

The Vatican Observatory

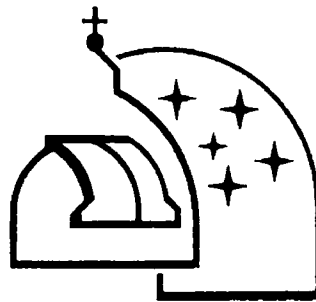


Vatican Observatory — *Specola Vaticana*

Castel Gandolfo, Italy

2004 Annual Report

Vatican Observatory Annual Report 2004



Vatican Observatory
(Castel Gandolfo)
V-00120 Città del Vaticano
Rome ITALY

Vatican Observatory
Research Group
Steward Observatory
University of Arizona
Tucson, Arizona 85721 USA

<http://vaticanobservatory.org>

Vatican Observatory Publications

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VATICAN OBSERVATORY

Contents

From the Director	6
I. Astronomical Research	
Theoretical Studies, Astrophysics, and Cosmology	13
Extragalactic Research	14
The Galaxy and Galactic Objects	15
Planetary Sciences	17
<i>Meteorite Studies</i>	17
<i>Lunar Studies</i>	21
<i>Kuiper Belt Objects</i>	22
History and Philosophy of Science; Interdisciplinary Studies	22
II. Instrumentation and Technical Services	23
III. Observatory and Staff Activities	
Vatican Observatory Conferences	27
Presentations and Academic Activities	27
Public and Educational Outreach	30
<i>News Media Contacts</i>	33
Conference Participation	34
IV. Publications	35
V. Observatory Visitors	41

FRONT COVER *Aerial view of Castel Gandolfo, overlooking Lake Albano. The Vatican Observatory's two telescope domes are visible on the roof of the Papal summer palace. (Photo permission granted by Ediz. Gasperini Souvenirs, Piazza della Libertà, 5, Castel Gandolfo)*

BACK COVER *During World War II, residents of Castel Gandolfo and nearby towns took refuge in the Papal gardens adjoining the Papal summer palace. (Vatican archive photo)*

Editor: Elizabeth J. Maggio
Cover Artist: Dave Fischer

From the Director

What is going on at Castel Gandolfo?

Nearly 70 years ago, on 29 September 1935, the Vatican Observatory headquarters were inaugurated at Castel Gandolfo. I would like to dedicate this issue of the Annual Report to the research activities that continue there in conjunction with activities conducted by the Vatican Observatory Research Group in Tucson, Arizona. I must admit honestly that I have a distinct issue I wish to address. The question, not lacking in sarcasm, is quite frequently asked: “What is going on at Castel Gandolfo since the Vatican Observatory moved to Tucson?” My reply is forthcoming, but first a bit of our beginnings at Castel Gandolfo.

The Inauguration at Castel Gandolfo

Viewed from this distance in time, the inauguration was a rather entertaining event. I refer to the photograph on the back cover of the Annual Report showing Pope Pius XI attending the ceremony held on the top terrace of the Papal Palace where two of the then-new telescopes had been installed. The Pope came with his entourage and was protected by the *Guardia Nobile*, the fellows with the peculiar helmets. When I am asked to explain the strange head wear, I suggest that their captain had heard of our precious collection of meteorites and wisely deduced that if meteorites fell once they can fall again and why not protect his guards. And why does the Pope not have a similar helmet? He is protected by the Holy Spirit! Jokes aside, the inauguration set off a period of modern research in astrophysics that continues to this day and is described in detail in *The Vatican Observatory: In the Service of Nine Popes*, the excellent history of the Observatory written by Sabino Maffeo, S.J. Successive Popes have continued, under the protection of the Holy Spirit, to support this work enthusiastically. For that we are grateful and are happy to serve.

Research at Castel Gandolfo

But allow me to return to the nagging question as to what is done at Castel Gandolfo now that the Observatory, with its modern Vatican Advanced Technology Telescope (VATT), has established a major research center in Arizona.

To approach an answer to this recurring question I would like to share with you a bit of my personal experience of my first years as director. In last year’s Annual Report I gave a brief history of the decision to construct the VATT in Tucson. Now I would like to reminisce on how in those earlier years even some of our closest friends, and indeed our superiors, skeptically viewed the decision to have two locations of the Observatory: Castel Gandolfo and Tucson. First of all, the Observatory did not move to Tucson. It opened a research institute there. As I explained last year, we simply could no longer carry out professional level observations at Castel Gandolfo because of the degraded nighttime sky conditions. But research in astrophysics consists of more than making telescopic observations. The observational data must be reduced, studied, and prepared for publication in international journals, and a fair percentage of this work is conducted with computers at Castel Gandolfo. In brief, for many of the Observatory’s research programs, the two centers compliment one another.

