The Vatican Observatory

2006 ANNUAL REPORT

TIMES OF TRANSITION

Vatican Observatory
Annual Report 2006

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Vatican Observatory Publications

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VATICAN OBSERVATORY

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Editor: Elizabeth J. Maggio
Cover Artist: Dave Fischer

From the Director

Times of Transition

A transition generates fear and hope. Fear for the unknown and hope for a better future. I am confident in the Providence that we will always face a better future, though we know that "all creation is groaning in labor pains even until now" (Romans 8:22). Here I would like to highlight two important transitions in the directorship of the Vatican Observatory.

One Hundred Years Ago: The First Jesuit Director

The year 1906 was a year of transition for the Vatican Observatory. That year, after a difficult period in the history of the Observatory, Johann Hagen, S.J., arrived in Rome following his appointment by Pius X as the new director of the Vatican Observatory. At that time, Father Hagen was a well-known astronomer and the Director of the Jesuit Georgetown College Observatory in Washington, D.C. The appointment of Father Hagen, a Jesuit, marked a new direction for the Observatory.

Father Hagen's contributions are described in a booklet written by Sabino Maffeo, S.J., Special Assistant to the Director. In this historical narrative, whose title in English is *J.G. Hagen, S.J., Astronomer and Priest*, Father Maffeo writes: "Today when the Jesuits at the Vatican Observatory are asked by visitors and journalists about the relationship between science and faith, the quick and easy answer to that question is to say that the fact that we are religious men and scientists tells more than words that science and faith are completely compatible." Father Hagen was an exemplar witness of science and faith. We try to follow in his steps.

And Now, Another Transition

The year 2006 was another time of transition at the Vatican Observatory. On 20 August *L'Osservatore Romano*, the Vatican's official newspaper, announced that Pope Benedict XVI had appointed me the new Director of the Vatican Observatory, succeeding George Coyne, S.J., in that office.

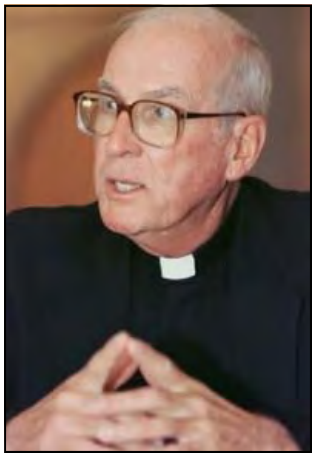
After 28 years of service, Father Coyne asked our superiors in May if they didn't think it was time for the Vatican Observatory to select a new director, and they agreed to accept his resignation as well as appoint a new director. He is taking a well-deserved sabbatical at St. Raphael Catholic Church in Raleigh, North Carolina and will rejoin the Vatican Observatory in September 2007. Father Coyne remains as President of the Vatican Observatory Foundation Board of Directors.

The entire Observatory staff is most grateful to Father Coyne for his years of inspired leadership. Personally, I am delighted that Father Coyne will continue his work with the Vatican Observatory Foundation and that after the sabbatical year he will be back with the Vatican Observatory.

Father Coyne's Directorship

Prior to being appointed Director of the Vatican Observatory in 1978, Father Coyne was Director of the Catalina Observatory and Acting Director of Steward Observatory; both institutions are part of

the University of Arizona. When the need arose to establish another observing station for the Vatican Observatory, Father Coyne was able to establish a formal collaboration in 1980 between the Specola Vaticana (the Observatory's name in Italian) and the University of Arizona. This led to the establishment of the Vatican Observatory Research Group (VORG) at the university. The clearest and most tangible sign of the fruitfulness of this collaboration is the Vatican Advanced Technology Telescope (VATT), which was inaugurated in 1993 on Mt. Graham. The existence and continued operation of VATT is possible thanks to the generosity of our friends of the Vatican Observatory Foundation.



George Coyne, S.J., retired in 2006 after 28 years as Director of the Vatican Observatory.

Under Father Coyne's directorship a new period began at the Specola. The Observatory's astronomers and astrophysicists now spend 10 months at the VORG in Tucson, although Castel Gandolfo continues to be the Observatory's administrative home, hosting the work of non-observing staff members and guest researchers. The Director's office is located in Castel Gandolfo, along with the Observatory's library and computers. During the summer months, staff members return there to discuss observatory programs, and to participate in scientific meetings and the Vatican Observatory Summer Schools.

The Vatican Observatory Summer Schools (VOSS) are another major achievement of Father Coyne's directorship. We are very proud of the success of our summer schools in encouraging young scholars to establish professional friendships with faculty and students. We have now held ten VOSS, producing around 250 alumni plus faculty members. Around 85% of the alumni are still active in research and/or are teaching astrophysics, many of them at major research centers throughout the world. I am proud to be an alumnus of the 2003 VOSS.

Under Father Coyne's leadership, the Specola has flourished. It has had a major impact on the mass media and popular culture. Consequently, the Vatican Observatory is a highly visible symbol of the Church's engagement with the contemporary world. The Observatory has also made its mark in interdisciplinary studies. In our service to the Holy See, the science–faith dialog is a natural consequence of our scientific activities. Our two-fold competency makes us special interlocutors in the dialogue between the Church and the world of Science. Father Coyne was a driving force behind this dialogue through the organization of many meetings and the publications generated by them.

At the time of my appointment as the new Director, I was participating in the International Astronomical Union General Assembly in Prague. The fact that I was participating in this prestigious meeting is not a minor detail. It tells me about the mission of the Vatican Observatory, which is to be the presence of the Church in the world of Science, in particular, astronomy. We are called to serve the Holy Father and our colleagues by doing astronomical research and helping others to collaborate scientifically through the organization of summer schools and scientific meetings. Our challenge is to keep doing good science in all the fields in which the Vatican Observatory is involved, from solar system studies to cosmology.

The Vatican Observatory I received is in very good shape. The challenge of filling Father Coyne's big shoes is a mission *impossible* that, with the help of our staff, friends, and colleagues, will be made *possible*.

Research Highlights

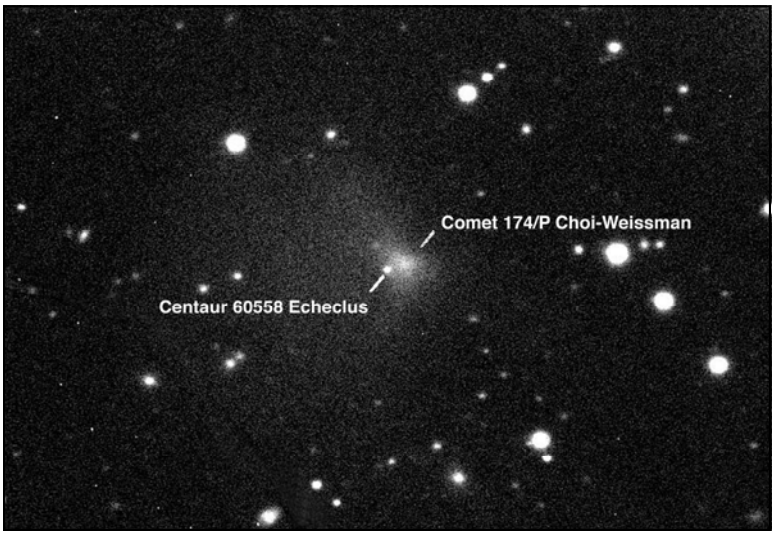
Asteroid Belts, and Maybe Planets, Can Form in Binary Star Systems

Our solar system is a single star system that includes a belt of asteroids, or planetesimals, orbiting the sun between Mars and Jupiter. This single star system is an exception since most stars in our galaxy occur in binary systems, that is, two stars revolving around their common center of mass. Now analyses of data obtained from NASA's Spitzer Space Telescope strengthen the suggestion that asteroids—and by extension, rocky planets—should be present in binary star systems as well as in singles. Christopher Corbally, S.J., and colleague Richard Gray from Appalachian State University, using ground-based telescopes, provided new MK spectral types and physical parameters for 62 binary systems so the orbiting telescope could investigate their debris disks. Another team of astronomers then used all these data to model the dust disks, finding evidence for the presence of planetesimal belts around the binary systems.

Shedding Light on Enigmatic Brown Dwarfs

Brown dwarfs are substellar objects spanning the mass range between planets and stars. Unlike stars, they possess insufficient mass to sustain the nuclear fusion of hydrogen in their cores. However, brown dwarfs can burn deuterium for a short period at the start of their lives, after which they cool, contract, and fade into obscurity. They have earned a reputation as failed stars, the veritable cinders of the Galaxy. Although brown dwarfs may outnumber all the stars in our Galaxy, these dim objects are very difficult to detect. In recent years, however, a number of these so-called failed stars have been detected as extremely bright sources of radio emission, thousands of times brighter than expected. Observations at the VATT, coordinated by Richard Boyle, S.J., have played a crucial role in a recent large multiwavelength campaign undertaken to investigate these anomalous radio emissions. This campaign, which consisted of observations conducted simultaneously at the VATT, at the Very Large Array in New Mexico, and at the U.S. Naval Observatory in Flagstaff, Arizona, should shed light on the mechanism producing these radio emissions and establish their association with the presence of magnetic spots on the surface of brown dwarfs.

Centaur Mystery Solved



Centaur 60558 Echeclus looked like it was sporting a coma in this image taken at the VATT. Further investigation, however, fingered a comet that just happened to be nearby: a once-every-1600-years coincidence.

Centaurs are a class of icy bodies in the Kuiper Belt found beyond the orbit of Neptune. With orbits that carry them from the Kuiper Belt into the main regions of the solar system, Centaurs are thought to be the predecessors of comets. So it wasn't unusual when astronomers reported in late 2005 that the Centaur known as 60558 Echeclus had developed an active coma. During their April 2006 run at the VATT, Guy Consolmagno, S.J., and colleague Stephen Tegler from Northern Arizona University decided to image this object. To their surprise, they discovered that the coma, a cloud of gas, had moved away from the Centaur! Another team of astronomers then used the VATT to track the mystery object over the next five months and found that by early May the gas cloud had not only moved back toward the Centaur but passed it. After much theorizing, the astronomers attributed the celestial puzzle to happenstance: the gas-emitting object is a comet, independently orbiting the Sun, that just happened to coincide with the Centaur. The comet may have come within 50,000 km of Echeclus... less than an eighth of the distance from the Earth to the Moon. The comet has been named 174/P Choi-Weissman for the astronomers who discovered it. Given their orbits, the two bodies will next encounter each other in 1600 years.

