obtains spectra of certain stars to verify and further characterize those that seem interesting for studies of stellar and molecular cloud evolution.

ESA evaluated the Strömvil filters after one of Boyle's collaborators—Vytautas Straizys with the Institute of Theoretical Physics and Astronomy in Vilnius, Lithuania—proposed them for Gaia. The Vilnius institute is where the forerunner of the Strömvil system was developed.

While construction and testing of the spacecraft move to completion, Boyle and colleagues continue their VATT work with the Strömvil filters to provide calibration and preparation for the space mission. This work is key to attaining accuracy for the vast amount of star data to come from Gaia as well as from a new generation of giant ground-based telescopes being developed.

A Violent Stellar Duo

About 30 percent of the trillions of stars in the universe are binaries—pairs of stars that revolve around each other held together by gravity. Studying how binaries interact is helping astronomers learn more about the processes that form stars, and how stars evolve.

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One such binary star system—W Serpentis in the constellation of Serpens (the snake)—has been thoroughly examined by Vilppu Piirola and colleagues at the Tuorla Observatory in Finland, in collaboration with Vatican Observatory director George Coyne.

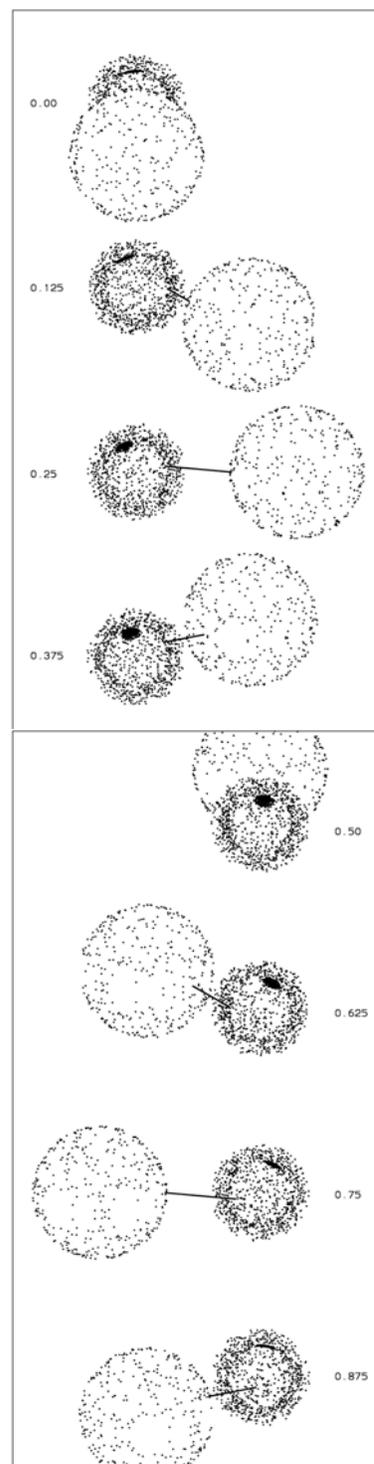
This model of W Serpentis shows the binary star system as it rotates through a 14-day orbital cycle (from top to bottom). Visible is the newly discovered bright spot on the system's smaller primary star. The thin line represents gaseous material that the primary star is siphoning off its larger companion star.

The primary member of this binary star system is a small but massive star that is literally sucking in gaseous material from its larger but lighter companion star. What makes W Serpentis and others like it peculiar is that the mass transfer rate is so high that violent interaction takes place between the mass gaining star and the in-falling gas.

Using telescopes at the European Northern Observatory in the Canary Islands, Piirola and his team monitored W Serpentis for changes in the brightness and polarization of its primary star as the binary system went through several 14-day rotations. In doing so, the astronomers found what looks like a bright spot or jet close to one of the primary star's poles (see figure). This is the first detection of a high latitude spot in such a binary system. The spot may be associated with an accretion disk that is building up around the primary star from the incoming material and completely engulfing it, according to the astronomers.

Tenth Vatican Observatory Summer School

The Tenth Vatican Observatory Summer School (VOSS) in Observational Astronomy and Astrophysics was held at the Observatory in Castel Gandolfo from 12 June to 8 July. The topic of this year's school, "Astrobiological," attracted 25 students from 19 countries. Christopher Corbally, S.J. served as Dean of the school. The faculty included: John Baross of the University of Washington, Seattle; Angioletta Coradini of the National Research Council (*Centro Nazionale di Ricerca*) Rome; Chris Impey of the University of Arizona, Tucson; Jonathan Lunine of the University of Arizona, Tucson; Woodruff T. Sullivan III, of the University of Washington, Seattle; and Nigel Woolf of the University of Arizona, Tucson. On 6 July the young scholars and faculty attended a general audience given by His Holiness Pope Benedict XVI in



St. Peter's Square. Two VOSS students received scholarships for graduate studies: Marcela Ewert of Colombia will study at the University of Washington, Seattle, with a joint scholarship from the university and the Vatican Observatory, and Nikolai Nikolov of Bulgaria will pursue his graduate studies at the University of Arizona with a joint scholarship from the university and the Vatican Observatory.

Personnel News

Ben Dalby has generously accepted the Chairmanship of the Vatican Observatory Foundation's Board of Directors after a unanimous and enthusiastic vote of the Directors. Even before chairing his first Board meeting, he has suggested new members for the Board, renewed the search for a Development Director for Major Gifts, and developed plans to hold an evening for our friends at the opening of the renovated Los Angeles Griffith Park Observatory in 2006.

From January through May, Guy Consolmagno, S.J., completed the Jesuit program of Tertianship, a period of prayer and study that includes a 30-day silent retreat. As a part of this program he spent six weeks at the Center for Science, Technology and Society at Santa Clara University in the San Francisco Bay Area, discussing spiritual issues with scientists and engineers in Silicon Valley and in Berkeley, California.

Gabriele Gionti, S.J., has been assigned to work at the Vatican Observatory Research Group and in the Jesuit Community of Tucson, Arizona, for a two-year period that is part of his Jesuit formation curriculum after philosophy studies are completed. Before entering the Society of Jesus, he earned his PhD in Mathematical-Physics in the field of quantum gravity from the International School of Advanced Studies at Trieste, Italy, and did one year of postdoctoral research in the Physics and Astronomy Department of the University of California at Irvine, California.

Emmanuel M. Carreira, S.J., an adjunct scholar with the Vatican Observatory, retired from teaching physics and astronomy for 32 years at the Catholic University in Washington, DC, and at John Carroll University in Cleveland, Ohio, and from teaching the philosophy of nature at the Pontifical University of Comillas in Madrid, Spain.

Guy Consolmagno, S.J., was voted in as Chair-elect of the Division for Planetary Sciences of the American Astronomical Society. He is currently serving as the Division's vice-chair for the 2005-2006 year; he will become chair in 2006; and in the following year he will continue as past chair.

Michael (Ned) Franz, who as mechanical engineer carried out numerous tasks for the VATT starting with the successful "Kresge project" upgrade between 1998 and 2000, was promoted to Staff Engineer for the VATT.

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Vatican Observatory Foundation Annual Meeting

The annual meeting of the members and directors of the Vatican Observatory Foundation was held on 25 February 2005 in Tucson, Arizona. The following were elected to serve as members and directors for a three-year period:

MANUEL J. ESPINOZA, RICHARD J. FRIEDRICH, JOSÉ FUNES, S.J., JOHN B. HENKELS, JOHN B. HOLLYWOOD, S.J., JAMES C. MCGEE, PETER P. MULLEN, JUNE SCOBEE RODGERS, FAITH VILAS, and ANDREW P. WHITMAN, S.J. A sub-committee for major gifts was constituted and consists of the following members: JAMES MCGEE and MANUEL ESPINOZA (co-chairs), CHARLES CURRIE, KAREN DALBY, NANCY KNOCHE, and ROCCO MARTINO.

On the day preceding the annual meeting, members of the Observatory staff conducted a seminar to present their research in a popular forum to friends of the Observatory and members of the Board; the following day, the same group was accompanied on an excursion to the Mt. Graham International Observatory, home of the Vatican Advanced Technology Telescope.

Through the efforts of NANCY KNOCHE, Development Director, and JAMES MCGEE, Chair of the Development Committee, the Foundation continues the two giving plans announced in previous Annual Reports: the *Circles of Giving* and *Reaching for the Heavens Guild Memberships*.

Once again through the efforts of BRENDAN D. THOMSON, Board Member, an official Vatican Observatory calendar for the year 2006 was produced with the theme "Passion and Participation."



George V. Coyne, S.J., Director

I. Astronomical Research

Theoretical Studies, Astrophysics, and Cosmology

GIONTI, following on his doctoral work (see Personnel News), is working on a formulation of quantum gravity called “quantum Regge calculus.” In this approach to quantum gravity the differential structure of manifolds are substituted by triangulated manifolds, and the resulting structure is called a simplicial complex on which it is possible to define a general relativity structure. This work deals with a manifestly local gauge-invariant formulation of Regge calculus, obtained by introducing a reference frame in each simplex and defining the curvature through holonomies around two dimensional simplexes called hinges. The main hope of this approach is to throw light on the problem of understanding the connections and differences between particle gauge and gravitational fields toward a formulation of a quantum unified theory of the fundamental interactions.

GIONTI continues his research started with D’Adda of the Istituto Nazionale di Fisica Nucleare-Turin section, during his postdoc at the University of California, Irvine. GIONTI is working on finding the right measure for quantum Regge calculus. Recently it was shown that, by assigning coordinates to the vertexes of the simplexes, it is possible to write a measure for quantum Regge calculus that allows a gauge-fixing and a calculation of the corresponding Faddeev-Popov determinant.

GIONTI and ROVELLI (Centre de Physique Theorique de Luminy, Marseille, France) are working to apply the local Regge calculus formalism to the spin foam formalism in loop quantum gravity. Loop quantum gravity is a canonical (Hamiltonian) approach to quantum gravity. The main result of the theory is that the space-area is quantized. The quantum dynamical evolution of the spin-networks happens to be equivalent to the path-integral over simplicial manifolds. This approach is known as spin foam. One of the problems of spin foam formalism is that it is not known how to couple gravity with fermionic as well gauge fields. The local Regge calculus, mentioned above, gives a natural answer to this problem. GIONTI and ROVELLI are working to rewrite spin foam models in terms of local Regge calculus.

GIONTI and BILLO (Physics Department, University of Turin, Italy) have started a research project to study how spin foam models can be derived from models of topological string theory. The goal of this project is to find connections between string theory and traditional quantum gravity.

GIONTI and STOEGER are studying how string theory includes general relativity. Some early work by JUST (Physics Department, University of Arizona) and STOEGER seems to show that in the weak field approximation of Einstein general relativity, the gravitational waves and also the graviton wave function as a low energy limit of quantum gravity and have more than two polarization states, which turn out to be the only polarization states also in string theory. Of course, this problem is crucial to understanding how gravity is included in string theory, as well the nature of the gravitational field and possible consequences for the structure of string theory.