For example, the Observatory's research on meteorites, under the direction of Guy Consolmagno, centers on the meteorite collection and laboratory at Castel Gandolfo. The work involves collaborators from around the world, with an especially strong link to the Natural History Museum in London. Details of current meteorite research are given in each Annual Report in Section I. Astronomical Research, Planetary Sciences.

An especially interesting effort that links the past history of the Observatory to modern research, and which is conducted exclusively at Castel Gandolfo, is the program directed by Alessandro Omizzolo to scan and digitalize the information available on the photographic plates in the Observatory's archives. These plates cover research conducted at the Observatory from the early 1900s to the 1980s. The digitization effort is a collaboration with other observatories in Italy, principally the Padua Observatory. This effort has already produced exciting results in the form of historic light curves of four Quasi-Stellar Objects (quasars). The variation in the energy output of these very distant and enigmatic objects over as much as 25 years, as revealed by the historic light curves, will undoubtedly contribute to our understanding of the origin of quasars which, we suspect, is closely related to the formation of structure in the early universe.

Conferences, Schools, and Group Visits

In addition to the research conducted at Castel Gandolfo, scientific conferences are held there at regular intervals. For example, Richard Boyle organized a workshop on photometry for the classification of stars that was conducted at Castel Gandolfo in July 2004 to discuss observations obtained for the most part with telescopes in Arizona (see Section I. Astronomical Research, The Galaxy and Galactic Objects). A conference exploring divine action and the problem of evil from a scientific perspective will be held in September 2005 at Castel Gandolfo in collaboration with the Center for Theology and the Natural Sciences of Berkeley, California. Another conference, this one on galaxy evolution, is being organized by Omizzolo and colleagues to be held in early October 2005 at Castel Gandolfo.

The renowned Vatican Observatory Summer Schools (VOSS) in Astrophysics have been held every other year in Castel Gandolfo since 1986. These month-long summer schools on selected topics in modern astrophysics bring together 25 young scholars, who are beginning graduate students, from around the world for an intense month of scientific study, one-on-one interactions with researchers and fellow students, and a variety of cultural activities. The 225 alumni of previous summer schools come from 52 different nations and five continents; 60% are from developing countries, and 85% remain active in astronomical research and/or teaching. We are justly proud that Castel Gandolfo has been able to host this exciting initiative in promoting the research careers of young scholars. The tenth VOSS is now being organized for June-July 2005.

Over the years, the Observatory at Castel Gandolfo has attracted visits by many school groups and cultural groups, who get a firsthand look at what we do mostly through the dedicated efforts of Sabino Maffeo. From many points of view this is a particularly important work of the Observatory, mostly because it emphasizes in a very direct way that the Church desires to be present in the world of science. In fact, the most conspicuous features of Castel Gandolfo are the Observatory's two telescope domes on the roof of the Papal Summer Palace and the Bernini dome on the local parish

VATICAN OBSERVATORY

church, St. Thomas of Villanova, just to the south (see cover picture). From a distance, the three domes form a single characteristic and well-known picture of this part of the Alban Hills, a pictorial symbol of the Church and science working hand-in-hand.

Final Thoughts

No work, not even the rather esoteric work of astronomical research, can remain isolated from the vagaries of human history. The young Observatory at Castel Gandolfo witnessed the human sufferings created by the Second World War, since it was in a strategic position as the Allied forces moved against the German occupation of central and southern Italy. The photograph shows war refugees in 1944 camped out around the Observatory's Carte du Ciel telescope in the gardens of the Villa Barberini, which adjoins the Papal palace.



Residents from Castel Gandolfo and nearby towns took refuge from the war in the Papal gardens, setting up camp near the Vatican Observatory's Carte du Ciel telescope. (Vatican archive photo)

Thus as we astronomers seek to understand the universe and our place in it, we can not avoid also being involved in the sufferings on planet Earth, whether they be self-inflicted as in war or the result of destructive natural phenomena such as the 26 December tsunami that created havoc along the rim of the Indian Ocean. This sad event reminds us all of how fragile human existence is and how much we need one another. Whether one is a fisherman or an astronomer, we have need of one another in the never-ending pursuit to be truly human with all the vicissitudes that involves.