Methane Ice Identified on "Dwarf Planet"

The icy bodies in the Kuiper Belt may qualify for the newly defined category of "dwarf planets," which now includes the former planet Pluto. For their ongoing program to observe Kuiper Belt Objects (KBOs), Guy Consolmagno, S.J., and colleagues collected data on KBO colors and rotation light curves using both the VATT and the Keck Telescope in Hawaii. In addition, they used the MMT, a 6.5 meter telescope south of Tucson, to obtain some of the first detailed visible spectra to determine the surface composition of two of the largest KBOs known as 2005 FY9 and 2003 EL61. They discovered that the spectrum of 2005 FY9 exhibits strong methane ice bands.

Eleventh Vatican Observatory Summer School

The eleventh Vatican Observatory Summer School in Observational Astronomy and Astrophysics will be held in Castel Gandolfo 8 June to 6 July 2007. This Summer School will focus on extrasolar

planets and brown dwarfs. Dante Minniti (Pontifcia Universidad Católica, Santiago, Chile) serves as Chair for the academic program. The faculty includes: France Allard, Centre de Recherche Astrophysique de Lyon, Lyon, France; Fernando Comeron, European Southern Observatory, Garching bei München, Germany; and Didier Queloz, Geneva Observatory, Sauverny, Switzerland.

Formation and Evolution of Galaxy Disks Conference

José Funes, S.J., with the help of his colleagues, is organizing an international conference, sponsored by the Vatican Observatory, on the formation and evolution of galaxy disks to be held in Rome 1-5 October 2007. The conference topics include: properties of nearby galaxy disks; star formation laws, chemical evolution; outskirts and environment, disk edges; accretion onto disks, mergers; secular evolution of disks; evolution of disk structural properties; and disk formation in a hierarchical Universe.

The Scientific Organizing Committee consists of Eric Bell (Germany), Francesco Bertola (Italy), Daniela Calzetti (USA), Francoise Combes (France), Enrico Corsini (Italy), Kenneth Freeman (Australia), José Funes (chair, Vatican), Robert Kennicutt (UK), John Kormendy (USA), Julio Navarro (Canada), Vera Rubin (USA), Yoshiaki Sofue (Japan), Rachel Somerville (Germany), Piet van der Kruit (Netherlands), Jacqueline van Gorkom (USA), and Dennis Zaritsky (USA).

Personnel News

George Coyne, S.J., is taking a sabbatical year from September 2006 through August 2007. During this time, he is working as an assistant to the pastor of Saint Raphael Catholic Church, staffed by Maryland Province Jesuits in the Diocese of Raleigh, North Carolina.

William Stoeger, S.J., has been named Coordinator for the Vatican Observatory's Science and Theology Programs. He will be involved in coordinating meetings, programs, and institutional collaborations relating to science and theology.

For the 2006-2007 academic year, Guy Consolmagno, S.J., is holding the Loyola Chair for visiting Jesuit scholars at Fordham University in New York City. His duties include teaching classes in astronomy and physics, and delivering two public lectures. He is also using this opportunity to continue his research on meteoritics at the American Museum of Natural History.

Guy Consolmagno, S.J., has been named the Vatican Observatory's Coordinator for Public Relations. He will provide resources and guidelines for dealing with the media to members of the Specola. He will coordinate press releases on newsworthy events at the Specola, and he will track press coverage of the Specola. He will also provide a file of commonly requested materials about the Specola and its staff, including a brief Specola history, staff biographies and photographs, and instructions for complying with Vatican policies and regulations.

José Funes, S.J., will serve as National Node Chair to the International Astronomical Union for the International Year of Astronomy 2009.

Michael Heller has been awarded membership in the Polish Academy of Science and Art (Cracow) and the First Prize for Work in Mathematics, Warsaw University of Technology.

Gabriele Gionti, S.J., after working at the Vatican Observatory for two years, has been assigned to study theology at the Jesuit School of Theology in Berkeley, California. These studies are part of the priesthood formation.

Alessandro Omizzolo is now associated with INAF, the National Institute for Astrophysics in Italy.

Vilppu Piirola, Tuorla Observatory, University of Turku, Finland, has concluded a two-year period as Research Astronomer at Castel Gandolfo. He and George Coyne, S.J., have collaborated on research into cataclysmic variable stars.

We regret very much that Randall Swift, mechanical staff technician for the Vatican Advanced Technology Telescope, had to retire, due to ill health. James "Jim" Kennedy assumed this position in November with responsibilities for the daily support of the telescope and for help with its current and planned upgrading. Jim transferred to VATT from the Mount Graham International Observatory staff. Previously he was a supervisor at a local mining company.

During 2006 we were pleased to have part-time help for VATT from three people in the Engineering Technical Services division of Steward Observatory: Chris Tardif for electronic control development, Chris Johnson for software development and maintenance, and Andrew Tubbiolo for mechanical and electronic help.

In Memoriam

We were saddened by the death in 2006 of both the father and the mother of Vatican Observatory Foundation Board Member James C. McGee.

José Funes, S.J., Director

I. Astronomical Research

Theoretical Studies, Astrophysics, and Cosmology

GIONTI continued working on the problem of inclusion of fermionic matter in the Spin Foam Formalism in Loop Quantum Gravity. This work is being done in collaboration with MORALES TECTOL (Universidad Autonoma Metropolitana Iztapalapa, U.AM.I. Mexico City, Mexico) and ROVELLI (Centre de Physique Theorique de Luminy, Marseille, France). Different models for Spin Foam Formalism in Loop Quantum Gravity, like the Barrett-Crane model, always exhibit a technical problem regarding the inclusion of coupling with fermions. Local Theory of Regge Calculus seems to indicate a solution for this standing problem. Moreover, there are some encouraging results showing that all different approaches of Spin Foam may be derived and connected to Regge Calculus. This appears very important because it would prove that Spin Foams might be directly derived from General Relativity and be a starting point to show, in a consistent mathematical way, that they are a good and promising proposal toward a Quantum Theory of Gravity.

GIONTI was invited to spend several months collaborating with Gary W. Gibbons in the Department of Applied Mathematics and Theoretical Physics at the University of Cambridge, UK. They worked on the problem of Black Hole Entropy either in Supergravity or in ADS/CFT formalism. As is well known, gravity and thermodynamics do not match well even at the classical level. This problem continues to exist in classical field theory and is severe in the quantum regime regarding Black Hole Entropy where the energy information is lost. ADS/CFT formalism seems to give some answers to these problems, basically from the String Theory side. Much work is still needed to understand this phenomenon even at the thermodynamic level. The work of Gibbons and Gionti aims to investigate the mathematical structure of the thermodynamics of Black Hole entropy with the hope that this research might give some insight to the problem of information energy loss.

Within the above framework, GIONTI has also tried to inquire into the possibility of using discrete approaches in String Theory. The main proposals for String Theory use a continuum formalism, which has many problems since all calculations can be performed around the linear approximation. Few things are known about non-perturbative approaches and strong fields in general. The main proposal, until now, is the ADS/CFT formalism. A discrete approach for String Theory would make it possible to perform, also numerically, some non-perturbative calculations. Some pioneering research has already been done, but much work remains. Gionti is investigating the possibility of implementing String Theory on Local Regge Calculus. The main problem remains how to implement supersymmetry on a random lattice case in an exact form. Hope comes from the regular lattice case where some authors, including Alessandro D'Adda, Gionti's Ph.D. thesis supervisor, proved that the supersymmetry can be implemented in an exact way.

HELLER, in collaboration with a group of mathematicians at Warsaw Technical University, continued a program concerning applications of noncommutative geometry to physics. The researchers have further developed a model unifying general relativity and quantum mechanics. Their main

achievements in 2006 were: (1) addressing the often-asked question in contemporary cosmology: Will the initial (or final) singularity in the standard cosmological model survive the advent of the future quantum gravity theory? Usually, either "yes" or (more often) "no" answers are given to this question. Their model discloses a third possibility. It shows that, because of the random character of dynamical equations, on the fundamental level the question concerning the singularities is irrelevant. Singularities emerge only when one goes from the fundamental level to macroscopic physics; (2) computing the closed Friedman world model within the framework of their approach. In this approach, Einstein's field equations are purely geometric; they do not contain matter terms. In spite of this fact, the correct matter terms do appear on the macroscopic level. In this sense, one can say that matter has been produced out of pure geometry.

STOEGER and GIONTI continued their investigation of the spin components of the full gravitational field, which is important for understanding how gravity is included in String Theory, as reported more fully in the last annual report.

STOEGER and ELLIS (University of Cape Town, South Africa) concluded their work on various physical and philosophical issues connected with ensembles of many universes, or universe domains (multiverses). They are now beginning to explore the very early stages of the cosmic history of our local domain, i.e., the Milky Way and its companion galaxies—particularly the likely origin of the little density fluctuations that led to the small-galaxy components that gradually combined to form the Milky Way. These undoubtedly were generated by inflation, immediately after the Big Bang. But did they have to be present as trans-Planckian perturbations at the start of inflation, or could they be generated toward the end of it? If the former, then quantum cosmology will be essential in determining how they arose. And then, how does one evaluate the many scenarios that have been suggested for doing this?

STOEGER and HELLABY (University of Cape Town, South Africa) continued their collaborative efforts on issues related to linking observations and theory in both homogeneous and particularly inhomogeneous universes. Though there is compelling evidence that our universe is almost homogeneous on the very largest scales, confirming this and determining the smallest scales on which this is true requires some consideration of inhomogeneous models. The long range goal is eventually to determine the metric of the universe more directly from observations. The researchers are looking at how a recent suggestion by HELLABY for determining the mass of a region surrounding us out to where the angular-diameter distance is a maximum may provide additional independent observational purchase for accomplishing this. This is particularly important in light of strong evidence for the presence of dark energy, which means we have to constrain at least two more parameters than originally anticipated.

RIBEIRO (Instituto de Fisica, Universidade do Brasil–UFRJ, Rio de Janeiro) and his students, together with STOEGER, completed their observational/theoretical study testing, and distinguishing between, the observational homogeneity and the theoretical homogeneity of galaxy distributions. They are now going on to finish their investigation of fitting Friedmann-Lemaitre-Robertson-Walker (FLRW) and Lemaitre-Tolman-Bondi (LTB) models, with non-zero cosmological constant to galaxy number count data, and comparing the results.

ARAUJO (Universidade Federal do Rio de Janerio) and STOEGER continue their program for solving the general perturbation equations with cosmologically relevant data, with the inclusion of the cosmological constant and other forms of dark energy. However, during the past year they have only been able to work sporadically on this problem.

JUST (Department of Physics, University of Arizona) with STOEGER's help is pursuing a number of projects in quantum mechanics and quantum field theory, including two that promise to help understand how gravity connects with other fundamental fields at low and intermediate energies.