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HELLER, in collaboration with mathematicians from the Warsaw Technical University, continued the program concerning applications of noncommutative geometry to physics. They elaborate a model unifying some aspects of general relativity and quantum mechanics. In previous works they used a simplified model (with a finite structural group). Now they have constructed a model free of this simplification and have studied its properties.

With ELLIS (University of Cape Town, South Africa), STOEGER continues to pursue several outstanding physical and philosophical issues concerning multiverses, particularly the question of their testability and the problem of realized infinity. These are important both for our understanding of quantum cosmological processes that generated our observable universe and the apparent fine-tuning (anthropic principle) it required.

STOEGER, RIBEIRO (Instituto de Física, Universidade do Brasil- UFRJ, Rio de Janeiro) and his students IRIBARREM and ALBANI, have continued testing the fitting of Friedmann-Lemaître-Robertson-Walker (FLRW) cosmological models with a cosmological constant to galaxy luminosity functions and more generally to galaxy number count data. This is a prelude to applying their techniques to more general cosmological models to determine more precisely whether the universe is almost-FLRW on various length scales. In a separate study, they are also investigating the differential density statistics of galaxy distributions and luminosity functions in an attempt to shed light on the connection between the *observational* distributions, which are measured down the observer's past light cone, and the space-like hypersurface distributions, which are not directly observed but correspond to the theoretical distributions in the universe at any given time.

ARAÚJO (Universidade Federal do Rio de Janeiro) and STOEGER are still pursuing cosmological solutions for general perturbations to the Einstein field equations with a cosmological constant in observational coordinates, based on the observer's past light cone, constrained by cosmological data both from astronomy and from the cosmic microwave background.

STOEGER began working with HELLABY (Department of Mathematics, University of Cape Town) and his students and collaborators on various theoretical issues of observational interest connected with inhomogeneous cosmologies, particularly the spherical symmetric, inhomogeneous (Lemaître-Tolman-Bondi (LTB)) cosmologies. In particular, they are investigating the two issues of whether or not acceleration in such models requires a cosmological constant and how density perturbations grow and decay in such models. These issues are directly connected with testing the adequacy and the uniqueness of FLRW models on various length scales.

STOEGER continues to collaborate with JUST (Department of Physics, University of Arizona) on projects relating to quantum field theory and extension of gravitational theory to intermediate energies.

Extragalactic Research

KENNICUTT (University of Cambridge, UK), LEE (Steward Observatory), SAKAI (University of California, Los Angeles), TREMONTI (Steward Observatory), VAN ZEE (Indiana University), and

FUNES continued with the survey named 11HUGS (11Mpc H-alpha and Ultraviolet Galaxy Survey), an outgrowth of the recently completed 11MPC Survey, a ground-based H-alpha and R-band imaging program of a volume-limited sample of 367 spiral and irregular galaxies within a distance of 11 Mpc. As such, the 11HUGS galaxies are a complete subset of the 11MPC Survey catalog that avoid the galactic plane and are observable by GALEX (Galaxy Evolution Explorer). The goal of 11HUGS is to characterize the demographics and star formation properties of nearby galaxies, with an emphasis on the dwarf galaxies that dominate the sample population. The data also provide a foundation for follow-up studies of the HII region populations, star formation, chemical abundance, and ISM properties of the galaxy sample. The combination of H-alpha imaging, which provides snapshots of the ongoing star formation, and UV imaging, which traces star formation over a much longer timescale, will yield powerful constraints on the systematic errors in the inferred star formation related quantities.

CASTILLO (Universidad Nacional Autonoma de Honduras), FUNES, and DIAZ (Córdoba Astronomical Observatory and Gemini Observatory) are studying supermassive black-hole masses and properties of disk galaxies. It is well known that the nuclear activity is related to the existence of supermassive black holes (SMBHs) in the center of galaxies. Different scaling laws are known for the mass of SMBHs and the global properties of their host galaxies, like central velocity dispersion, bulge luminosities at different wavelengths, etc. The researchers have reviewed those correlations for 17 disk galaxies, and they are exploring any possible correlation between the mass of SMBHs and disk properties. No clear correlation between the mass of the SMBHs and the disk properties has been found. There seems to be no dependence on the Hubble type.

FUNES continued his study of elliptical galaxies with dust lanes. The formation and evolution of early-type galaxies is not yet completely understood. The study of the ionized-gas distribution and star formation properties in elliptical galaxies with dust lanes can shed light on the formation process of elliptical, E+A, polar ring, SO, and Sa galaxies. To address this issue, FUNES has started an observational program aimed at obtaining H-alpha and UBR images. With NGC 5128 (Centaurus A) as a prototype, it appears that these galaxies have undergone a major merger event at some point in their evolution. H-alpha and UBR images of six galaxies with a dust lane along the minor axis have been obtained using the VATT. The preliminary analysis of the H-alpha images shows that the observed galaxies have a disk of ionized gas. In the case of NGC 5363, a spiral structure is clearly observed in a disk with intense star formation, which is in agreement with simulations that predict merger remnants have a spiral-like morphology but elliptical-like kinematics.

GUTIERREZ (Instituto de Astrofisica de Canarias, Spain), ALONSO (Consejo Nacional de Investigacion Cientificas y Tecnicas, Argentina), FUNES, and RIBEIRO (Instituto de Fisica, Universidade Federal do Rio de Janeiro, Brazil) continued with the study of star formation in satellite galaxies. They obtained narrow-band observations of the H-alpha emission with the VATT for a sample of 31 spiral and irregular satellite galaxies orbiting giant spiral isolated galaxies. The star forming regions show a rich structure in which discrete complexes are imposed over more diffuse structures. In general, the current star formation rates are smaller than the mean values of the past star formation rates obtained from the current stellar content. However, the current reserve of gas is enough to continue fueling these levels of star formation activity for at least another Hubble time.

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OMIZZOLO, in collaboration with RAFANELLI (Department of Astronomy, University of Padua), carried out spectroscopic observations on active galactic nuclei at the Bok telescope of the University of Arizona on Kitt Peak and photometric observations with the VATT. The data have been reduced, and a publication is in preparation.

The Galaxy and Galactic Objects

BOYLE and JANUSZ, with their collaborators PHILIP (Union College and Institute for Space Observations, ISO); STRAIZYS, KAZLAUSKAS, LAUGALYS, and BARTASIUTE (Institute of Theoretical Physics and Astronomy, Vilnius, Lithuania); SMRIGLIO (University of Rome); and ZAMBRANO (Metropolitan University, San Juan, Puerto Rico) continue research on VATT observations of star clusters. Despite the presence of some scattered light arriving in the focal plane of the CCD camera on the VATT, they now use a method to calibrate the stellar magnitude scale that gives photometry accurate to 1%. Thus they can classify the stars, even if reddened by intervening dust, in temperature and surface gravity. This calibration, or flat-fielding method, relies on observing the galactic star cluster M67 in each observing run at the VATT.

In 2000, three members of the Infrared Space Observatory science team (ADELMAN, BOYLE, PHILIP) wrote a Chretien grant proposal to support STRAIZYS to set up primary standards in the Strömvil system. The American Astronomical Society awarded the grant in 2000, and since that time STRAIZYS has sent four groups of astronomers to Tucson to observe on University of Arizona telescopes. BOYLE was the prime investigator for these observing runs. This phase of the work now concludes with the publication in *Baltic Astronomy* of the photoelectric photometry of 780 stars that have been set up as standards in the Strömvil system. BOYLE and STRAIZYS now hope to send astronomers to South Africa to continue this work in the Southern Hemisphere.

In 2012, the European Space Agency (ESA) will launch GAIA, a satellite that will make astrometric, spectroscopic, and photometric measures of a billion stars down to magnitude 21 for a census of stellar population in our Milky Way Galaxy. Early on STRAIZYS suggested that the Strömvil system, which is used on ground-based telescopes including the VATT, be used in GAIA's intermediate-band filter system. ESA tested this and other proposed systems to see which one would best classify the spectral energy distributions of a large number of stars of all types, and in 2005 chose the Strömvil system. So now the GAIA 14-filter intermediate-band filter set will include seven filters virtually identical to the Strömvil band-passes and seven other filters that are more to the red. After the satellite's photometric measures are completed, this means that the GAIA and Strömvil photometric systems will be the systems used to make the most measures of stars, by orders of magnitude. At present BOYLE, JANUSZ, and PHILIP work on VATT observations; the Lithuanian group makes measures of standard stars and classifies stars; and PHILIP and PINTADO work at the CASLEO (Complejo Astronómico El Leoncito) facility in Argentina. BOYLE and ZAMBRANO are making Strömvil measures using the VATT observations in regions to be studied by NASA's Kepler Mission (to be launched in 2008), which will probe solar-type stars in Cygnus for orbiting terrestrial-sized planets. After 2012 the GAIA photometry will start.

BOYLE tutored LUISA ZAMBRANO, a student selected for the ten week Model Institution for Excellence Project of the Universidad Metropolitana, San Juan, Puerto Rico. This project, directed by Juan Arratia and funded by NSF, involved her participation in the research of BOYLE by making CCD observations with him at the VATT and then moving to Castel Gandolfo to carry out computer processing of the data. BOYLE continued to guide ZAMBRANO in her semester research project during the academic year.

The Nearby Stars (NStars) project of CORBALLY and his colleagues is now two-thirds complete in data analysis. This project has been obtaining spectra, spectral types, and basic parameters of the 3600 stars within 40 parsec of the sun and earlier than M0 spectral type. The principal collaborators are GRAY (Appalachian State University, Boone, North Carolina), CORBALLY, GARRISON (David Dunlap Observatory, University of Toronto), and O'DONOGHUE (St. Lawrence University, Canton, NY). They are using the spectra to provide new, precise spectral types and basic physical parameters (T_{eff} , $\log g$, $[M/H]$). In addition, they are providing measures of the chromospheric activity of these stars. Their efforts in 2005 were on deriving these data for the stars south of -10 degrees declination. Observed and derived data from this project are being released on the project's website (<http://stellar.phys.appstate.edu>) as they are finalized.

CORBALLY continued supporting the investigation of STRAIZYS and collaborators (Institute of Theoretical Physics and Astronomy, Vilnius, Lithuania), with BOYLE, into heavily reddened stars in clusters and other interesting stars. He has completed MK spectral classifications for nearly all stars in the Serpens/Aquila Rift that Vilnius 7-color photometry indicated as "uncertain" and some of such stars in the North American/Pelican nebulae region. The group finished analysis of CCD photometry and classification of about 200 stars in the Aries molecular cloud. Preliminary results were reported in January 2005 at the American Astronomical Society meeting in San Diego. This investigation revealed a considerable number of interesting stars that could be either peculiar or binaries.