Extragalactic Research

KENNICUTT (University of Cambridge, UK), LEE (National Optical Astronomy Observatory), SAKAI (University of California, Los Angeles), TREMONTI (Steward Observatory), VAN ZEE (Indiana University), and FUNES continued the survey named 11HUGS (11Mpc H-alpha and Ultraviolet Galaxy Survey). FUNES obtained *UVB* imaging for spiral and irregular galaxies (mostly dwarf galaxies) within a distance of 11 Mpc. Ten nights were granted on the CTIO 0.9m telescope to observe 31 galaxies in the Southern Hemisphere. The requested data combined with H-alpha, *R* and UV imaging from the 11HUGS GALEX (Galaxy Evolution Explorer) Legacy project will provide a comprehensive multi-wavelength image atlas of the local universe. The *UBV* colors will be used to constrain the star formation history. This data will allow us to shed light on the correlation between underlying galaxy color and current star formation activity. AKIYAMA (Steward Observatory) is reducing the data.

FUNES with the assistance of AXLINE (undergraduate student, University of Arizona) continued his study of elliptical galaxies with dust lanes. The formation and evolution of early-type galaxies is not completely understood. Study of the ionized gas and the stellar populations in elliptical galaxies with dust lanes can shed light on the formation process of elliptical, E+A, polar ring, S0 and Sa galaxies. To address this issue, in 2004 Funes started an observational program aimed at obtaining H-alpha and UBR images with VATT. In 2006 new H-alpha and UBR images were obtained with VATT for 7 galaxies. He plans to continue observations for the entire sample (46 galaxies) and derive the star formation rates (SFRs) and the ratio of the current to average past SFR (birthrate parameter); obtain color maps and compare them to those available in the literature for E+A, polar ring, S0 and Sa galaxies; study the environment of these galaxies; and explore the AGN–starburst connection.

OMIZZOLO became a member of the WINGS (Wide-field Nearby Galaxy-clusters Survey) group, involved in the study of the properties of nearby clusters of galaxies ($0.04<z<0.06$) (http://web.pd.astro.it/wings/index.html). They observed in June and in November with the 90prime at the Steward Observatory 90" Bok Telescope to obtain large (1 degree x 1 degree) mosaic images of clusters. They conduct the data reduction of the images to derive the astrometry and photometry of the clusters. A side product of this research is the study of Ultra Compact Dwarf Galaxies, a particular class of dwarf galaxies whose study is important for understanding the evolution of galaxies and the role of dark matter in their formation and in the dynamics of the clusters.

OMIZZOLO continued scanning the plates of the Vatican Observatory at Castel Gandolfo: about 50% of the plates from the Schmidt telescope archive have been digitized.

The Galaxy and Galactic Objects

BOYLE and JANUSZ with their collaborators PHILIP (Union College and Institute for Space Observations), STRAIZYS, KAZLAUSKAS, LAUGALYS (Vilnius, Lithuania), SMRIGLIO (University of Rome), and VRBA (U. S. Naval Observatory, Flagstaff) continued observations of star clusters with Stromvil and Vilnius photometry. The CCD observations are made at the following telescope facilities: VATT, CASLEO, Loiano, Moletai, and USNO-Flagstaff.

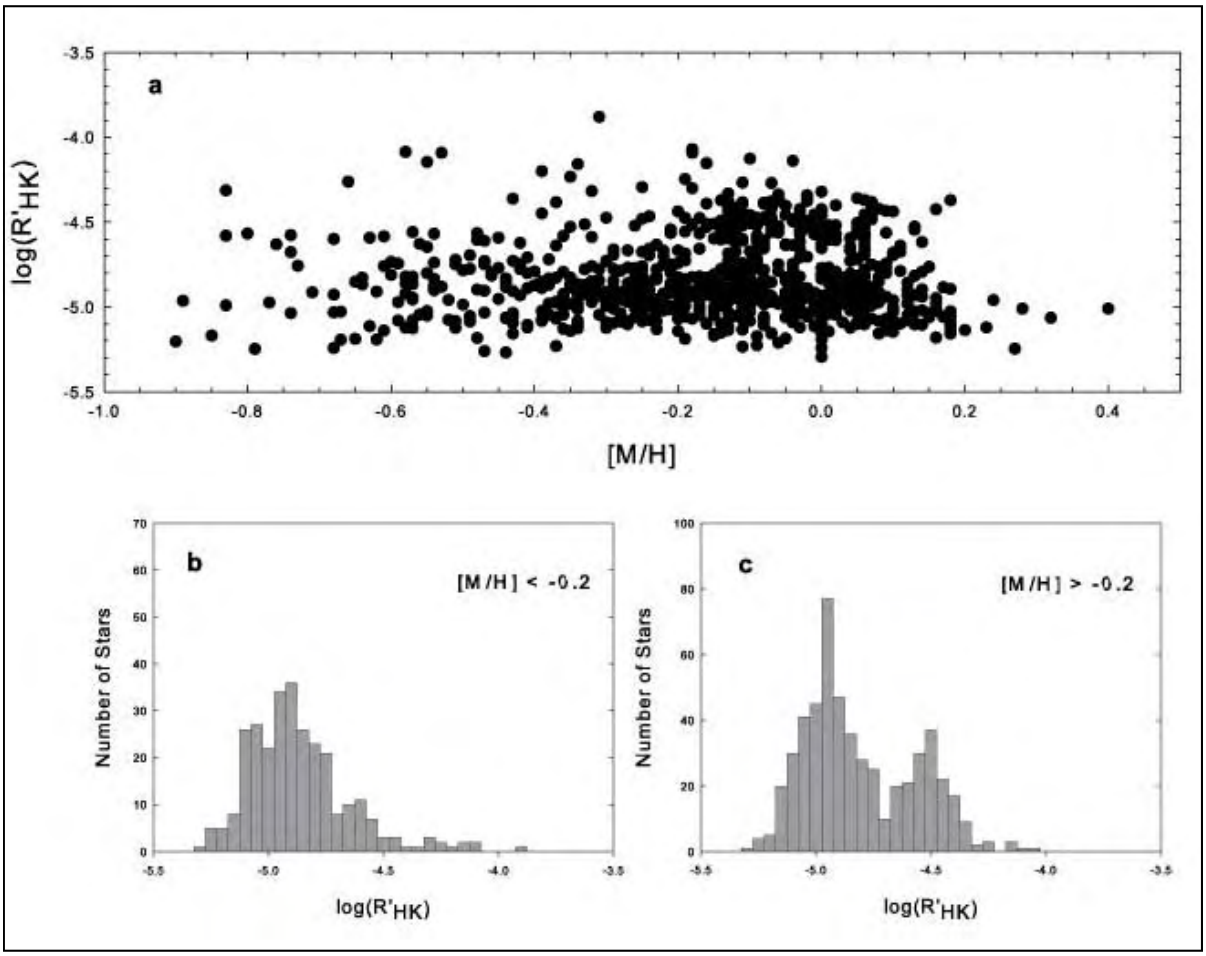
SPERAUSKAS (Vilnius, Lithuania), with support from BOYLE, PLATAIS (Johns Hopkins University), and BARTASIUTE (Vilnius, Lithuania), continued his long-term observational program with his CORAVEL radial velocity spectrometer on many stars over the course of seven autumn weeks at the 40-inch, 61-inch, and 90-inch telescopes of Steward Observatory.

BOYLE with LANE in the group of HALLINAN (National University of Ireland, Galway, Ireland) made continuous I-band CCD observations at VATT for two nights in May of the ultracool rapidly rotating M9 dwarf TVLM 513-46546 while simultaneous radio observations were made at the VLA in New Mexico. HALLINAN interprets the radio data with the VATT I-band lightcurve as being the discovery of a new subclass of brown dwarf, which he named “Sporadically Pulsing Ultracool Dwarfs” (SPUDs).

CORBALLY and GRAY have started to search for classical A-type shell stars in open clusters in order to determine their evolutionary state. It is commonly assumed that the classical A-type shell stars represent an extension of the Be/shell phenomenon toward cooler effective temperatures. However, contrary to the Be/shell phenomenon, many of the classical A-type shell stars show shell features that are stable over time scales of decades. The question arises whether the classical A-type shell stars can really be explained with the same mechanism as the Be and Be/shell stars. An important step in answering this question is to determine the evolutionary state of these stars. The spectroscopic search for classical A-type shell stars in open clusters is designed both to reveal their evolutionary state and to give a rough estimate of the frequency of these stars in clusters, an important clue to the nature of the shell-star mechanism. The data from an initial 3-night observing run on the Steward Observatory 2.3m telescope is being processed and analyzed.

For an investigation of debris disks in main sequence binary systems using the Multiband Imaging Photometer on the Spitzer Space Telescope, GRAY and CORBALLY provided new MK spectral types and physical parameters for 62 systems. TRILLING, STANSBERRY (Steward Observatory), and colleagues used these data to help model the dust disks around these systems. The calculated dust temperatures suggest that about half of the excesses observed are derived from circumbinary planetesimal belts, while one third clearly suggest circumstellar material. Three systems with excesses have dust in dynamically unstable regions. These results strengthen the suggestion that asteroids (and by extension, rocky planets) should be present in binary star systems as well as in singles.

The Nearby Stars (NStars) project has been obtaining spectra, spectral types, and basic parameters of the 3600 stars within 40 parsec of the Sun, according to the Hipparcos catalog, 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. The second paper in the series, containing the southern hemisphere sample, was published in 2006. In this paper it was demonstrated that the bimodal nature of the chromospheric activity parameter, log R'_{HK}, depends strongly on the metallicity, and the nature of the "low-metallicity," chromospherically active, K-type dwarf stars was explored. The data analysis concentrated on classification of the final set of stars in the northern



The distribution of the chromospheric activity parameter, log R'_{HK}, for dwarf F, G and early K-stars as a function of metallicity. In (a), activity increases along the vertical axis, in (b) and (c) to the right. Panels (b) and (c) show histograms of the distribution of points in panel (a). Note that for stars with [M/H]> -0.2 the distribution is strongly bimodal, but it is single-peaked for [M/H]< -0.2. Also note that a tail of very active dwarf stars persists in the metal-weak distribution.

hemisphere. Observed and derived data from this project are being released, as they are finalized, on the project's website: http://stellar.phys.appstate.edu.

GRAY and CORBALLY continued to work on a book, *Stellar Spectral Classification*, which covers the ultraviolet and infrared as well as the classical, optical wavelength region. The chapters on the MK classes from O- to M-type are fairly complete. For the chapters on the hottest and the coolest stars, the researchers are kindly joined by colleagues in the field of stellar classification. This book is under contract for publication by Princeton University Press.

PIIROLA, in collaboration with COYNE, continued work on strongly interacting binary stars. Applying new codes for electron scattering in circumstellar matter to analyze an extensive set of multicolor (UBVRI) polarimetry, they performed studies of the structure of ionized circumstellar gas in W Serpentis-type massive binaries. These stars are in a stage of very intense mass transfer between the binary components, and a violent interaction of the mass-gaining star with the infalling gas takes place. Observations of the W Ser-type binary SX Cassiopeiae revealed a clear phase-locked polarization pattern over the 36.6-day binary orbital period, showing pronounced effects at the primary eclipse, when the hot component and the circumstellar matter are obscured by the companion star. The major features of the polarization curves are well explained by a model with an extended scattering region on the trailing side of the accreting star, where the stream from the companion hits the accretion disk. The modeled scattering region is above the orbital plane by about 10 deg, as seen from the center of the mass gainer. The researchers attribute this to dominant electron scattering taking place on the upper side of an optically and geometrically thick accretion disk seen at an inclination ~78 deg by the observer. The results give new insights into accretion phenomena in binary stars that are in the phase of very rapid mass transfer.

Planetary Sciences

Meteor Densities

The bulk density for small meteoroids—interplanetary dust particles that become visible as “shooting stars” when they hit the Earth’s upper atmosphere—is an important proxy of the physical nature of their host parent body. Furthermore, variations in bulk densities among meteoroids may reflect various evolutionary processes, such as sintering, thus providing some insight into the orbital evolution of individual meteoroids. However, the mean bulk density of small meteoroids remains a poorly measured quantity. Directly measuring their density is a central part of KIKWAYA ELUO’s Ph.D thesis at the University of Western Ontario.

During the Eta-aquarid shower from April 26 to May 6, KIKWAYA ELUO and his collaborators BROWN, CAMPBELL-BROWN, and NUDDS (all with UWO) set up a series of cameras in the Tucson area to photograph incoming meteoroids. By comparing images of the same events taken from different locations, it is possible to triangulate position of the meteoroids and thus determine both their initial velocity and the rate at which the upper atmosphere slows them down; from the latter, an estimate of the meteoroid density can be made. Analysis of one such observed meteor in

this shower indicated that it hit the upper atmosphere with a velocity 49.3±0.2 km/s and then decelerated at a rate of -13.4±0.8 km/s^2. The three light curves of the same meteor observed by three different cameras at two different sites (Kitt Peak and Whipple Observatories) allow them to measure the brightness of the meteor to be 3.1±0.7 mag. From this, the bulk density is determined to be 750 kg/m^3. Even though these particles are made of dust, this density is significantly less than that of water ice, indicating that this particle was significantly porous. Results such as these can now be compared to theoretical predictions for meteor dust particles, to determine the possible structure and composition of this dust.

Meteorite Porosity and Asteroid Structure

Meteorites—rocks that, unlike meteors, survive passage through the Earth's atmosphere to be collected and studied in the laboratory—remain our primary source of detailed information about the composition of asteroids. Their mineralogy provides a baseline against which other remote sensing techniques can be compared; their densities indicate the importance of large scale void spaces within asteroids; and the physical fabric of the meteorites revealed by shock features, microcracks, and total porosity, shows how shock events shaped the asteroids. Research into all these topics continued at the Vatican Observatory in 2006, and invited reviews of the work to date were presented by CONSOLMAGNO at international symposia in Singapore and Beijing this past summer.

STRAIT (Alma College, Michigan), CONSOLMAGNO, and BRITT (University of Central Florida) extended their comparison of meteorite microcracks and hand specimen porosities to determine the nature of the events in the early solar system that formed and lithified the meteorites and asteroids. They measure the porosity of meteorites using two methods: hand sample measurements using helium pycnometry and thin section measurements using backscatter scanning electron microscopic images and a computer measurement program. For validation, a suite of typical terrestrial rocks covering a wide range of rock classes and porosities was measured using both methods.

The porosities of the terrestrial rocks match the range of porosities observed in the meteorites. The porosity visible in the terrestrial samples also looked like porosities in ordinary chondrite and achondrite meteorites. However, carbonaceous chondrite meteorite porosities measured using hand samples range up to 25%, but their pore space is not as evident in SEM images as that exhibited in terrestrial samples with similarly high porosities. In fact, the highly porous carbonaceous chondrites appear in thin section to look much like the very low porosity terrestrial samples such as quartzite. This suggests that the voids in the carbonaceous chondrites are either too large to be included in thin sections, or too small to be visible by SEM imaging (which can see only down to about a micrometer). In either event, these meteorites are very different in structure from terrestrial rocks or ordinary chondrites.

Most meteorites show at least some degree of thermal (and in some cases aqueous) processing that presumably occurred on their parent bodies before they were ejected into Earth-crossing orbits. Finding the actual setting where this metamorphism took place has been a long-term goal of work by CONSOLMAGNO and BRITT (UCF). Their detailed analysis of asteroid densities indicates that virtually all such rocky bodies with masses less than 1020 kg are today significantly porous, with many of them showing extensive macroporosity (>40%). It is not clear that these asteroids could

have provided the physical environment needed to produce the observed degrees of metamorphism seen in meteorites, which suggests that meteorites may not be good representatives of their original parent bodies.

Data from recent spacecraft missions and new observations have allowed this analysis to be extended to cometary nuclei, additional small asteroids, planetary satellites (especially using Cassini measurements of the densities of Saturn's moons), and Centaurs and Trans-neptunian objects, where densities have been estimated from their shape and spin characteristics (see below). From this analysis CONSOLMAGNO and BRITT find a general trend that, regardless of composition or location in the solar system, not only asteroids but all bodies larger than 1020 kg mass tend to be well-compacted objects while smaller bodies, down to fragments much smaller than a few hundred meters diameter, are either extensively fragmented or loose piles of rubble.

The universal nature of this size limits suggests that it may reflect an underlying physics, either that such-sized bodies are able to withstand catastrophic disruptions or that they are able to reshape themselves after such disruptions. Thus, this mass range may mark the boundary between small solar system bodies, which appear to be highly macroporous, and the newly defined "dwarf planets" (including Pluto, Ceres, and the newly named object Eris, which is larger than Pluto and orbits farther from the Sun.)

Theory suggests that one can place limits on the density of small irregular solar system objects by studying the relationship between their shape and spin state. CONSOLMAGNO has begun an analysis that, unlike previous work assuming strengthless bodies, includes the role of internal strength in maintaining certain body shapes against the resulting stresses. He has examined how shape, spin, and density are related for those bodies (mostly asteroids) with already known shapes and densities, noting where the direction of the uncertainties drives the data. From this he draws conclusions from trends of data for many bodies, rather than attempting to make strong statements about any given body.

Using the average spin rate of the 29 Kuiper Belt Objects (KBOs) for which accurate light curves have been found, and adjusting for known biases in the data, a "mean density" of 0.45 g/cm^3 can be derived for KBOs. This is similar to the mean densities reported for comet nuclei visited by recent spacecraft, including comets Borrelly, Wild, and Tempel 1, and significantly lower than the density of ice, indicating that these bodies too are probably loose piles of rubble.

One significant exception is the newly discovered large KBO, 2003 EL61, whose rapid spin and large light curve indicate that it must be at least as dense as Pluto. This object is also nearly the size of Pluto, with a mass that is certainly larger than the 1020 kg limit noted above. Thus it is an excellent candidate for the category of "dwarf planet."

Observations of Trans-Neptunian Objects

The ongoing program of CONSOLMAGNO, TEGLER (NAU), and ROMANISHIN (Oklahoma) to observe KBO colors entered a new phase in 2006. They continue to use the VATT as well as the Keck Telescope in Hawaii, the world's largest, to collect data on the BVI colors and rotation light

curves for these objects. In addition, time was acquired on the MMT, a 6.5 meter telescope south of Tucson, to take some of the first detailed visible spectra to determine the surface composition of the largest of these objects: bodies that may qualify for the newly defined category of "dwarf planet."

At the MMT, the team obtained high signal precision optical reflectance spectra of the large KBOs 2005 FY9 and 2003 EL61, and discovered that the spectrum of 2005 FY9 exhibits strong methane ice bands. However, a comparison between the observed spectrum and a Hapke model for the spectrum indicates the methane bands are shifted 3.25 ± 2.25 Angstroms relative to pure methane ice. This suggests that another ice component may be present on the surface of 2005 FY9, possibly nitrogen ice, carbon monoxide ice, or frozen argon. By contrast, the spectrum of 2003 EL61 is remarkably featureless, with only a hint of a frozen oxygen ice band at 5773 Angstroms; this feature needs to be confirmed by future spectroscopic observations of 2003 EL61 with a higher continuum signal precision. Participating in the acquisition and interpretation of these ice bands were GRUNDY (Lowell Observatory), MOGREN (NAU), and VILAS (MMT).

The Centaur and the Comet

Centaurs are a class of KBO whose orbits carry them from the Kuiper Belt into the main regions of the solar system; they are thought to be the predecessors of comets. In December 2005, CHOI and WEISSMAN (JPL) announced that the Centaur 60558 Echeclus had developed an active coma. While it is not unprecedented that such an object should develop a comet-like coma in the outer solar system, this development was sufficiently unusual that TEGLER (NAU) and CONSOLMAGNO decided to image this object during their April run at the VATT. To their surprise, they discovered that the cloud of gas appeared to have actually moved away from the object itself!

Observations during the next five months, including runs at the VATT by Choi, Weissman, and STANSBERRY (Arizona), showed that the apparent source of activity was probably at a maximum distance of ~7 arc-seconds (a projected distance of ~65,000 km at the Centaur) in late February 2006. The activity source then moved back toward, and past, the primary to only 2.7 arc-seconds in early May 2006. Although the apparent motion at first seemed to suggest that an orbiting secondary fragment was emitting the cloud of gas, the speed with which this secondary moved over the distances involved would require that the mass of the primary being orbited was at least 200 times more massive than expected for an icy body. Rather, it appears that the secondary object is more likely moving on a hyperbolic orbit relative to the primary, which is to say it is essentially in an independent orbit around the Sun: it is a comet (which should properly be renamed 174P/Choi-Weissman) that happened to coincide with this Centaur. Their two independent orbits are such that they should encounter each other once every 1600 years.

Because comets are in general assumed to be derived from bodies like Centaurs, it is certainly reasonable to assume that this comet was once a fragment of the Centaur. However, if the disruption occurred recently, perhaps due to an explosion of volatile gases or the impact on the primary by some other small solar system body, one would expect that the primary body would be emitting gas as actively as the comet. Since it isn't, one can conclude that either the splitting occurred at least one 1600 year period before the present, or the secondary is actually an escaped satellite of the primary. But although the existence of a Centaur with a satellite is not unusual, it is not clear what forces

could have led to its escape; at its current heliocentric distance, non-gravitational forces resulting from outgassing would not be sufficient to explain the escape. Additional details of this unusual object remain to be explored. In addition to the astronomers already named, others taking part in this sequence of observations and their analysis include CHESLEY and BAUER (JPL).