PIIROLA has continued work on magnetic cataclysmic variables (mCVs) in collaboration with COYNE and colleagues at Tuorla Observatory, Finland. Circular spectropolarimetry has been applied to study these strongly interacting binaries where the collapsed star, a white dwarf (WD), has a very high magnetic field (10-200 MG). The material accreted from the low mass companion streams onto the WD surface near the magnetic pole(s) with a velocity of several thousand km/s and creates a high temperature (10-40 keV) shock, which is a prominent source of both hard and soft X-rays and optical/near IR cyclotron radiation. At these high temperatures most of the energy of cyclotron emission goes to higher harmonic overtones of the fundamental frequency determined by the magnetic field strength.

The figure on the next page gives an example of the circular polarization and intensity spectrum for EV UMa, which has shown the strongest degree of continuum polarization so far detected in any astrophysical object, $>60\%$ in the near infrared. The upper spectrum reveals two sets of cyclotron harmonic peaks in polarization, evenly spaced on the $1/\lambda$ scale and corresponding to field strengths 11.3 0.2 and 19.5 0.5 MG.

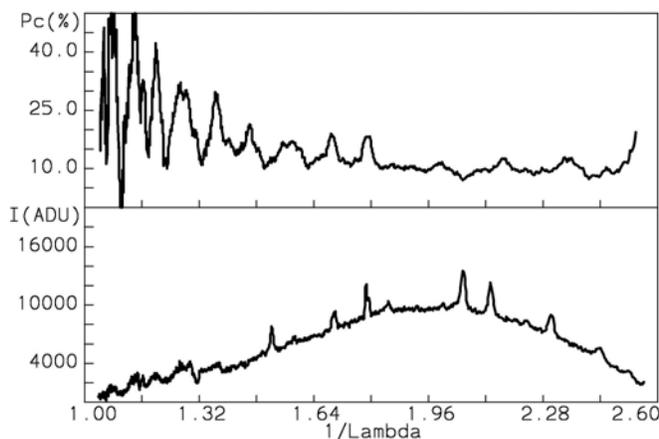
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This illustrates the power of circular spectropolarimetry, which may reveal harmonics even if no cyclotron humps are seen in the intensity spectrum. Furthermore, circular polarization gives the sign of the magnetic field where the cyclotron features originate. This is particularly valuable for complex multiple pole systems, as demonstrated in the snapshot shown for EV UMa, where two magnetic poles of the same sign, but of different field strength, contribute simultaneously. The phase dependence of circular polarization spectra over the spin cycle of the WD, when the visibility of the emission regions changes, carries a wealth of information about the structure of the emission regions on the WD surface and the magnetic field geometry.

In collaboration with COYNE and with colleagues in Tuorla Observatory, Finland, PIROLA has made a comprehensive polarimetric study of the massive, strongly interacting binary W Serpentis. From the phase locked polarization pattern observed over the 14-day binary orbital cycle and by applying new model codes for electron scattering in the circumstellar plasma, the team has discovered a high-latitude scattering spot/jet above the mass-gaining stellar component.

A model of W Ser (see figure in From the Director) shows the spot appearing at different aspect angles as the system rotates through a full orbital cycle. The cool companion star, from which mass is being transferred, is so faint that it can only be seen from the eclipse effects when passing in front of the primary. The polarization changes during the eclipse also reveal a shell of free electrons around the primary star.

W Ser is in a stage of very intensive mass transfer. As an explanation of the high latitude spot/jet, the team suggests that the scattering volume is associated with an accretion disk so thick that it envelopes the primary star entirely—the obscured central object can only be seen through the scattered radiation in the polar directions of the disk, where the circumstellar envelope is thinner and light can escape more easily from the hot central star. The study of W Ser has been published in the October 10 issue of the *Astrophysical Journal* (2005).



Circular polarization (top) and intensity spectra of EV UMa plotted against inverse wavelength. Two sets of evenly spaced harmonics are seen in the circular polarization spectrum. The six peaks to the left from the center correspond to cyclotron emission harmonics 17-12 from a magnetic field of $B = 11.3 \pm 0.2$ MG. The three broader peaks to the right from the center correspond to harmonics 12, 13, and 14 from a field of $B = 19.5 \pm 0.5$ MG. The narrow peaks in the lower spectrum are emission lines from the accretion stream.

Planetary Sciences

Centaur Colors

Significant progress has been made toward identifying different populations of Kuiper Belt Objects (KBOs) by CONSOLMAGNO, TEGLER (Northern Arizona University), and ROMANISHIN (University of Oklahoma) through telescopic observations and analysis of the orbits and colors of the KBOs. The orbital distribution of the observed color classes will help constrain models for the origin and evolution of these distant solar system objects. One particularly fruitful approach has been to look carefully at Centaurs, small bodies that have been perturbed out of the Kuiper Belt into orbits that approach the Sun (and Earth). Because they come closer to us, Centaurs can be more easily observed; as a result, more precise colors can be observed for much smaller objects than is possible for objects in the Kuiper Belt itself.

Although a number of Centaurs have been discovered since the early 1990s, over the past two years the discovery rate for Centaurs bright enough to be well observed with 2-meter-class telescopes (like the VATT) has fallen off; only two such objects have been found since the end of 2003. Thus this moment appears ripe to review the observations of all such objects to date, including unpublished B–R colors of several Centaurs measured this year at the VATT. With these data, both the VATT observers and other observers now have reported colors for 26 Centaurs brighter than 22nd magnitude in R.

There is excellent agreement (mean difference 0.02 magnitudes) for B - R colors of the 15 objects observed both at the VATT and at other observatories; this increases our confidence that there are no hidden systematic errors in the observations. More intriguingly, because different observers should by chance be observing different sides of the objects, the uniformity of the observed colors rules out any large variation in color over the surfaces of these objects. Centaur surfaces appear to be homogeneous. All observers have noted that Centaur colors split into distinct red and gray groups. There are 16 gray objects and 10 red objects, with no objects having colors intermediate between these two groups; this distinct bimodal splitting appears to be statistically significant at a 99.5% confidence level. Most differences in the original orbital parameters between the red and gray groups were presumably lost by the gravitational scattering that moved these bodies from the Kuiper Belt into their present orbits, and indeed there is no statistically significant differences between the red and gray objects' orbital perihelion or eccentricity, nor is there any difference in their absolute magnitude (i. e., the amount of light they reflect back to us, which is in part related to their size). However, there is a hint of systematic differences in other orbital parameters: red Centaurs have slightly larger orbits. The average gray body's distance from the Sun is 17.8 AU, while the average red distance is 19.8 AU; likewise, the median gray aphelion (farthest distance from the Sun) is 21.8 AU, while the median red object aphelion is 29.1 AU. More significantly, the orbits of red objects have lower inclinations—all but one inclination are lower than the mean inclination of the gray group. Statistically, there is only a 10% probability that the inclinations of the two groups are the same.

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These observations support the two-source model for the origin of Centaurs proposed earlier by TEGLER, ROMANISHIN, and CONSOLMAGNO. Red Centaurs may arise from the more distant, dynamically cold, classical belt, while gray ones come from among the Plutinos (KBOs with orbits similar to that of Pluto, i.e., trapped in a resonance with Neptune) or scattered disk objects, which are bodies in more dynamically excited orbits, originally scattered out from the region of Uranus or Neptune. This fits the observed colors of other KBO classes. It is also consistent with our understanding of what happens to KBO orbits when they are perturbed into Centaur orbits, since such perturbations are expected to alter the orbital inclinations and aphelia the least, among all the orbital parameters.

Centaur Light Curves

As reported last year, TEGLER, ROMANISHIN, and CONSOLMAGNO found a double-peaked light curve for the Centaur Pholus, indicative of a spinning, irregularly shaped object. This was compared with other Pholus light curves measured over 15 years, as the relative orientation of its spin axis towards the Earth changed during its orbit around the Sun. From measuring these changes, the shape and spin pole positions of Pholus were determined and assuming this shape is in static equilibrium, a density of 0.5 g/cm^3 was deduced. The success of this procedure has led to observations of other Centaurs. In October and November, light curves for two Centaurs, Asbolus and Thereus, were also measured in preparation for a similar analysis of their shapes and densities.

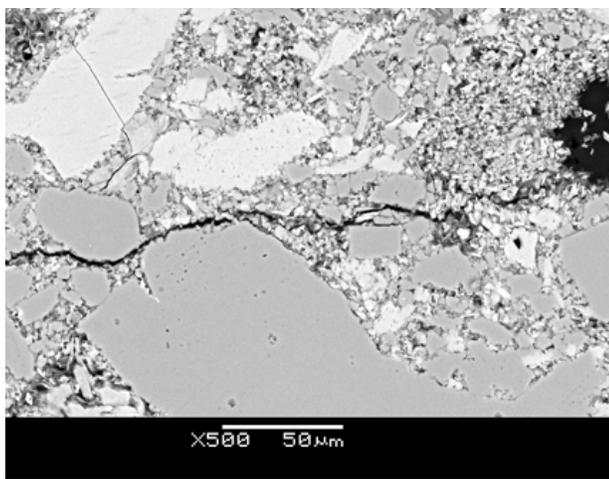
Meteorite Microcrack Porosity

CONSOLMAGNO and STRAIT (Alma College, Michigan) continued their measurements and analysis of meteorite porosity to obtain a better understanding of how individual grains accumulate and lithify to form meteorites. The process begins by imaging a thin section of the meteorite using backscatter scanning electron microscopy (SEM). The resulting images are digitized, and the number of pixels in the grayscale range that corresponds to void space (or different materials of interest) are counted. This porosity is then compared against the porosity of the hand sample from which the thin section was taken, as measured at the Vatican's meteorite laboratory at Castel Gandolfo. Finally, a model porosity is calculated that accounts for changes in grain density because of weathering experienced by a meteorite in the corrosive terrestrial atmosphere, and this value is compared to physical measurements.

Most of the porosity seen in SEM images is in a network of microcracks a few micrometers wide but hundreds of micrometers long. For the most part there is a correlation between the porosities found by the two methods for ordinary chondrites but there appears to be significant scatter. Deviations can be accounted for in a number of ways, including experimental uncertainties in both types of porosity measures. Error in determining the hand specimen porosity comes from errors in the sample grain and bulk densities, which in the past were on the order of 0.1 g/cm^3 ; however, recent measurements have been able to cut this error in half.