History and Philosophy of Science; Interdisciplinary Studies

CARUANA completed his historical study on 17th century Jesuit cosmologists, which will be a chapter of a forthcoming volume entitled *The Cambridge Companion to the Jesuits* (Cambridge University Press). In the area of philosophy of science, Caruana continues to work on how falsification functions in science and in theology, and is now engaged in a collaborative project with the Department of Theology of Heythrop College London University, where his contribution will be mainly on the doctrine of Creation. He finalized publication of his book called *Science and Virtue: An Essay on the Impact of the Scientific Mentality on Moral Character* (October 2006). Apart from other purely philosophical projects not listed here, he continues to work with doctoral students in two main areas: on how Karl Popper's ideas on verisimilitude can be applied to the philosophy of scientific models, and on how a study of the Cartesian mechanistic ontology can facilitate the understanding of current environmental problems.

CORBALLY examined cultural encounters of the Jesuit missionaries in the late 17th and 18th centuries with the people of the Pimería Alta (now northern Sonora, Mexico, and southern Arizona). The missionaries' impact included their science, their agricultural innovations, and their cartography.

MAFFEO completed the transfer to computer files of the Secchi-Denza correspondence from the archive of Collegio di Moncalieri. He also oversaw the Portuguese edition of the book *Galileo: For Copernicanism and for the Church*, by Annibale Fantoli, to be published by Edições Loyola (São Paulo, Brazil).

II. Instrumentation and Technical Services

Vatican Advanced Technology Telescope (VATT)

Technical activities at VATT in 2006, supervised by McKENNA, mainly concerned the performance of the primary mirror. Progress was made on the imaging system by integrating the 2K and 4K camera system to a single PC. This success is now paving the way to decommission the aging SUN computer system. Telescope support subsystems like the dry air system are being integrated with the telescope control system to prevent unsafe conditions from persisting.

An attempt to recoat the primary mirror this summer was not successful due to scheduling difficulties with the aluminizing chamber. Advantage was taken of this time period to study the present mirror support system. FRANZ and TUBBIOLO removed all the side supports and tested, lubricated, and installed felt washers to protect the bearings from contamination. Their measurements indicate

that the current side supports can produce over 200 pounds of force due to binding. Additional data are now on hand about the performance of the hard points and side support system, indicating that unpredictable motions of VATT's primary mirror are compromising the image quality. A design study has been initiated to explore possible solutions.

The primary mirror side supports were removed from the VATT in 2006 for cleaning and evaluation.. (Photo by C.Corbally, S.J.)

TARDIF completed the design and construction of a mirror support control and display panel allowing the technical staff to observe and control the pressures and forces applied to the mirror support system. This modification will also prevent the mirror support from cycling when the VATTTEL is reset, hopefully reducing the mirror wander.

TARDIF also completed a new auto-fill system that will allow automatic filling of the detector dewar, relieving the tight scheduling that was needed to keep the detector cold between observing runs.

Problems with the quality of the supplied AC power necessitated the installation of a power monitor system. This device will be used to identify the power quality related events that seem to come at increasing intervals.

JOHNSON rebuilt a spare telescope control PC (vattpc1) and is resolving issues needed to produce a "hot spare" that can be substituted immediately.

The two vertical counter weights were modified to include a "sight window" for weight position display; the drive screws were straightened, the bearing plates rebuilt, and a safety stop added to prevent the weight from falling if the bearing should fail again.

Cyber Activities

CORBALLY and PELETIER (Groningen) maintained the website of the Vatican Observatory and its Foundation, updating such items as the Annual Report, Newsletters, Calendar, details about the Summer School and its alumni, and VATT observer information. They also maintained the site for the Joint Discussion 13 at the IAU General Assembly in Prague and included slides for the talks that were given. PELETIER, using input from FUNES, crafted the website for the the Formation and

Evolution of Galaxy Disks meeting to be sponsored by the Vatican Observatory in 2007. See http://kino.as.arizona.edu/~disks.

Activity in 2006 on the Vatican Observatory website rose about 10% again, receiving an average of 8,575 hits per day. As usual, spikes in the frequency of hits occur when newsworthy events happen, such as the changeover of directors at the end of August. More interesting perhaps is that the website is accessed from about 90 countries worldwide each month. The website can be accessed at http://vaticanobservatory.org.

III. Observatory and Staff Activities

Vatican Observatory Foundation Annual Meeting

The annual meeting of the members and directors of the Vatican Observatory Foundation (VOF) was held 24 February 2006 in Tucson, Arizona. The following were elected to serve as members and directors for a three-year period: Richard Boyle, S.J., Michael A. Cronin, Charles L. Currie, S.J., Karen Dalby, Rocco L. Martino, and Brendan D. Thomson. Jim Considine of Los Angeles was elected to the board.

Steward Observatory director Peter Strittmatter (left) explains new Mirror Lab developments to VOF friends who visited the facility during the Foundation's annual board meeting in February. (Photo by Christopher Corbally, S.J.)

On the day preceding the annual meeting a seminar was conducted by members of the Observatory staff to present their research in a popular forum to friends of the Observatory and to members of the Board. On the day after the meeting the same group was accompanied on an excursion to the Mt. Graham International Observatory where the Vatican Advanced Technology Telescope is located. That Friday night, friends celebrated the 20th anniversary of the VOF and of the Vatican Observatory Summer Schools

(VOSS) at the Westin La Paloma. Speakers included VOSS participants Chris Impey and Miguel Chavez. The memories of Thomas J. Bannan and Fred A. Lennon, founding donors of the VATT, were honored. Ben Dalby, representing the Arline and Thomas J. Bannan Foundation, and Chris Hitchcock of the Fred A. Lennon Charitable Trust, recalled the enthusiasm and passion that these friends brought to the VOF and to construction of the VATT.

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 2007 was produced with the theme: *Education.*

Vatican Observatory Conferences

July 9-14 Stoeger participated in the "Creatio ex Nihilo Today" conference at the Vatican Observatory in Castel Gandolfo, Italy, for which he was one of the organizers, along with Janet Martin Soskice (Cambridge) and David Burrell (University Notre Dame). Stoeger presented a paper, "The Big Bang, Quantum Cosmology and Creatio ex Nihilo."

Presentations and Academic Activities

CARUANA • Presented the standard courses on metaphysics and philosophy of science at Heythrop College, London University. • In January, published a short paper on the internet to respond to the popular atheist-biologist R. Dawkins on his TV program *The Root of all Evil*. • Delivered a paper 30 March entitled "Falsification in Science and Theology: A Reappraisal" as the main address to the Graduate Conference for doctoral students held in the Jesuit Faculty of Philosophy, Trnavska univerzita, Kostolna 1, Bratislava, Slovakia; the same paper with further modifications was presented and discussed at a conference in Granada, Spain, on "Belief and Metaphysics" held 15–18 September and organized by the Nottingham University Centre of Theology and Philosophy, in partnership with the Instituto de Filosofía Edith Stein de Granada. • Delivered a paper 26 May entitled "A Christian Evaluation of Scientific Attitudes in Ethics and Economics" to the Heythrop Institute of Religion, Ethics and Public Affairs.

CASANOVAS • Gave a seminar on the Gregorian Calendar, School of Philosophy, Cracow. October 5, 2005, a lecture on the teaching of astronomy in the XVIII century, University of Budapest. November 30, a paper at the Symposium on Matteo Ricci: Alle origini del Missionerato, Scientifico nell'Asia oritentale: Clavio e il Collegio Romano, Symposium on Matteo Ricci. March 2, a lecture on Francesco de Vico, professor of astronomy in the Collegio Romano. A paper on the teaching of astronomy after Galileo's condemnation, in the symposium on Faith and Science, La Palma (Canary Islands) 12-16 September. A lecture on Copernicus at the Regina Apostolorum University (Rome) 31 October.

VATICAN OBSERVATORY

CONSOLMAGNO • Spoke on "Colors in the Kuiper Belt" in an astronomy seminar at the University of Washington, February 16; discussed "Meteorite Density and Asteroid Structure" to the physics department of Illinois Wesleyan University, Bloomington, February 17. • Spoke to the physics and astronomy department of Northern Arizona University, Flagstaff, March 27; as a presenter of the annual Barringer Lecture at the University of Arkansas, Fayetteville, April 10; to the physics department at Lafayette College, Easton, Pennsylvania, September 27; at the department of Earth, Atmospheres, and Planetary Sciences of MIT, Cambridge, Massachusetts, November 1; and to the astronomy department of the University of Maryland, December 6. • September 6, discussed "Classifying Meteorites by Density and Dusceptibility to the Earth Sciences Division of the American Museum of Natural History in New York City. • Began duties as chair of the Division for Planetary Sciences of the American Astronomical Society; his term runs until October 2007. As part of these duties, he traveled to Washington, DC, to meet with NASA officials and congressional staffers May 17-19, October 25, and December 1. • Served on the NASA Planetary Geology and Geophysics (PG&G) Asteroids and Spectra panel at the PG&G meeting in Denver, Colorado July 30-August 3; the panel evaluated more than 100 proposals for funding from the American space agency. • Completed his term as president of Commission 16 (Planets and Satellites) of the International Astronomical Union (IAU). In this role he successfully chaired the Joint Discussion on "Progress in Planetary Exploration Missions" held at the General Assembly (GA) in 2006, and served on the IAU Working Group on Planetary Surface Nomenclature. At the GA he was re-elected to the post of Secretary of Division III, Planetary Systems Sciences. • Completed his second two-year term on the Meteoritical Society Council and took part in the Council meeting in Zurich, Switzerland, August 6. • In August, began a one-year appointment as the holder of the Loyola Chair for visiting Jesuit scholars at Fordham University, New York. Along with his teaching duties at Fordham, he continued his research into meteorite physical properties with an appointment as an adjunct researcher in Physical Sciences at the American Museum of Natural History, New York City.

CORBALLY • In August, at the International Astronomical Union's XXVIth General Assembly in Prague, chaired the Resolutions Committee, an especially interesting duty given the last-minute question of Pluto's status as a planet; was co-chairman of the Scientific Organizing Committee for the Joint Discussion 13 on "Exploiting Large Surveys for Galactic Astronomy;" was National Representative for the Vatican City State; was elected to be the Vice President of Division IV (Stars); became the Immediate Past President of Commission 45 (Stellar Classification); and was reappointed as Chairman of the Working Group on Standard Stars. • Subsequent to the General Assembly, Corbally was chief editor for the proceedings, in versions for both Highlights of Astronomy and Memorie della Società Astronomica Italiana, of the Joint Discussion 13. • Was elected to the Institute on Religion in an Age of Science Council for a three-year term, 2006-09, and continued to moderate the IRAS Discussion Group, Nature and God. • Continued to collaborate with Steward Observatory and other local observatories and personnel to improve and implement the outdoor lighting codes in Arizona and especially around Mt. Graham. Significant for this collaboration a project was started, with the help of the University of Arizona's Office of Economic and Policy Analysis, to assess the economic impact of astronomy, space and planetary sciences in Arizona. • Continued on the Board of the St. Albert the Great Forum for science and theology at the Catholic Newman Center, University of Arizona. He contributed to the introductory presentations from Forum Board Members on 20 September by speaking on "Recent Talk about Creation and Science in the Catholic Church."

COYNE • Served on the Council of the Pontifical Academy of Sciences and participated in the Council Meeting of 20 May. • Represented the Vatican Observatory as a member of the International Center for Relativistic Astrophysics at the Board Meeting on 8 March in Tucson, Arizona. • Participated in the meetings of the advisors for the project "Science, Theology and the Ontological Quest" held in the Vatican at the Domus Sancthae Marthae • Served on the Organizing Committee for the symposium "Science, Philosophy and Theology" held at La Armonia, Mar del Plata, Argentina in October. • On 4 January gave a colloquium on "The Age of the Universe" to the Physics Faculty of St. Mary's University, Halifax, Nova Scotia, Canada. • Presented a paper on "Evolution and Intelligent Design" at the national meeting of the American Association for the Advancement of Science, 8–12 January, and served on several panel discussions with science teachers. • During Jesuit Heritage Week at the University of Scranton, Pennsylvania, 28-31 March, presented lectures on evolution in cosmology and in biotic systems; on Jesuit mission and scientific research; and on the heritage of John Paul II in the dialogue between science and religion. On that occasion he was presented the University's Arrupe Award. • On 18 April gave a colloquium on the "Age of the Universe" at the University of Puerto Rico at Mayaguez and the same on 26 April to the Physics Department at Marquette University. • At the Accademia dei Lincei in Rome on 22 May lectured on "The Laws of Nature." • At the North Italian Seminar on Science and Faith, 9-11 June, lectured on the significance for religious belief of the evolution versus intelligent design controversy.

FUNES • Taught the General Astronomy course during the spring semester in the Department of Astronomy, University of Arizona. • Gave two seminars on "Star Formation in Nearby Galaxies" at the Department of Astronomy of the Pontifical Catholic University, Santiago, Chile, on 18 October and at the Observatorio Astronómico de Córdoba, Argentina, on 3 November. • Worked with Dante Minniti on the organization of the 2007 VOSS at the Department of Astronomy of the Pontifical Catholic University, Santiago, Chile, 9-20 October. • Observed at the 0.9m telescope at the Cerro Tololo Inter-American Observatory, Chile, in October. Ten nights in total were awarded to the project on "UBVI Imaging of Star-Forming Galaxies in the Local 11 Mpc Volume." • On 2 June taught four lectures on the "Contemporary Image of the Universe" in the course on Philosophy of Nature, at the School of Philosophy, Colegio Máximo, San Miguel, Argentina.

GIONTI • March 3-11 visited Hugo Morales Tectol at Universidad Autonoma Metropolitana Iztapalapa, Mexico City, for a period of scientific collaboration. • March 31 to June 26, he is visiting scholar from at D.A.M.T.P. of University of Cambridge (UK) working with Gary Gibbons.

MAFFEO • Gave two lectures in the program Master Scienza e Fede, Ateneo Regina Apostolorum, Rome, on "Scienza e Fede in P. Angelo Secchi, S.J.,"11 March; and on "P. Hagen, S.J., Astronomo e Direttore spirituale della beata Elisabeth Hesselblad," 14 November.

PIIROLA • Made a March observing trip in to ESO-VLT (Paranal, Chile) for polarization observations of Magnetic Cataclysmic Variables. • Invited to and acted as panel member (Stellar Evolution) of the ESO Observing Program Committee.

STOEGER • Continues to team-teach MCB 414, Science and Theology, with Tom Lindell (Molecular and Cellular Biology Department, University of Arizona) each semester. • Continues to

serve as a member of the Board of Trustees, Brophy College Preparatory School, Phoenix, and as Chair of the Board of Directors of the Center for Theology and the Natural Sciences (CTNS), Berkeley, California; in this last capacity, attended and helped host the 25th Anniversary celebrations of the CTNS, September 14-16. • With George Coyne, continues as a member of the Steering Committee for the Sir John Templeton grant, Astrobiology and the Sacred, awarded to the Department of Astronomy, University of Arizona. The University was awarded a 4th-year extension of the grant, for 2007-2008, following a competition among 3-year awardees. • Spent October 11-14 at the University of Notre Dame, Notre Dame, Indiana: October 12, gave a colloquium, "Recent Cosmology: Its Relevance to the Theology/Science Dialogue," at the O'Reilly Center for the History and Philosophy of Science; October 13, led a seminar discussion with about 30 Notre Dame faculty on current issues relating to theology and the natural sciences. • On November 15, gave a brief Journal Club presentation on Charles Hellaby's recent Monthly Notices of the Royal Astronomical Society article, "The Mass of the Cosmos," at Steward Observatory, University of Arizona.

WHITMAN • Participated in the 44th Summer Meeting of the Clavius Group of Mathematicians, a community of Jesuits, other Religious, and lay persons founded by WHITMAN and another Jesuit in 1963. The Group met July 3-30 at the College of the Holy Cross. WHITMAN was one of the organizers of a seminar on "Topics in Differential Geometry," and presented the history of three of the fundamental theorems in the Theory of Lie Algebras: 1) The complete reducibility of a representation of a semi-simple Lie algebra; 2) The Levi Decomposition Theorem for a Lie Algebra into a linear direct sum of its radical and a semi-simple Lie algebra; 3) Ado's Theorem, which states that every Lie algebra is linear, i.e., it has a realization as a matrix Lie algebra.

Public and Educational Outreach

CARREIRA • In December, gave four lectures at a cultural center attached to a church in Madrid (Santos Inocentes) on the *Origin and Evolution of the Universe* and the *Origin of Life and of Man*. A DVD is about to be released including the presentations with numerous slides. • In March, two lectures in Barcelona at the State University (Philosophy Dept.) and at the Balmesiana Cultural Foundation, on the *Origin and Evolution of the Universe* and the *Origin of Life and Intelligence.* • March, two lectures for upper class students at a high school in Madrid on the *Structure and Evolution of the Universe*. • In April, gave two lectures to the general public in the city of Lugo on the *Concept of Human Person* and on *Science and Faith*; a lecture to the Astronomical Society of Madrid on *Relativity and Cosmology*; a lecture to the Astronomical Society of Yecla (Murcia) on *Modern Cosmology*; and in Alicante, three lectures at two schools, one for teachers, on *Relativity* and two for teachers and students on *Science and Faith*. • May 1, a lecture at a Symposium on *Science and Faith* at the Catholic University of Valencia. • May 30 to June 2, four lectures in Washington, D.C. on topics from astronomy, physics and theology to Spanish-speaking members of the Arlington Diocese. • At the Metanexus meeting in Philadelphia, June 6, presented a paper on *Evolution and the Origin of Intelligence*. • June 27, gave the opening lecture on *Man's Place in Nature* at a Summer Course organized by the Universidad San Pablo of Madrid at La Granja, near Segovia. • August 1-3, as part of the yearly festivities of the town of Canete, gave three lectures to the general public in Cuenca dealing with the *Anthropic Principle, the Earth as a Planet and Human Rationality.* A DVD was made of the lectures, and more than 80 copies have been sold to date. • August 5, a lecture

on Science and Faith to more than 200 young people (mostly college age) in Pamplona. • September 6-14, in Bogota (Colombia), a lecture as the final synthesis of an international Symposium on the *Philosophy of the Human Person* attended by professors and students of the Universidad Catolica de Colombia, with six more lectures on *Science and Faith* given to students. Also took part in a TV program with the President and two teachers of the Universidad Gran Colombia, again dealing with issues of Science and Theology. • September 16-19, lectures at two Universities and two secondary schools in Lima (Peru) with over 100 professors and students present, on *Finality, Creation, Miracles* and the scientific study of the *Turin Shroud*. • Sept 22 and 23, two lectures at a meeting of young people in Salamanca (Spain) on *Science and Faith* and the concrete issues of the *Origin of the Universe and Human Life*. • Participated in nine interviews directed at the general public in Spain and in Spanish-speaking areas of America and aired over the Radio station *Lumen Dei* of Barcelona, dealing with topics ranging from the *Origin of the Universe* to the tenets of Catholic Theology. • In October, two lectures on Science and Faith, the Origins of the Universe, and Life and Man, presented to university students at the Universidad San Pablo of Madrid.

CASANOVAS • Gave a public lecture in Cavezzo (Modena) on Faith and Science July 19.

CONSOLMAGNO • As the holder of the Loyola Chair for visiting Jesuit Scholars at Fordham University, New York, taught one section of Astronomy at Fordham's Rose Hill Campus. He presented the Loyola Chair Lecture, "God's Mechanics: How Scientists and Engineers Practice Religion," at both the Lincoln Center and Rose Hill campuses on November 6 and 14, respectively. • Gave classroom presentations on planetary sciences and the role of the Vatican Observatory on January 25, at the University of Alberta; February 14, at Seattle University; and February 17, at Illinois Wesleyan University, Bloomington. • Presented the talk "Heaven or Heat Death?" at the University of Alberta, Edmonton, Alberta, on January 25, and at the Evolving Cosmos Conference, Marist College, Poughkeepsie, NY, Oct 21. • Spoke on "Astronomy, God, and the Search for Elegance," at the University of Alberta on Jan 25; St. Bonaventure College, St. John's Nova Scotia; at Lyon College, Batesville, Arkansas, on April 6; and at SUNY Stonybrook, on Ocrober 26. • Gave three presentations at the Capricon Science Fiction Convention in Chicago February 10-12. • On March 6, spoke on the topic, "Where was God? Natural Disasters and Human Freedom" at Loyola University of New Orleans. • In connection with the heightened interest in the definition of a planet, he addressed the issue of "Pluto and Planets X" at the following institutions: Chicago's Adler Planetarium on Feb 8; at Louisiana State University on March 9; as the Keynote address of the annual meeting of the Arkansas Academy of Sciences, Lyon College, Batesville, Arkansas, April 7; to the Civil Air Patrol, Rockford, Illinois, April 24; at the Marquette University Physics Colloquium, April 25; at Stonyhurst College, England, April 28; at Fordham University, September 13; at the Cranbrook Museum, Detroit, October 1; at Wagner College, Staten Island, NY, November 9; and at Iona College, November 30. • Spoke on Galileo and the Church on March 27 at Northern Arizona University, Flagstaff. • With Davis (SUNY Stonybrook), was invited guest speaker at the annual meeting of the Astronomical League, Central Division, held in Appleton. Wisconsin on April 22; their joint presentation was based on their book for amateur astronomers, *Turn Left at Orion*. • Discussed "Why the Pope Has an Astronomer" at the Milwaukee Public Museum on April 25; at the Birmingham, England, Planetarium on May 2; at the Glasgow Planetarium May 4; at the University of Dallas Rome Campus, May 5; and at St. Ignatius Church, Prague, August 18.