Meteorites as Biological Carriers

CONSOLMAGNO and STRAIT, along with ROGOFF and ROTHSCILD (NASA Ames Research Center, Mountain View, California), have begun an experimental program to test the possibility that extraterrestrial life could enter meteorite microcracks, seal off a small volume within them, and eventually travel with these meteorites from planet to planet, protected from the vacuum environment and shielded from the cosmic ray and UV environment by the centimeters of rock between it and interplanetary space. Typical widths for microcracks in all meteorites, ranging from ordinary chondrites to those rare achondrites thought to come from Mars, range from 0.5 mm to >5 mm. Bacteria and other microbes mostly range from 0.2 mm to 10 mm. Eukaryotic cells can be very small (pico-eukaryotes, perhaps the most abundant eukaryotes on Earth, are between 0.2 mm and 2-3 mm in diameter) or very large (> 1 cm), but they tend to range from 5-100 mm in diameter. Virus diameters are about 0.05-0.1 mm. Are these meteorite microcrack pore spaces suitable for a microbe habitat and transport from, perhaps, Mars to Earth? It is impractical to do destructive experiments on the very rare meteorites thought to come to Earth from Mars, but the size and geometry of their porosity is similar to that of ordinary chondrites and terrestrial shocked impactites.



An electron microscope image of a rock obtained near a terrestrial impact site shows that the force of the impact creates cracks and voids in the rock. These cracks may be large enough to shelter microbes, suggesting such life forms could travel through space inside meteorites. (Image by Sara Russell, Natural History Museum of London, and Guy Consolmagno, S.J.)

As a test case, a terrestrial impactite from the Cluff impact site in Canada was measured for porosity both in hand sample and by microcrack imaging and then heat sterilized to remove terrestrial contaminants. Then two sets of samples from this terrestrial impactite were infected with known and easily traceable microbes: large yeast microbes in one set, and the smaller marine bacterium *Synechococcus* in the other. Other samples were left untreated as controls. The samples were again sterilized by flame, as a simple analogue for the variety of effects that might sterilize the surface of a meteorite in space and during its fall through the Earth's atmosphere, and then immersed in a growth medium. The uninfected samples and the samples treated only with the large yeast microbes showed no evidence of reaction with the growth medium, but the sample treated with *Synechococcus*, which is similar in size to the microcracks, showed significant reaction. Thus it appears that sufficiently small microbes can enter microcracks and survive heat sterilization. Future work will attempt to repeat these results with actual meteoritic material subjected to the hostile radiation and vacuum of the space environmental chamber at NASA Ames, to simulate more accurately the conditions that might sterilize meteorites in space.

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Anisotropic Magnetic Susceptibility and Meteorite Chondrule Foliation

The relationship among the anisotropy of magnetic susceptibility (AMS) measurements, porosity, and foliation in chondrites was explored in a series of experiments performed by GATTACCECA and ROCHETTE (CERENGE/Università Paul Cézanne, Aix- Marseille, France), DENISE (Muséum National d'Histoire Naturelle, Paris), CONSOLMAGNO, and FOLCO (Museo Nazionale dell'Antartide, Siena, Italy). In addition to providing some of the samples for this research, CONSOLMAGNO also measured the porosities of the samples, including the first ever measurement of porosity for a sample of the rare Rumaruti meteorite class (NWA 753, a recent donation to the Vatican collection). Study results suggest that the most likely cause for the observed relationship between foliation and AMS is the impact history of the meteoritic material, with its subsequent lithostatic compaction on the meteorite parent body.

History and Philosophy of Science; Interdisciplinary Studies

CARUANA has completed his study of how the scientific mentality may affect the ethical dimension of human beings, forthcoming as a book entitled *Science and Virtue*. He continues to engage in research in two other areas. The first project involves a historical paper on how 17th century Jesuits struggled with the two conflicting cosmologies of Aristotle and Copernicus within the constraints determined by the Church authorities. The paper will be published as a chapter of a forthcoming book with the title *The Cambridge Companion to the Jesuits*, to be published by Cambridge University Press. The second project involves the study of how the discussion on verisimilitude initiated by Karl Popper can be applied to the philosophy of scientific models; he is doing this as director of a doctoral student who is working on this subject.

COYNE continues to study the outcome of the work of the Galileo Commission (see Publications) and the history of the controversy concerning evolution and intelligent design. He is researching the latter in preparation for a book on the same topic requested by the Yale University Press.

STOEGER has been working out a comprehensive approach to divine action in light of the realities of natural and moral evil and developing further the relationship between God's role as Creator (*creatio ex nihilo*) in nature and God's special action in Jesus as Incarnate Word, as Redeemer and as Savior in history.

II. Instrumentation and Technical Services

Vatican Advanced Technology Telescope (VATT)

The VATT technical projects in 2005, under McKENNA, with FRANZ and SWIFT, fell into two categories. The first category was the *mandatory* projects to keep the telescope functioning. These projects included rebuilding the compressed air system, due to failure of a valve that had become

contaminated with rust particles; replacement of a filter wheel belt drive; and addition of an interface in the 2K CCD camera shutter to allow vacuum cleaning of moths while the camera is mounted (a convenience much appreciated by observers). Also, maintenance of the building and safety modifications received a special priority in late summer and early fall before the onset of winter weather. The second category is the in-progress *upgrade* projects that concerned the telescope itself. These projects include enhancing the reliability of all systems and achieving the optical and control performance of the original telescope specifications to take complete advantage of the unique optics and high-quality mountain skies enjoyed by the VATT. Scintillation Detection and Ranging (SCIDAR) experiments in the past year confirmed the characteristics of the overall atmospheric seeing, yet pointed to the further control needed for the thermal environment close to the telescope. Thus all systems are under engineering review, with an upgrade timescale of about five years. Progress was made particularly in testing and modeling of the telescope control system and in planning the upgrade, relocation, and rewiring of the computer network components. A sky monitor camera and sky brightness monitor have been built and are awaiting integration into the software system.

Instrumentation

The VATTSpec, a medium-resolution optical spectrograph for the VATT, was delivered by Astronomical Consultants & Equipment, Tucson, in late spring. This initiated modeling, fabrication, and purchase of equipment needed to mount the spectrograph regularly and safely on the telescope. This will also improve installation of its other instrumentation. A smart motor controller was designed and constructed for the VATTSpec, and again this system will be used for control of motors elsewhere, for example, in the guide box. Other modifications and integrations are in progress to complete the spectrograph package on the telescope. This work is being done by CORBALLY, FRANZ, HARMER (National Optical Astronomy Observatories, Tucson) McKENNA, and TARDIF.

Through the initiative of MAFFEO, support was obtained from the *Fondazione Compagnia di San Paolo* and from the *Fondazione Monte dei Paschi di Siena* for the restoration of the dome of the Zeiss Double Astrograph at Castel Gandolfo.

Cyber Activities

CORBALLY and PELETIER (Groningen, the Netherlands) continue to maintain the Web site of the Vatican Observatory and its Foundation (<http://vaticanobservatory.org>), updating such items as the Annual Report, Newsletters, VOSS Summer School and alumni details, and VATT observer information. They also created a new site for the Joint Discussion 13 at the IAU General Assembly in Prague. The average activity in 2005 for the Vatican Observatory Website rose 10 percent to about 7,700 hits per day. A spike of 166,086 hits on 31 March no doubt reflected worldwide interest in the passage of Pope John Paul II.

At the request of CONSOLMAGNO, the Vatican telephone service put in place at the Observatory's headquarters in Castel Gandolfo a secure wireless ethernet system. This upgrade is meant to offer

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easy yet secure computer access by authorized Observatory visitors as well as by staff. ROSSI tested and proved access by Windows systems, while BOYLE did so for the LINUX operating system.

OMIZZOLO continued scanning and preparing data from the Observatory's archive of Schmidt spectral plates and has completed about one-half of the work. This data collection will be a valuable resource for many research programs, especially those that explore long-term variations in the energy output of celestial objects.

Vatican Meteorite Collection

In 2005, eleven meteorites samples were loaned from the Vatican's meteorite collection at Castel Gandolfo to researchers in France and Italy, and three new thin sections of meteorites were prepared for the collection. Three samples of well-documented finds from Europe were loaned to FOLCO (Museo Nazionale dell'Antartide, Siena, Italy) and D'ORAZIO (Università di Pisa) for studies to characterize the nature of terrestrial weathering as a function of location on Earth, while eight samples were loaned to GATTACCECA (CERENGE/Università Paul Cézanne, Aix-Marseille, France) for the anisotropic magnetic susceptibility measurements described in Section I under Planetary Sciences. The Vatican Observatory's Meteorite Laboratory at Castel Gandolfo obtained a Chicago Instruments micrometer for more precise measurements of meteorite and standard sizes.

III. Observatory and Staff Activities

Vatican Observatory Conferences

From 11 to 17 September, eighteen scholars from around the world participated in a conference on *Physics and Cosmology: Scientific Perspectives on the Theological Problem of Evil in Nature*. The conference, held at Castel Gandolfo and co-directed by STOEGER, was sponsored jointly by the Observatory and the Center for Theology and the Natural Sciences, Berkeley, California.

From 3 to 6 October, thirty-five observers and theorists met in Castel Gandolfo for a workshop on Active Galactic Nuclei (AGN). Under the leadership of OMIZZOLO, the group of international scholars reviewed, confronted, and discussed recent progress in understanding AGNs. Through the initiative of MAFFEO, support for the workshop was obtained from the *Ente per le Nuove Tecnologie, l'Energia e l'Ambiente* (ENEA), from the *International Consortium and Network for Relativistic Astrophysics* (ICRANET), and from the transport company *Calabresi*.

Presentations and Academic Activities

Solar Eclipse Expedition From 1 to 6 October KOCH and MAFFEO took part in a solar eclipse expedition to Tunisia that was organized by the *Unione Astrofili Italiani* (UAI). The annular eclipse occurred on 3 October and was successfully observed at Douz, Tunisia, in the H-alpha line with the

Coronado MaxScope 90 telescope of the Observatory. Through the auspices of SASSONE CORSI, President of the UAI, the photographs were transmitted live on the Web sites of the UAI and of the Italian daily newspaper *Corriere della Sera*. NASA also had a link to the UAI site.

CARUANA Presented the annual undergraduate course “Philosophy of Science and Nature” at the Pontifical Gregorian University in Rome and also the more advanced course “Science, Nature and God” for 2nd cycle students. In June concluded the direction of two doctoral theses in philosophical psychology: one on empirical and conceptual accounts of consciousness, the other on self-deception and weakness of will. Gave a paper comparing scientific with philosophical accounts of the emotions at an International Philosophy Conference on *Religious Emotions: Historical and Contemporary Perspectives*, Department of Philosophy, University of Antwerp, 19-21 September 2005.