VATICAN OBSERVATORY

CORBALLY • 19-20 May represented the University of Arizona Mirror Laboratory, Steward Observatory, Mount Graham International Observatory, Whipple Observatory, as well as the Vatican Observatory, at Spotlight on the Stars III, a public outreach event organized by the Astronomy Society in Prescott, Arizona. He gave talks there on "Personalities of Stars" and "An Astronomer's Filter". • On 27 September talked to the Las Artes Youth Program, Tucson, on "Defining a 'Planet' ". • Regularly engaged in video links with the astronomy club of St. Agatha Church, Portland, Oregon, during its monthly meetings, and discussed astronomy and faith & science. • Continued as an advisor to the Earth & Sky radio series, which celebrated its 5,000th radio program—on the subject of hope in a human world—broadcast in October. • Gave a talk on 19 October about the impact of Jesuit Missionaries for the Tubac Historical Society and Tumacácori National Historical Park "Encounters" series. Gave a similar talk on 21 November to the Padre Kino Assembly of the Knights of Columbus, Green Valley. • Answered enquiries by e-mail and phone from the general public. Hosted visits to the Mirror Laboratory on campus and to the VATT on Mt. Graham, including visits by Scout Troop 818, Scottsdale, and the ASU instrumentation graduate class.

COYNE • Gave a public lecture on 4 January at St. Mary's University, Halifax, Nova Scotia, Canada, on "The Dance of the Fertile Universe." • Gave lectures on evolution and on Galileo at the Palm Beach Atlantic University, Florida, 31 January to 3 February. • Spoke at Our Mother of Sorrows Church in Tucson on 5 February on "Evolution and Catholic Teaching." • On 19 February at the regional meeting in St. Louis, Missouri, of the American Association for the Advancement of Science spoke about the teaching of evolution in grades K to 12. • On 4 and 5 March gave public lectures at Duquesne University, Pittsburgh, Pennsylvania, on evolution in a cosmological framework. • On 19 April gave a public lecture sponsored by the Astronomy Club of Puerto Rico in Santiago on "Chance and Necessity in Evolution," and also spoke on the same topic on 22 April to the Knights of Columbus in Tucson • On 28 April inaugurated the series of Coyne Lectures at Marquette University, Milwaukee, Wisconsin, with a talk on the "Dance of the Fertile Universe," and spoke on the same topic on 29 April in Tucson to the Mission Foundation. • At the Universal Unitarian Church in Tucson on 30 April spoke about a scientist's approach to religious belief.• Spoke to the International Staff of the School Sisters of Notre Dame on 28 June on the topic "Evolution and Church Teachings." • On 18 August spoke on the religious implications of evolutionary science at the Butterfly Lodge Museum in Greer, Arizona.

FUNES • Gave two classroom presentations and a public lecture at Colegio del Salvador, Buenos Aires, Argentina 7-8 June • Gave a public lecture on the "Contemporary image of the Universe" at the Catholic University of Córdoba. • Gave a public lecture on Science and Faith at the European Southern Observatory, Santiago, Chile.

HELLER • Gave talks and lectures to the general public on cosmology, philosophical aspects of science, science, and theology.

MAFFEO • Gave public lectures on the history of the Vatican Observatory to the amateurs astronomers of Pordenone (Italy) and at the Santa Anna parish in the Vatican.

STOEGER • Continues as Chair of the St. Albert the Great Forum Board at the University of Ari-

zona Catholic Newman Center. The Forum organizes and sponsors lectures/discussions on issues in theology and science four to six times each semester. • February activities included: February 12, a presentation on "Creation and Evolution: A Biblical Approach," to the Dominican Lay Group at the Newman Center, University of Arizona; February 13, an interview to the Australian Broadcasting Company on science and religion that aired in March. • February 23, presented one of the Vatican Observatory Foundation Seminars, "The Continuing Debate: Evolution and Intelligent Design"; February 27 and 28, two of the principal lectures at Gonzaga University's (Spokane, WA) annual Physics and the God of Abraham Conference: "The Beginnings of the Universe: Big Bang Cosmology and Creation," and "God as Creator: Divine Immanence, Evolution and the Laws of Nature." While there also taught two classes and participated in faculty discussions. • March activities included: March 23, lectured in the St. Francis Xavier Parish Lecture Series at Xavier High School in Phoenix. The title of his talk was "Finding God in the Wonders of Creation: Faith and Science in Dialogue"; May 23-25 visited the University of California, Davis, to present a lecture May 24 on "Faith and Science on Cosmology, Evolution and Creation: Conflict or Coherence," sponsored by the UCD Newman Center. While there, spent a day interacting with various members of the UCD cosmology group. • September activities included: September 19, a public lecture, "Cosmology, Creation and Theology: From Conflict to Conversation," at Moorpark College, Moorpark, California. Earlier that day, he led a discussion with about 20 Moorpark faculty on science and religion. The previous morning he gave separate classes on religion and science to 5th and 6th graders, and to 7th and 8th graders, at Our Lady of Lourdes Catholic School, Northridge, California. • October activities included: October 18, a presentation at the St. Albert the Great Forum on Theology and Science, Catholic Newman Center, the University of Arizona. His title was "Creation from Nothing and Big-Bang Cosmology"; October 23-26, visited St. John's Jesuit High School in Toledo, Ohio. While there gave the first Berchmans Public Lecture for 2006/2007 on "Cosmology, Evolution and Creation: Understanding the Universe through Science, Philosophy and Theology." Earlier he gave a shortened version of that lecture to St. John's juniors and seniors. He also taught two physics classes and two theology classes during his stay. • November activities included: November 6, the inaugural DuMaine Lecture at Stanford University (Palo Alto, California), sponsored by the Catholic Community at Stanford in honor of Bishop Pierre DuMaine, retired Bishop of San Jose and a enthusiastic supporter of the Vatican Observatory and of the Church's engagement with the natural sciences. He spoke on "Science and Theology: Creation and Natural Process."

TERES • Chaired the Organizing Committee for the three-day Manreza Symposium on "Natural Science and Religion" in Dobogokö, Hungary, and gave preparatory lectures on "The History of the Theory of Evolution: Its Fundamental Conceptions and Problems" for student participants at the Symposium. • Gave lectures on "The Origin and Evolution of Life and the Possibility of Extra-Terrestrial Intelligence in the Universe" at colleges during a tour through several Hungarian towns.

News Media Coverage

CONSOLMAGNO • Television appearances: January 18, on the Italian religious cable network SAT 2000; May 18, on the NBC program *Today*. • Radio interviews: March 20, on CBC Radio in St. John's, Newfoundland, Canada; during May and June, prepared a 30 minute program for BBC Radio 4 on the interplay of astronomy and government, "Br. Guy Goes to Washington," aired in December; May 4, participated in the BBC Scotland radio program *Good Morning Scotland*. • Print

interviews: March 23 and 28, featured in articles appearing in the *Arizona Daily Sun* (Flagstaff); April 11, in the Batesville (Arkansas) *Daily Guard*; May 5, in the *Scotsman* (Glasgow); May 9, in a featured profile in the *Guardian* (London and Manchester); in the September issue of the BBC *Sky at Night Magazine*; October 2, in the *Detroit Free Press*.

CORBALLY • Together with COYNE , MAFFEO, and STOEGER, featured in "Tsunami: Where was God?" that aired December 26, 2005, in a *Can you believe it?* episode on UK Channel 4 TV by Mark Dowd of 3BM TV London. • Together with COYNE, FUNES, GIONTI, and STOEGER, featured in *Mission Magazine*, Spring/Summer 2006, in an article "Heavenly Science" by Julieta Gonzalez. • Together with STOEGER, featured in a 7 August *Chicago Tribune* article by Kirsten Scharnberg, "Vatican Keeps Eye to the Heavens,"which also appeared in *The Seattle Times*, *The Blade* of Toledo, Ohio, and other newspapers; was also featured in the UK's *SJ* magazine in "Searching the Far Reaches of Space," adapted by Ged Clapson from the *Chicago Tribune* article. • Provided the following interviews: 20 April to Stephanie Vizcaya, University of Arizona, for a class project; 24 May to Alan Elsner, *Reuters*, for a story also including FUNES and STOEGER; also in May to Patricia Wargocki, a freelancer for *Catholic News Service*, on Evolution and God; In June to Susy Hodges, *Vatican Radio*, on VORG; 2 July to Rich Barlow, for the Spiritual Life column in *The Boston Globe*, on Stuart Kauffman's Emergence & Creativity; 18 August to Colin Cheney, *Seed Magazine*, on the Vatican Observatory; 28 August via Tom Szyszkiewicz , *Relevant Radio*, on Pluto's status for the Drew Mariani show; 11 September to Emily Martin, *Ciel et Espace*, on Intelligent Design, Creationism, and change of Vatican Observatory director. • Answered questions from: Theresa Oliver, Assistant Layout Editor, *The Florida Catholic*; Andrey Serdechnov, a Russian journalist with *RosBusinessConsulting*; Jim Brown, *American Family Radio News*; Edward Pentin, *Catholic Herald*, Houston, Texas; and Michael Clancy, *Arizona Republic.*

COYNE • Gave the following interviews: to Yonat Shimron, Raleigh, North Carolina, published in the *News and Observer*, 17 September; in *Kontinente Missio*, July/August edition; to Nicola Allegri, published in *Gente*, 17 August; to James McDermott, S.J., of *America, National Catholic Weekly*, 23 October edition; to Colin Cheney of the Expository Writing Program, New York University.

FUNES • Gave an interview to Colin Cheney of the Expository Writing Program, New York University and to the following media: *La Voz del Interior* (Córdoba, Argentina), *Radio María* (Córdoba, Argentina), *La Nación* (Buenos Aires Argentina), *Diario Perfil* (Buenos Aires, Argentina), *Radio Rivadavia* (Buenos Aires, Argentina), *Radio CNN en Español* (Buenos Aires, Argentina), *Radio 10* (Buenos Aires, Argentina), *Radio FM Continental* (Rosario, Argentina), *El Mercurio* (Santiago, Chile), *Canal 13* (Santiago, Chile), *Revista Mensaje* (Santiago, Chile), *Iglesia Viva* (Santiago, Chile), *Radio Vaticana*, television station RAI Due *TG2,* (Italy), *Radio RAI Tre* (Italy), *Il Corriere Della Sera* (Italy), *La Reppubblica* (Il Venerdì) (Italy), *Catholic News Agency* (Germany), *Catholic Service News* (USA). • Wrote a column for *Revista Noticias* (Buenos Aires, Argentina).

GIONTI • Gave interviews to Von Max Rauner for the article "STERNWARTE DES VATIKANS" of *Spiegel on Line*, published February 26; and to Andrea Fontana for the article "Gesuiti in missione nello spazio," published October 2006 in *Popoli*, the monthly magazine of the Italian Jesuits.

HELLER • Was interviewed by various Polish media (newspapers, journals, radio) on science, philosophy, science and theology.

KOCH • Gave interviews to Filippo Golia of RAI Due *TG2 Dossier Storie*, 6 March, and to Colin Cheney of the Expository Writing Program, New York University, 13 October.

MAFFEO • Wrote an article for the Vatican newspaper *L'Osservatore Romano* with the title "L'astronomo p. Johann Georg Hagen, direttore spirituale della Beata Maria Elisabetta Hesselblad," published 28 April.

STOEGER • Gave an interview February 13 to the Australian Broadcasting Company on science and religion, that aired in March; and September 13, an interview the University of Arizona TV station, KUAT, on the interactions between religion and the natural sciences, and on the St. Albert the Great Forum on Science and Theology, that aired October 16.

TERES • Gave interviews to the Hungarian Catholic Radio and Duna TV, Budapest.

Conference Participation

8-12 January: Washington, DC. 207th Meeting of the American Astronomical Society. RICHARD BOYLE, S.J., and CHRISTOPHER CORBALLY, S.J., presented papers.

11-12 February: Tucson, Arizona, Workshop on "College Astronomy Teaching." JOSÉ FUNES, S.J., participated.

8 March: Tucson, Arizona, Executive Council of the International Center for Relativistic Astrophysics. GEORGE V. COYNE, S.J., as a councilor, participated.

March 13-17: Annual Lunar and Planetary Science Conference, Houston, Texas; GUY CONSOLMAGNO, S.J., presented a paper and co-authored two others.

16-17 March: Tucson, Arizona. Annual General Meeting of the International Dark-Sky Association. CHRISTOPHER CORBALLY, S.J., participated.

24-25 March: Tucson, Arizona. Tucson's Mission & Garden conference. CHRISTOPHER CORBALLY, S.J., was a panel discussant.

3-7 April: Cambridge, United Kingdom. EuroStrings. GABRIELE GIONTI, S.J., participated.

5-10 April: Iasi, Romania. XIth European Conference on Science and Theology. CHRISTOPHER CORBALLY, S.J., participated.

27-29 April: Vienna. "Horizons of Truth" Gödel's Centenary. MICHAEL HELLER attended.

8-11 May: Blankenberge, Belgium. The Future of Photometric, Spectrophotometric and Polarimetric Standardization. ROBERT JANUSZ, S.J., gave a paper.

18-19 May: Poland. Tenth Cracow Methodological Conference, "Man as a Creation of the Universe and Creator of Science." MICHAEL HELLER organized.

20 May: Vatican City. Council of the Pontifical Academy of Science. GEORGE V. COYNE, S.J., as a councilor, participated.

26-27 May: Rome, Italy. Advisory Committee of the International Project, Science, Theology and the Ontological Quest. GEORGE V. COYNE, S.J., as an advisor participated.

8-11 June: San Antonio, Texas. Catholic Theological Society of America's Annual Convention. WILLIAM STOEGER, S.J., convened and chaired the Theology and the Natural Sciences Program Session.

9-10 June: Gródek, Poland. "Theology and Science" conference. MICHAEL HELLER attended.

3-30 July: Worcester, Massachusetts. 44th Annual Summer Meeting of the Clavius Group of Mathematicians, College of the Holy Cross. ANDREW WHITMAN, S.J., organized and lectured.

July 9-14: Castel Gandolfo, Italy. Creatio ex Nihilo Today conference at the Vatican Observatory. WILLIAM STOEGER, S.J., presented a paper.

8-13 July: Cambridge, England. International Society for Science and Religion conference and Annual General Meeting. CHRISTOPHER CORBALLY, S.J., participated.

10-14 July: Singapore. Asia Oceania Geosciences Society annual meeting. GUY CONSOLMAGNO, S.J., presented an invited review paper.

17-22 July: Beijing, China. Committee on Space Research (COSPAR) biennial meeting. GUY CONSOLMAGNO, S.J., presented an invited review paper.

7-11 August: Zurich, Switzerland. Meteoritical Society. GUY CONSOLMAGNO, S.J., presented a paper.

13-25 August: Prague, Czech Republic. XXVIth General Assembly of the International Astronomical Union. RICHARD BOYLE, S.J., gave papers; GUY CONSOLMAGNO, S.J., chaired a Joint Discussion; CHRISTOPHER CORBALLY, S.J., chaired a Commission meeting, a Working Group meeting, and a Joint Discussion, attended the National Representative meetings and a Division committee meeting, and chaired several meetings of the Resolutions Committee; JOSÉ FUNES, S.J., gave a paper at the Symposium "Galaxy Evolution across the Hubble Time" and attended meetings of the Nomination Committee, Commission 46 (Astronomy Education and Development), and Commission 28 (Galaxies); ROBERT JANUSZ, S.J., gave a paper; JEAN-BAPTISTE KIKWAYA ELUO, S.J., gave a paper.

28 August-8 September: Lithuania. Moletai Observatory, Workshop on the Stromvil Photometric System. RICHARD P. BOYLE, S.J., and ROBERT JANUSZ, S.J., gave papers.

3 September: Cambridge, United Kingdom. Conference on "Relational Ontologies" at Queens College. MICHAEL HELLER attended.

4-8 September: Cambridge, United Kingdom. Newton's Institute of Mathematics conference on "Noncommutative Geometry and Physics: Fundamental Structure of Space and Time." MICHAEL HELLER presented a paper.

9-13 October: Pasadena, California. Division for Planetary Sciences of the American Astronomical Society. CONSOLMAGNO co-authored three papers.

15-18 October: Tucson, Arizona. Astronomical Data Analysis Software & Systems XVI. RICHARD P. BOYLE, S.J., participated.

22-24 October: Philadelphia, Pennsylvania. Geological Society of America annual meeting. GUY CONSOLMAGNO, S.J., presented a paper.

3-6 November: Rome, Italy. Plenary Session of the Pontifical Academy of Sciences, "Predictability in Science: Accuracy and Limitations." MICHAEL HELLER presented a paper.

20-22 December: Córdoba, Argentina. Jornadas de Ciencia y Sociedad. JOSÉ FUNES, S.J., gave an invited talk.

IV. Publications

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CONSOLMAGNO, G. J. 2006, in *Harpers*, April

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CONSOLMAGNO, G. J. 2006, Fluffy comets and cosmic joy, *The Tablet*, 260, March 25, 48

CONSOLMAGNO, G. J. 2006, Direct revelations, *The Tablet*, 260, April 22, 40

CONSOLMAGNO, G. J. 2006, Creationism tends to the pagan, *The Tablet*, 260, May 20, 40

CONSOLMAGNO, G. J. 2006, Ordinary but unique, *The Tablet*, 260, June 24, 40

CONSOLMAGNO, G. J. 2006, Small steps for mankind, *The Tablet*, 260, July 22, 40

CONSOLMAGNO, G. J. 2006, Setting the controls, *The Tablet*, 260, August 26, 36

CONSOLMAGNO, G. J. 2006, Words that change reality, *The Tablet*, 260, Sept. 23, 48

CONSOLMAGNO, G. J. 2006, Spicy planet stories, *The Tablet*, 260, Oct. 27, 48

CONSOLMAGNO, G. J. 2007, What happened to Pluto? *The Physics Teacher*, 45, 628-633

CONSOLMAGNO, G. J. 2006, Evidence from meteorites, Asia-Oceana Geophysics Society annual meeting (abstract CD), 694

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V. Observatory Visitors

During 2006 the Vatican Observatory was honored to receive visits by His Excellency Monsignor Giovanni Lajolo and His Excellency Monsignor Renato Boccardo, President and Secretary, respectively, of the Pontificia Commissione per il Governatorato, Vatican City State.

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 FUNES, MAFFEO, and KOCH at Castel Gandolfo. In particular, FUNES hosted a group led by Jerry Colapinto and two groups of Swiss Guards in service during the Holy Father's stay in Castel Gandolfo. The following groups were hosted by MAFFEO: Superiors and students of the Università Europea dei Legionari di Cristo; Rotary Club of Latina; Students of the Liceo Galilei di Macerata; priests of the Collegio Pio Brasiliano; students of the Liceo Einstein di Cerignola (Foggia); students of the Liceo James Joyce, Ariccia (Italy) with students from its twin high school in Denmark; students of the University of California in Rome; amateur astronomers of Grosseto (Italy); participants attending the meeting "I Padri e la Scienza" at the Istituto Patristico "Augustinianum" in Rome; students of the Liceo Spallanzani di Roma; students of the Master Scienza e Fede, Ateneo Regina Apostolorum; the Rotary Clubs of Lindau (Germany), Avignon (France), and Asti (Italy); Associazioni di ambientalisti; Associazione Terza Età; the Rector and students of the Collegio Germanico; members of the Swiss Guard and Italian Police in service during the Holy Father's stay in Castel Gandolfo; members of the Catholic Academy of Hamburg; His Excellency Fredrik Vahlquist, Swedish Ambassador to the Holy See,; and students of the Liceo Cavour di Roma.

The following paid working visits to the Observatory:

ELIZABETH CONDIE-PUGH, Northwestern University, Evanston, Illinois, USA

RICHARD GRAY, Appalachian State University, Boone, North Carolina, USA

ELIZABETH GRIFFIN, Herzberg Institute of Astrophysics, Victoria, British Columbia, Canada

ARENDT LATUSSECK, Hildeshaim, Germany

JONATHAN LUNINE, University of Arizona, Tucson, USA

PETER MARTIN, U. S. Embassy to the Holy See

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

RODNEY THEBE MEDUPE, Astronomy Department, University of Cape Town, South Africa

PIERO SICOLI

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

JULIUS SPERAUSKAS, Vilnius University, Vilnius, Lithuania