CONSOLMAGNO Spoke on the “Density, Susceptibility and the Sources of Meteorites” to the Physics Department of Santa Clara University on 25 April; and at the UCLA Geochemistry Seminar on May. Presented a talk on “The Colors of Kuiper Belt Objects” at the Natural Sciences Seminar at LeMoyne College (Syracuse, NY) on 30 September. Explored the topic “From Dust in a Vacuum to Ordinary Chondrites: What Lithified the Meteorites?” at the University of Rochester Department of Astronomy on 3 October. Discussed “Pluto and Planets X: What’s A Planet? And Why Does It Matter?” to a lunchtime asteroid study group at the University of Arizona on 7 November, and for a Sigma Xi lecture at Portland State University on 9 November. Served as a panel chair for the NASA Planetary Geology and Geophysics (PG&G) panel, organizing the Asteroids and Impacts panel at the PG&G meeting in Denver, Colorado, from 14-19 August, which evaluated more than 100 proposals for funding from the American space agency. He also attended the PG&G Working Group meeting at Arizona State University (Tempe) on 15-16 September. Continued as president of Commission 16 (Planets and Satellites) of the International Astronomical Union (IAU). In this role he successfully proposed a Joint Discussion on “Progress in Planetary Exploration Missions” to be held at the General Assembly in 2006, serving as chair of the Joint Discussion Organizing Committee and editor of the proceedings. As President of IAU Commission 16, served ex-officio on the IAU Working Group to Define a Planet. This group attempted to tackle the controversial issue of defining the planetary status of newly discovered objects close in size to Pluto; he delivered the results of the group’s discussions to the Executive Committee of the IAU in November. Continued to serve on the IAU Working Group on Planetary Surface Nomenclature and participated in a special meeting of this Working Group held in Hardingasete, Norway, from 1-2 September. Began a second two-year term on the Meteoritical Society Council and took part in the Council meeting in Gatlinburg, Tennessee, on 11 September.

CORBALLY Chaired the nominations committee for the Institute on Religion in an Age of Science. Continued to moderate the IRAS Discussion Group, Nature and God. Activities for the International Astronomical Union included work on the Division IV (Stars) Organizing Committee, President of Commission 45 (Stellar Classification), Chairman of the Working Group on Standard Stars, and Co-Chairman of the Scientific Organizing Committee for the Joint Discussion 13 “Exploiting Large Surveys for Galactic Astronomy” to take place 22-23 August 2006 at the XXVI General Assembly in Prague. With the IAU’s approval for the Joint Discussion received in May, Corbally coordinated invitations to speakers and created the Joint Discussion’s Web site. In April was a guest at the Hyde

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Park Discussion Group, Chicago, on science and religion. Was dean of the 10th Vatican Observatory Summer School, Castel Gandolfo (see report elsewhere). Led a Small Group Sharing Workshop at the IRAS Annual Conference, Star Island, NH, using the theme “From Nature to Prayer.” In September gave a talk entitled, “Religious Naturalism in the Science and Theology Dialogue,” at the IX Conference of the European Jesuits in Science in Namur, Belgium. Was an invited speaker at the international congress “Science and Orthodoxy, a Necessary Dialogue” in Romania in October, and spoke on “Taking Science Seriously and Talking about God.” Gave a colloquium in November at Lowell Observatory, Flagstaff, on “Achieving the Potential of the Gregorian Chance at the VATT,” and consulted with the project team for Lowell Observatory’s 4.2m Discovery Channel Telescope now under construction. Later that month paid a working visit to Robert Garrison, David Dunlap Observatory, University of Toronto. With co-author Richard Gray, Appalachian State University, North Carolina, signed a book contract with Princeton University Press for a volume on the spectral classification of stars. Continued to collaborate with Steward Observatory’s Light Pollution and Radio Frequency Interference advisory working group and with personnel from other observatories to improve and implement the outdoor lighting codes in Arizona, especially around Mt. Graham. Also promoted the start of a University of Arizona group, at the School of Architecture, to study campus light pollution. Continued on the Board of the St. Albert the Great Forum for science and theology at the Catholic Newman Center, University of Arizona.

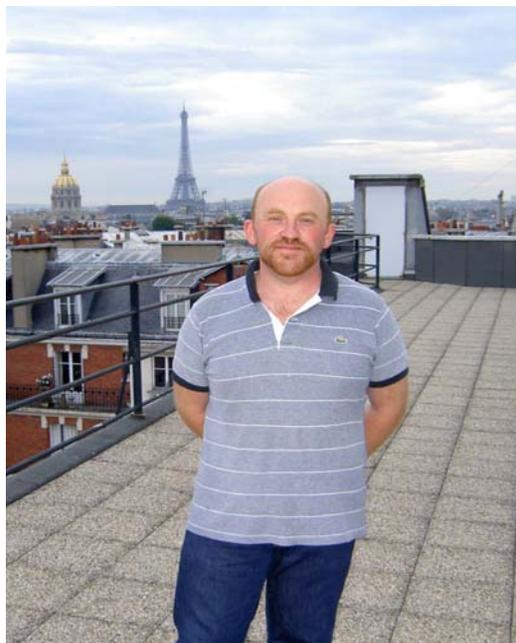
COYNE Was awarded an Honorary Doctor of Science Degree by Marquette University, Milwaukee, Wisconsin, on 22 May. As a councilor of the Peter Gruber Foundation’s Cosmology Prize, participated in the award of the prize to James Gunn in Krakow, Poland, 4-5 November. Continues to serve on the Council of the Pontifical Academy of Sciences and participated in the three council meetings held in 2005 and in the visit of Pope Benedict XVI to the Academy on 21 October. Represented the Observatory as a member of the International Center for Relativistic Astrophysics at the Board meeting on 7 February at Stanford University, Palo Alto, California. Participated in the meetings of the councilors for the project Science, Theology and the Ontological Quest held at the Pontifical Gregorian University, Rome, 9-12 March and at the Hotel Michelangelo, Rome, 12-13 November. Served on the Organizing Committee for the symposium Physical Evil as Seen by the Natural Sciences, La Armonia, Mar del Plata, Argentina, 7-10 October, and gave a paper on “Cosmology and the Problem of Physical Evil in the Universe.” Gave a Keynote Address, “Science Does Not Need God. Or Does It?” at the meeting Science Wars: Should Schools Teach Intelligent Design?, American Enterprise Institute, Washington, DC.

FUNES Was invited in May by the Universidad Nacional Autonoma de Honduras to be part of the board for the defense of student Yvelice Castillo’s master thesis. Under his direction, she worked on the study of supermassive black-hole masses and global properties of disk galaxies. On 27 May gave a seminar on his extragalactic research and a public lecture at Central America Suyapa Astronomical Observatory in Tegucigalpa (Honduras). Taught the General Astronomy course during the fall semester in the Department of Astronomy, University of Arizona.

GIONTI Attended the International Spring School on String Theory in Hangzhou, China, from 21 April to 20 May. Attended the Albert Einstein Century International Conference at the UNESCO Palace in Paris, 18-22 July, where he gave the talk “Discrete Theory of Gravity as a Local Theory of

the Poincaré Group in the First Order Formalism.” Also gave this talk at the LOOP 2005 conference 10-14 October at the Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut) in Potsdam Gave a talk “On the Nature of Space and Time” at the Vatican Observatory Summer School.

HELLER Gave the paper “Noncommutative Unification of General Relativity and Quantum Mechanics” on 4 February at the Physics Institute of the Prague University, Czech Republic. Spoke on “Emergence and Structure” 16-17 May at the IX Kracow Methodological Conference, Poland, which he also helped to organize. 11-16 September at the Congress of Polish Physicists in Warsaw presented the paper “Einstein, the Universe and Ourselves.” 26-27 September at the symposium “Science–Religion– History,” held at the Catholic University of Lublin, Poland, gave the paper “On the Structural Understanding of Science.” At a workshop on the “Controversial Relationships between Science and Philosophy,” 30 October to 1 September at the Pontifical Gregorian University, gave the paper “Unification Theories of Everything. Philosophical Aspects.” 14-17 October, at the symposium, “Relational Ontology in Science and Theology,” Athens, Greece, gave the paper “Is the Universe a Self-Contained Structure?”



Gabriele Gionti, S.J., at the Jesuit Community on Rue de Grenelle in Paris while attending the Albert Einstein Century International Conference. (Photo by Konrad Grech, S.J.)

STOEGER Attended the conference *Multiverse and String Theory: Towards Ultimate Explanations in Cosmology*, at Stanford University, Palo Alto, California, and gave an invited lecture, “Multiverse Hypotheses and Their Testability.” 5-10 July attended the Cape Town Cosmology Meeting 2005 in Cape Town, South Africa. He gave an invited presentation, “Are Multiverses Legitimate Objects of Scientific Cosmology?” From July 1 to August 16 worked with the Theoretical Cosmology group in the Department of Mathematics at the University of Cape Town, principally with George F. R. Ellis and Charles Hellaby and their students. While there, he gave a colloquium entitled “Multiverses Revisited.” On 3 August gave a presentation in the Philosophy Department, University of Cape Town, on “Science, Philosophy and the Problem of Natural Evil.” 11-12 August attend the annual meeting of the South African Religion and Science Forum at UNISA, Pretoria, South Africa. He gave two invited presentations: “The Problem of Evil: The Context of a Resolution” and “Evolution, God and Natural Evil.” 11-17 September helped direct and participated in the Vatican Observatory/Center for Theology and the Natural Sciences conference at Castel Gandolfo on *Physics and Cosmology: Scientific Perspectives on the Theological Problem of Evil in Nature*. There he presented the paper “Entropy, Emergence and the Physical Roots of Natural Evil.”

WHITMAN Was one of the organizers of the 43rd Summer Meeting of the Clavius Group of Mathe-

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maticians at the University of Notre Dame, 3-31 July. He helped organize a seminar on differential geometry and gave six lectures on the material leading to “Real Representations of Semi-simple Real Lie Algebras.” During the meeting, a one-day symposium was held to commemorate the archiving of the works of Christopher Clavius in the Notre Dame library. This archive is open to the general public.

Public and Educational Outreach

CARREIRA On 1 February spoke to the Astronomical Association of Madrid, Spain, on “The Theory of Relativity in Cosmology.” By invitation of the Archdiocese of Oviedo, Spain, lectured on the “Theological Implications of Modern Science” on 3 February. On 8 February, talked to high school students in Madrid on the “Structure and Origin of the Universe” and to the Astronomical Association of Madrid on the “Origin and Evolution of Life.” 21-23 February gave three public lectures in Pamplona, Spain, on “The Origin of the Universe,” “The Origin of Life,” and “Order and Beauty in the Cosmos.” 4-7 March, in Lugo, Spain, presented public lectures, sponsored by the Lugo Diocese, on “Science and Faith” and on “The Origin of Life and Man.” 15 March lectured at the state university *Jaume the First* in Castellon, Spain, on “Boundary Issues on Science and Philosophy” for faculty and students. 29 March-1 April, at the request of the Ferrol-Mondonedo Diocese, Spain, gave six lectures to members of the clergy and to the general public on “Science and Faith,” “The Origin of the Universe,” “The Origin and Evolution of Life,” “Man as a Rational Animal,” and Theological Implications of Modern Science.” 18-19 April lectured in Avila, Spain, to university students and the general public on the “Origin of the Universe” and “The Modern Concept of Matter in Relation to Faith in the Resurrection.” 21-22 April gave four public lectures in Cuenca, Spain, on the “Origin of the Universe,” “The Earth as a Habitable Planet,” “The Origin and Nature of Intelligence,” and “The Concept of Matter and the Resurrection.” 29 April- 6 May talked to high school students and the general public in San Francisco, California, on the “Scientific Study of the Turin Shroud.” 10-14 May lectured in Bogota, Colombia, for groups of faculty and students at the Catholic University on the “Origin of Life,” “Creation in the Bible and in Science,” “Natural Law, Mind and Brain,” “Truth, Beauty and Goodness,” and “Matter and the Risen Body.” 16-23 May in Lima, Peru, lectured at four universities (Catholic University, Universidad de Ingenieria, Universidad Femenina, Universidad Sedes Sapientiae) and in cultural centers of two parishes and two religious schools on “The Origin of the Universe,” “Evolution and Intelligence,” “The Turin Shroud,” “Creation,” and “The Concept of Matter.” 2 June at the Astronomical Association of Madrid lectured on “Recent Ideas in Cosmology.” 7 July, during the Vatican Observatory Summer School, presented a talk on the “Origin and Evolution of Life.” On three occasions—24-26 July, 8-10 August, and 28-30 August—gave a series of three public lectures on the “Origin of the Universe,” “The Earth as a Habitable Planet,” and “The Origin and Evolution of Life,” as part of the cultural events marking the yearly town festivities in three locations in Cuenca Province, Spain; the series was recorded and offered as a DVD. From Fall of 2004 through the Summer of 2005, gave weekly talks to the Association of University Graduates in Madrid, dealing with issues of science and faith, and at Galapagar, Madrid, made eight weekly presentations to the *Hijas de Sta. Maria* covering topics from stellar evolution to the dogmas of Catholic faith. Lectured in Guadalajara, Mexico, on 24 and 27 October, at the *Instituto Tecnico de Estudios Superiores del Oeste* on, respectively, “The Concept of Matter”

and “The Resurrection and The Relationship between Science and Faith”; also in Guadalajara, lectured at the *Universidad del Valle de Atemajac* for students and faculty on “The Concept of Matter,” “The Theory of Relativity,” “The Nature of Man and the Biological Revolution,” and “The Scientific Study of the Turin Shroud”; at the University of Guadalajara, lectured on “Science and Faith”; an interview with Carreria on this subject was aired live by the university’s radio station. 12-19 October, at the *Universidad Catolica de Colombia* in Bogota, lectured to students and faculty on the “Origin of the Universe,” “The Anthropic Principle,” “The Origin of Life on Earth,” “The Nature of Man,” and “Science and Faith.” 20-21 October, in Cali, Colombia, at the *Universidad Javeriana*, lectured on “The Universe as Presented by Science of the 21st Century,” “Recent Developments in Cosmology,” and “The Anthropic Principle.” In Peru, 2-12 November, lectured at the *Universidad Catolica de Lima* on “The Nature of Man from Science, Philosophy and Theology”; presented another lecture on the same topic at the diocesan seminary, and two more lectures at the *Universidad Sedes Sapientiae* on “Science and Faith” and “The Scientific Study of the Turin Shroud”; presented the same lectures in Arequipa at the *Universidad San Pablo*. 15 November, lectured at the *Universidad Catolica de Valencia*, Spain, on “Man and the Universe,” at a symposium on our relationship with nature and the environment, and at another symposium in San Sebastian, at the *Forum Larra-mendi*, on “The New Landscapes of the Planets” as shown by current space probes.

CONSOLMAGNO Presented a two-hour talk, “The Universe in a Grain,” at the Adler Planetarium, Chicago, on 20 January. 21-23 January gave four presentations at the Confusion Science Fiction Convention in Detroit. 4-8 August served on five panels at the Interaction World Science Fiction Convention in Glasgow, Scotland. On 19 August was the keynote speaker at the Archdiocese of Detroit Youth Day celebration, speaking on “The Star in the Sky the Night Christ was Born.” Spoke on “When Science Meets Religion: Experiences of a Vatican Astronomer” at St. Theresa’s Church in Briarcliff Manor, New York, on 19 September, and again at LeMoyne College, Syracuse, on 29 September. 15 October presented two talks at a Study Day on Science and Religion held at the St. Theosevia Orthodox Church Centre in Oxford, UK, on: “Why Does the Pope Have an Astronomer?” and “Astronomy, God and the Search for Elegance.” On 14 November, spoke on “Heaven or Heat Death? Modern Cosmology and Traditional Christianity” for the Carthage College, Wisconsin, Arts and Lecture Series. In connection with the Whirlpool Amateur Astronomy Conference in Birr, Ireland, held 7-9 October, gave a series of lectures to amateur astronomy groups across Ireland and England: on 6 October, he spoke presented the talk “Why Does the Pope Have an Astronomer?” at Gonzaga College, Dublin; on 10 October at the Lincolnshire Astronomical Society; and on 11 October at the West Yorkshire Astronomical Society. He gave the talk “Turn Left at Orion,” about finding deep sky objects with an amateur telescope, at the Whirlpool convention on 9 October, and on 12 October at the Bristol Astronomical Society. Gave presentations at Notre Dame High School, San Jose, California, on 27 April; at Verbum Dei High School on 24 May; and at Central Catholic High School, Portland, Oregon, on 9 November. 26-30 September visited LeMoyne Jesuit College in Syracuse, New York, giving fifteen classroom presentations as well as a talk to the Jesuit novices of the New York, New England, and Maryland Provinces. Spoke on cosmology to students in a joint science and religion seminar at Carthage College, Wisconsin, on 15 November.

CORBALLY In April, in Prescott, Arizona, represented the University of Arizona Mirror Laboratory, Steward Observatory, the Mount Graham International Observatory, the Whipple Observatory,

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as well as the Vatican Observatory at *Spotlight on the Stars*, a public outreach week organized by the Astronomy Society. Gave a talk in November to the Phoenix Salon, Spirit of the Senses, on “The Personalities of Stars.” Regularly engaged in phone and video links with the astronomy club of St. Agatha Church, Portland, Oregon, during its monthly meetings. Continued as an advisor to the *Earth & Sky* radio series (www.earthsky.org). Answered enquiries by e-mail and phone from the general public. Answered research questions from graduate student Kathryn Hansen (Johns Hopkins University) and graduate student Stephen Thompson (Swinburne University of Technology). Hosted visits to the Steward Observatory Mirror Laboratory and to the VATT on Mt. Graham.

COYNE Taught the general astronomy course in the Astronomy Department, University of Arizona, during the Spring semester. Gave a talk on 20 January about the evolving universe to the Sun City Astronomy Club, Tucson. Spoke on the evolving universe at Pelican Landing, Fort Myers, Florida, on 29 January. Gave a talk on the history of the Vatican Observatory to the Sage Group at the University of Arizona on 4 February. Gave the Twentieth Timothy J. O’Leary Lecture on 17 February at Gonzaga University, Spokane, Washington, speaking on cosmology and the origins of life, and spent 16 February speaking to the physics and biology classes. Gave a talk on “The Dance of the Fertile Universe” at the Arizona Science Center, Phoenix, on 4 March. Spoke on the expanding universe to the Community School of Naples, Florida, on their annual trip to Tucson on 5 April. On 15 April gave a lecture on “Galileo Still Haunts the Church” to the students and faculty of Methodist College, Raleigh, North Carolina. Spoke on 15 April on the history of the Vatican Observatory at the Pima County Prison, Tucson, Arizona. On 22 April gave a talk on “The Dance of the Fertile Universe” to the Alumni Association of Carnegie Mellon University, Pittsburgh, Pennsylvania. At Ames Research Center, Mountain View, California, joined biologist Lynn Rothschild in a discussion of “Evolution and the Universe: Science and the Human Spirit” to the friends of the Vatican Observatory Foundation. Gave the following talks in Italy: “The Fertile Universe” at Tesero, Val di Fiemme, 15 July; “The Church and Science” at Castel Gandolfo to students in the Rome program of the University of Washington, Seattle, 6 September; “The Gregorian Reform of the Calendar” in Bologna on 23 September at the meeting on *The Sun in the Church* “The God of Albert Einstein” at Alassio on 25 September at the meeting *Oltre lo Spazio*; “The Church’s Position Today with respect to Neo-Darwinian Evolution” in Padua on 13 October at the inauguration of the academic year at the *Istituto Filosofico Aloisianum*; “The Appearance of Life and God the Creator” in Florence on 25 October at the program of the Stensen Institute, *Il Viaggio: Percorso di Formazione Teorico-Pratico*; “Cosmological Time: Measuring the Age of the Universe and Its Significance” in Bari 27-28 October at the symposium *Tempo della Natura, Tempo dell’Uomo, Tempo di Dio*; “Measurements of the Age of the Universe and Their Significance” in Rome at the Pontifical Lateran University, on 9 November, at the meeting *Infinity in Science, Philosophy and Theology*; “The Dance of the Fertile Universe” in Sora on 22 November at the *Liceo Scientifico Leonardo Da Vinci*; “Ethical Implications of Human Origins in the Universe” in Milan on 25 November at the meeting *Science and Society: New Ethical Interactions*, organized by the *Fondazione Carlo Erba*.

FUNES Gave a talk on 19 May to the Sun City Astronomy Club on “Monster Inc., Supermassive Black Holes.” On 27 May gave a public lecture on galaxies at Central America Suyapa Astronomical Observatory.

GIONTI Gave a talk “On the Nature of the Space and the Time” 9 November at the St. Albert the Great Forum on Science and Theology, University of Arizona Catholic Newman Center.

MAFFEO Gave a talk on the history of the Vatican Observatory at the Jesuit residence of the *Gesù* in Naples, Italy, on 11 January; at the Golden Age University in Ariccia, Italy, on 5 April; and at the *Ateneo Regina Apostolorum*, Rome, to the students of the Masters Program in Science and Faith on 8 November Lectured on “Angelo Secchi, S.J., a Pioneer in Astrophysics” at the Rome planetarium on 16 April, and at Grosseto, Italy, to the *Associazione Maremmana Studi Astronomici* on 3 June.

STOEGER Continued to teach an upper-division undergraduate course on “Science and Theology” each semester at the University of Arizona with LINDELL of the Molecular and Cellular Biology Department. Is on the Board of Directors of the Center for Theology and the Natural Sciences, Berkeley, California, and is presently functioning as Chairperson Is also on the Board of Trustees for Brophy College Preparatory School, the Jesuit high school in Phoenix, Arizona Serves as Chairperson of the Board of the St. Albert the Great Forum on Science and Theology, Catholic Newman Center, the University of Arizona Is Convener of the Theology and Natural Sciences Continuing Group for the Catholic Theological Society of America Serves on the Editorial Board for the journal *Theology and Science*, and on the Committee directing the implementation of the 3-year Templeton Foundation grant “Astrobiology and the Sacred” awarded to the University of Arizona During the Spring semester Stoeger led several St. Albert the Great Forum discussions at the Catholic Newman Center, University of Arizona. He visited St. Mary’s University in Halifax, N. S., Canada, on 17-19 February and gave a public lecture “Science, the Laws of Nature and Divine Action”; and a physics and astronomy colloquium on “Cosmology, Multiverses and the Anthropic Principle.” 13-16 April attended the 80th Annual Meeting of the American Association for the Advancement of Science (Southwest and Rocky Mountain Division) at the University of Arizona and participated in a panel on “Sustainability and Progress for the 21st Century.” He gave a brief presentation with the same title, laying out an interactive practical, scientific-philosophical framework for approaching this issue. 27 July gave a popular talk on “Science and Religion” at Kolbe House, the Catholic Chaplaincy at the University of Cape Town. 4 October gave a presentation of “An Overview of Contemporary Cosmology” to the Tucson Amateur Astronomy Association at Steward Observatory, University of Arizona. 22 October participated in a seminar at Loyola-Marymount University, Los Angeles, California, on the legacy of Vatican II and Teilhard de Chardin. He gave one of the keynote lectures, “Vatican II, the Church and Engagement with the Sciences.” 18-20 November attended the “Catholic Earthcare” Conference in Canberra, Australia. He gave one of the invited lectures, “Our Intimate Links with the Universe and Nature: The View from Cosmology and Astrobiology.” 15 December gave the presentation “Cosmological Mysteries: Evidence for Unseen Dark Matter and Dark Energy” at the Sun City Amateur Astronomy Club, Tucson, Arizona.

News Media Coverage

CONSOLMAGNO Was interviewed 13 January by BBC Radio about the South Asia Tsunami; on 14 January by Vatican Radio about the Huygens lander on Saturn’s moon Titan; on 10 October by BBC Radio Lincolnshire, to discuss the Vatican Observatory; and again on 15 October for BBC radio and on 17 October for Vatican Radio concerning the implications of extraterrestrial intelligence.

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Also served as the host for a half hour program, *The Goldilocks Planets*, concerning astrobiology in science and science fiction presented on BBC Radio 4 on 31 August. Was interviewed on the American Catholic radio network *Relevant Radio* on 3 November, and was also a guest on *The Morning Show* of WGTD-FM (Racine, Wisconsin) on 15 November. Was interviewed on 2 May for a BBC television documentary on the history of religion.

CORBALLY Together with FUNES, was featured in *Religion & Ethics Newsweekly* for 3 June, episode no. 840, on the “Jesuit Arizona Observatory” by Saul Gonzalez; in a *Reuters Report*, “Pope’s Stargazers Teach Tomorrow’s Astronomers,” by Philip Pullella, 29 June; together with CARREIRA, in an on-line article 29 June about the 2005 Vatican Observatory Summer School for www.redorbit.com; together with COYNE, in the University of Arizona *Alumnus Magazine*, Fall 2005, for the article “A Divine Partnership” by Dan Huff. Provided interviews to the following media and journalists: Blake Morlock, *Tucson Citizen* and Craig Smith, *KGUN 9 TV News*, on Pope John Paul II and the Vatican Observatory; Francis Reddy, *Astronomy Magazine*, *Astro Bytes*, April, on the discovery of supernova SN 2005bk at the VATT; Jon Hamilton, *National Public Radio*, on the Catholic Church and science; John Byrne, *BBC Radio 4*, for *The Goldilocks Planet*, a documentary presented by CONSOLMAGNO; Tomasz Pompowski, *FAKT*, Warsaw, Poland; Blake Morlock, *Tucson Citizen*, on God, creation, and Intelligent Design; and Renee LaReau, *National Catholic Reporter*, for a profile of Aileen O’Donoghue. Answered questions from: James Campiani ; Mark Dowd, *UK Channel 4*; Ashley Lawson, *Science & Theology News*.

COYNE Gave the following interviews: 16 March to Mikko Lukinmaa of *MTV3 Finlandia*; 23 March to Andrew O’Neill of the *Arizona Daily Wildcat* for a story on the relationship between faith and science; 13 April to Frances MacKinnon of *Canadian PBS*; 30 April to Dan Huff, *University of Arizona Alumni Magazine*; 7 June to Luca De Mata of *Agenzia Fides*; 8 June to Jan Regner, S.J. of the Czech Republic for a TV show celebrating the Ignatian Year; 16 June to Allison Rose of *Inigo Films*, Toronto, Canada; 18 June to Gerard Grizbec of *France 2 TV*; 1 July to Antonio Pelayo of *Antena 3 TV Spagnola*; 5 July to Mary Villalobos of *Rome Reports*; 15 July to John Allen, Vatican Correspondent, *National Catholic Reporter* for his 22 July article “Word from Rome”; 17 September to Mark Dowd of *3BM TV London* on “Theodicy, Science and the Problem of Evil”; 4 October to the *Vatican Radio English Program* on evolution and intelligent design; on 5 October to Max Rauner of *ZeitWissen Reuters* on the Active Galactic Nuclei conference; 24 October to Holmar Mück of *Deutschland Radio Berlin* on “Astronomy at the Vatican”; 7 November to Jonathan Greaves of *BBC Horizons London* on science and religion in the modern world; 9 November to John Thavis of *Catholic News Service*, Rome, on the evolution– intelligent design debate; 14 November to Andreas Hirstein of the *Neue Zürcher Zeitung Zürich*, Switzerland, on the relationship of science and religion; 14 November to Stacy Meichtry, Vatican Correspondent, *Religion News Service*; 28 November to Barbara Hagerty, Religion Correspondent, *National Public Radio*, on evolution and intelligent design.

FUNES Was interviewed on 16 March for the TV program *Aqui y Ahora* of UNIVISION, Spanish TV network with national coverage in the US. On 30 October gave an interview to *Radio Mitre* of Buenos Aires, Argentina. On 13 November *Diario Perfil*, Buenos Aires, Argentina published a three-page interview with him.

HELLER Gave several interviews to various Polish media (newspapers, journals, radio) on science, philosophy, and science and theology.

KOCH Gave interviews to the Swiss weekly, *Facts*; to the Croatian daily, *Globus Nacionalni Tjednik*; to *Rome Reports*; and to Lord Robert Winston of the BBC program *Dangerous Film*.

PIIROLA Was interviewed by Finnish TV reporter Mikko Lukinmaa, and the program was broadcast 6 April on Finnish National TV channel 3 (MTV 3).

STOEGER Was interviewed by Nandagopal R. Menon about neo-Darwinism and Christianity for an article published in the December issue of *Science and Theology News*.

Conference Participation

9-13 January: San Diego, California. 205th Meeting of the American Astronomical Society. RICHARD BOYLE, S.J., CHRISTOPHER CORBALLY, S.J., and JOSÉ FUNES, S.J., each presented papers.

7 February: Palo Alto, California. Executive Council of the International Center for Relativistic Astrophysics. GEORGE V. COYNE, S.J., as a councilor participated.

9-12 March: Rome, Italy. Advisory Committee of the International Project *Science, Theology and the Ontological Quest*. GEORGE V. COYNE, S.J., as an advisor participated.

7-9 April: Tucson, Arizona. Annual General Meeting of the International Dark-Sky Association. RICHARD P. BOYLE, S.J., and CHRISTOPHER CORBALLY, S.J., participated.

12-16 May: The Hacienda, Hunter-Liggett, California. A Synergistic Salon: Evolutionary Directionality, Emergent Complexity and the Future of Humanity. CHRISTOPHER CORBALLY, S.J., was an invited participant.

26-30 June: Connecticut College, New London, Connecticut. Gordon Conference on Solar System Origins. GUY CONSOLMAGNO, S.J., chaired a session.

3-31 July: University of Notre Dame, Notre Dame, Indiana. 43rd Annual Summer Meeting of the Clavius Group of Mathematicians. ANDREW WHITMAN, S.J., organized and lectured.

4-8 July: Terschelling, The Netherlands. Island Universes: Structure and Evolution of Disk Galaxies. JOSÉ FUNES, S.J., presented a poster.

30 July-6 August: Star Island, New Hampshire. Annual Conference of the Institute on Religion in an Age of Science. CHRISTOPHER CORBALLY, S.J., led a candlelight service and a small group sharing.

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7-13 August: Santa Cruz, California. Nearly Normal Galaxies in a LCDM Universe. JOSÉ FUNES, S.J., presented a poster.

4-9 September: Cambridge, England. Annual Meeting of the Division for Planetary Sciences of the American Astronomical Society. GUY CONSOLMAGNO, S.J., chaired a session, presented a paper, and co-authored another.

7-11 September: Namur, Belgium. IX Conference of European Jesuits in Science. CHRISTOPHER CORBALLY, S.J., and ROBERT JANUSZ, S.J., gave papers. RICHARD BOYLE, S.J., participated.

11-14 September: Gatlinburg, Tennessee. 68th Annual Meeting of the Meteoritical Society. GUY CONSOLMAGNO, S.J., organized and chaired a special session and presented a paper.

11-17 September: Castel Gandolfo, Italy. CTNS/VO conference on Physics and Cosmology: Scientific Perspectives on the Theological Problem of Evil in Nature. GEORGE COYNE, S.J., hosted, WILLIAM STOEGER, S.J., gave a paper, and CHRISTOPHER CORBALLY, S.J., attended.

12 September: Pescara, Italy. First Board Meeting of ICRANET. RICHARD P. BOYLE, S.J., as proxy for GEORGE V. COYNE, S.J., represented Vatican City State at the signing of the minutes. ROBERT JANUSZ, S.J. attended.

7-10 October. Mar del Plata, Argentina. Epistemology of the Natural Science: The Problem of Physical Evil. GEORGE V. COYNE, S.J., helped organize and gave a paper.

17-18 October: Tucson, Arizona. Steward Observatory Internal Symposium. CHRISTOPHER CORBALLY, S.J., and JOSÉ FUNES, S.J., participated.

21-25 October: Bucharest and Constantza, Romania. Congress on Science and Orthodoxy, a Necessary Dialogue. CHRISTOPHER CORBALLY, S.J., gave an invited paper.

4-5 November. Krakow, Poland. The Peter Gruber Foundation Cosmology Prize. GEORGE V. COYNE, S.J., as an advisor participated.

12-13 November. Rome, Italy. Advisory Committee of the international project *Science, Theology and the Ontological Quest*. GEORGE V. COYNE, S.J., as an advisor participated.

IV. Publications

ALBANI, V. V. L., IRIBARREM, A. S., RIBEIRO, M. B., and **STOEGER**, W. R. "Differential Density Statistics of Galaxy Distributions and the Luminosity Function," 2005, submitted for publication

BARTASIUTE, S., ASLAN, Z., **BOYLE**, R. P., KHARCHENK, O. N., OSSIPKOV, L., and SPERAUSKAS, J. "Studying the Stellar Populations of the Galactic Disk," (abstract) 2005, in *From Satellites to Galaxies*, ed. L. P. Ossipkov (Saint Petersburg State University: Sobolev Astronomical Institute), 4-5

BARTASIUTE, S., ASLAN, Z., **BOYLE**, R. P., KHARCHENKO, N., OSSIPKOV, L., and SPERAUSKAS, J. "Studying the Stellar Populations of the Galactic Disk," (abstract) 2005, in *Transactions of the Sternberg Astronomical Institute* (Moscow), 78, 52, in Russian

BOYLE, R. P., JANUSZ, R., PHILIP, A. G. D., LAUGALYS, V., and KAZLAUSKAS, A. "CCD Flatfielding for Strömvil Photometry in M 67," (abstract) 2005, *BAAS*, 37, 1212

BRITT, D. T., **CONSOLMAGNO**, G. J., and MERLINE, W. J. "Update on Small Body Density and Porosity," 2005, *BAAS*, 37, 627

CARUANA, L. "God's Eternity and Einstein's Special Theory of Relativity," 2005, *Revista Portuguesa de Filosofia*, 61, 89-112

_____. Book Review of *Is Science Value Free? Values and Scientific Understanding*, by Hugh Lacey (London: Routledge, 1999), 2005, *Heythrop Journal*, 46, 587-8

_____. Book Review of *From Chance to Choice: Genetics and Justice*, by Allen Buchanan, Dan W. Brock, Norman Daniels, and Daniel Wikler (Cambridge: Cambridge University Press, 2000), 2005, *Heythrop Journal*, 46, 4, 584-7

_____. Book Review of *Jesuit Science and the Republic of Letters*, ed. Mordechai Feingold (Cambridge, London: MIT, 2003), 2005, *Gregorianum*, 86/3, 703-4

CONSOLMAGNO, G. J. "Talking to Techies," 2005, *America*, 192, 11-13

_____. "A Brief History of the Vatican Meteorite Collection," 2005, *The History of Meteoritics and Key Meteorite Collections* (London: The Geological Society), in press

_____. "The Kind of World This Is," 2005, *The Tablet*, 259, January 8, 10; Swedish trans. by Anna Maria Hodacs, *Signum* 31, 6-8

_____. "A Mission into Space," 2005, *The Tablet*, 259, July 30, 8-9

_____. Monthly columns in *The Tablet*, 2005: "Deserts or a Dessert?" January 29; "Making Sense of Mars," February 26; "The Unexpected Celebrity," April 2; "Orbiting a New Sun," April 23; "Tech Support from the Jesuits," May 28; "The Comet's Mysterious Heart," June 25; "Heavenly Peace," July 23; "A Thumbnail Sketch," August 26; "Going Round in Circles," September 24; "Stars in Their Eyes," October 21; "Star-Crossed Data," November 25; "Spinning Our Hopes," December 31, 36

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_____. "Intelligent Life in the Universe?" 2005, Catholic Truth Society, London. 48 pp

_____. Book review of *Searching the Heavens and the Earth: The History of Jesuit Observatories*. Archivum Historicum Societatis Iesu. In press

CONSOLMAGNO, G. J., Fegley B., and Kring, D. In Memorium: Alistair G. W. Cameron (1924-2005). *Meteorit. Planet. Sci.*, in press

CONSOLMAGNO, G. J., MACKE, R. J., ROCHETTE, P., BRITT, D. T., and GATTACCECA, J. "Density, Magnetic Susceptibility and the Characterization of Ordinary Chondrite Falls and Showers," 2005, *Meteorit. Planet. Sci.*, in press

CONSOLMAGNO, G. J., ROMANISHIN, W., and TEGLER, S. C. "Centaur Colors: New Data and Analysis," 2005, *BAAS*, 37, 744-745

CONSOLMAGNO, G. J., ROTHSCHILD, L. J., STRAIT, M. M., and BRITT, D. T. "Can Meteorite Porosity Provide Habitats for Interplanetary Transport of Microbes?" 2005, *Meteorit. Planet. Sci.*, 40, A33

CORBALLY, C. J. "10th Vatican Observatory Summer School," 2005, report for *IAU Commission 46 Newsletter*, Astronomy Education and Development, no. 63, October

_____. "Commission 45: Stellar Classification," 2005, for *Reports on Astronomy 2002-2005*, IAU Transactions XXVI A, ed. O. Engvold, in press

_____. "Will Organized Religion Survive an Encounter with Extraterrestrials?" 2005, in *Actas de Fórum Internacional, Ciência, Religião e Consciência, CTEC, Cons-Ciências 2*, 321-329

CORBALLY, C. J. and GRAY, R. O. "Characteristics of Our Neighboring A-Stars," 2004, in *The A-Star Puzzle*, proceedings of IAU Symposium 224, eds. J. Zverko, J. Ziznovsky, S.J. Adelman, and W. W. Weiss, (Cambridge, UK: Cambridge University Press) 907-910

COYNE, G. V. "Today's Playing Field: Theology and Science," 2005, in *Festschrift for Robert John Russell*, to be published

_____. "Destiny of Life and Religious Attitudes," 2005, in *Life as We Know It*, ed. J. Seckbach (Dordrecht: Springer Science 2005)

_____. "Discovery in the New Cosmology of Copernicus, Kepler and Galileo," 2005, in *Paths of Discovery* (Vatican City: Pontifical Academy of Sciences 2005)

_____. "L'origine della vita nell'universo in evoluzione," 2005, in *Creazione* (Bergamo: Seminario Vescovile di Bergamo 2005) 61-82

_____. “The Church’s Most Recent Attempt to Dispel the Galileo Myth,” 2005, in *The Church and Galileo*, ed. E. McMullin (Notre Dame, Indiana: The University of Notre Dame Press 2005) 340-359

_____. “God’s Chance Creation,” 2005, *The Tablet*, August 8, 6-7

_____. “Infinite Wonder of the Divine,” 2005, *The Tablet*, December 3

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V. Observatory Visitors

During the 2005 Vatican Observatory Summer School at Castel Gandolfo, the Observatory was honored to receive the following representatives of their countries to the Holy See: His Excellency Custer Carlos Luis, Ambassador of Argentina; Escobar-Herrán Guillermo León, Ambassador of Colombia; David Brent Hardt, Chargé d'Affaires, Embassy of the United States; His Excellency Gerhard Friedrich Karl Westdickenberg, Ambassador of the Federal Republic of Germany; and Quintero Prieto Abraham, Chargé d'Affaires, Embassy of Venezuela.

The Vatican Observatory at Castel Gandolfo and the Vatican Observatory Research Group in Tucson, Arizona hosted a number of visitors during the year. Noteworthy were the number of school groups and cultural groups received by MAFFEO and KOCH at Castel Gandolfo. In particular, the following groups were hosted by MAFFEO: on 4 March, a group of students from the University of California, Berkeley, USA; on 23 April, the Golden Age University of Ariccia, Italy; on 16 May, students from the University of Tampa, Florida, USA, and a group of students from Turkey; on 18 May, an international group of physicists, participants in the Spring School *Bruno Touschek* held at INFN at Frascati, Italy; on 22 October, the Association of Austrians in Rome, accompanied by the Austrian Ambassador to the Italian Republic; on 31 May, the College of Lombardy, Italy.

Members and friends of the Vatican Observatory Foundation visited Rome and the Observatory at Castel Gandolfo, 26 June to 2 July. On 28 June, they assisted at the Mass celebrated by Cardinal William Keeler, Ecclesiastical Advisor of the Foundation, in his titular church in Rome, *Santa*

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Maria degli Angeli e dei Martiri. On 29 June they assisted, together with the students and faculty of the Summer School, in St. Peter's Basilica at the celebration by His Holiness Pope Benedict XVI of the Mass for the Feast of Saints Peter and Paul.

MAFFEO hosted the Occultation Group of Italian Amateur Astronomers for a day-long meeting at Castel Gandolfo on 10 December.

In addition to Vatican Observatory astronomers, regular observers at the VATT included astronomers from the University of Notre Dame, Wheeling Jesuit University, New Mexico Institute of Mining and Technology, University of Virginia, University of Arizona, Arizona State University, and Northern Arizona University.

The following paid working visits to the Observatory:

ANDREA AHUMADA, Observatorio Astronómico de Cordoba, Argentina

PETER ALEGI, Yale University, New Haven, Connecticut, USA, Yale Club of Italy

GENNARO AULETTA, Pontifical Gregorian University, Rome, Italy

BRUCE BALICK, University of Washington, Seattle, Washington, USA

STANISLAVA BARTASIUTE, Vilnius University, Vilnius, Lithuania

ROBERT BELOIN, Yale University, New Haven, Connecticut, USA

JOHN BYRNE, London, United Kingdom, BBC Radio 4

GIANLUCA CASAGRANDE, Ateneo Pontificio *Regina Apostolorum*, Rome, Italy

YVELLICE CASTILLO, Central America Suyapa Astronomical Observatory, Tegucigalpa, Honduras

KAZIMIERAS CERNIS, Institute of Theoretical Physics and Astronomy, Vilnius University, Vilnius, Lithuania

MIGUEL CHAVEZ, Departamento de Astrofisica, Puebla, Mexico

WERNER FRANK, University of Ulm, Germany

THOMAS GOLDEN, Yale University, New Haven, Connecticut, USA

AMARA GRAPS, Institute of the Physics of Interplanetary Space, CNR, Frascati, Italy

KATHRYN HANSEN, John Hopkins University, Baltimore, Maryland, USA

NAOKI ITOH, Sophia University, Tokyo, Japan

ARNDT LATUSSECK, Hildesheim, Germany

VYGANDAS LAUGALYS, Institute of Theoretical Physics and Astronomy, Vilnius University, Vilnius, Lithuania

MARC LECLERC, Pontifical Gregorian University, Rome, Italy

DOUGLAS O'HANDLEY, Jet Propulsion Laboratory, Pasadena, California, USA

RAFAEL PASCUAL, Ateneo Pontificio *Regina Apostolorum*, Rome, Italy

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

FRANCESCO POMATI, University of South Wales, Sydney, Australia

FILIPPO SMRIGLIO, Department of Physics, University of Rome "La Sapienza," Rome, Italy

CLAUDIA VOIT, Astronomy Department, Cranbrook Institute of Science, Michigan, USA

LUISA ZAMBRANO, Universidad Metropolitana, San Juan, Puerto Rico





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