Research Highlights

Mapping Star Formation in the Universe

Vatican Observatory astronomer José Funes is part of a research team awarded a large allotment of observing time with the Galaxy Evolution Explorer (GALEX). This orbiting space telescope, launched April 28, 2003, is observing galaxies in ultraviolet light across 10 billion years of cosmic history, that is, 80% of the way back to the Big Bang. The goal of GALEX is to map the history of star formation in the Universe and gain deeper insight into how galaxies like our own Milky Way were formed. In September 2004, GALEX began surveying a sample of dwarf galaxies in the nearby Universe (within 11 megaparsecs or 36 million light years) selected by Funes and his col-

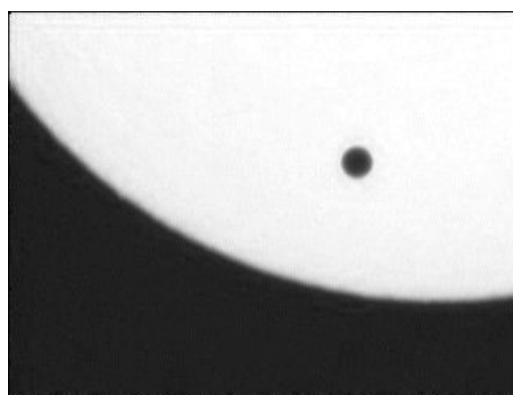
leagues from the University of Arizona Steward Observatory, UCLA, and Indiana University. The researchers will combine the GALEX results with those from a larger galaxy survey conducted over the past few years by Funes and colleagues using several ground-based telescopes, including the VATT. The ground-based observations provide a snapshot of ongoing star formation, while the GALEX observations will trace star formation over a much longer timescale. The result will be a more accurate picture of where stars form in galaxies, how frequently galaxies undergo intense bursts of star formation, and how long those starbursts last. (For additional details, see Section I. Astronomical Research, Extragalactic Research.)

Transit of Venus

Rainy and overcast days at Castel Gandolfo gave way to clear skies on 8 June 2004, delighting nearly one hundred amateur astronomers who had brought their telescopes to the Vatican Observatory to photograph an event that last occurred in 1882: the transit of Venus. From the terrace of the Papal palace, the visitors had a ring-side seat for the 6-hour spectacle as Venus journeyed across the face of the Sun. The group was organized by *Sky & Telescope* and hosted by the Vatican Observatory. Other observers recorded the event



Amateur astronomers set up their telescopes on the roof of the Papal palace in Castel Gandolfo to view the transit of Venus on 8 June 2004. The event was also followed with the Coronado Solar Telescope newly installed on the Vatican Observatory's Zeiss visual telescope in the background. (Photo by Christopher Corbally, S.J.)



Venus begins its transit across the Sun in this image taken with the Vatican Observatory's Coronado Solar Telescope. (Photo by Claudio Costa)

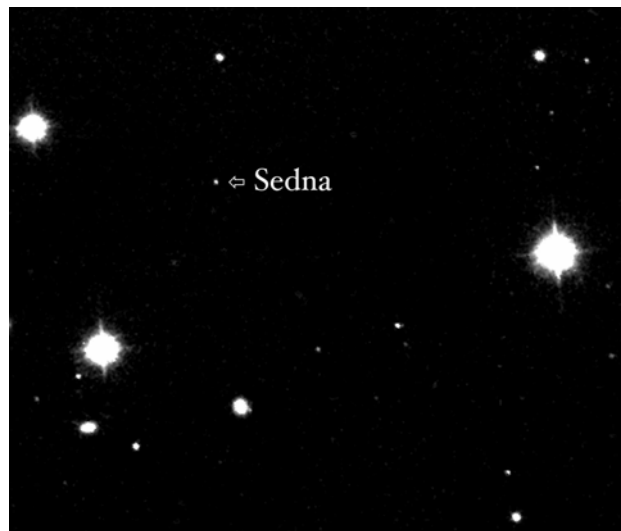
with the new Coronado Solar Telescope mounted on the Observatory's Zeiss visual telescope (see Section II. Instrumentation and Technical Services).

The Coronado Solar Telescope had been presented in May to the Observatory by David Lunt and Geraldine Hogan in memory of their mothers, Frances Maude Lunt and Kathleen Hogan. David and Geraldine founded Tucson-based Coronado, Inc., the world's leading manufacturer and distributor of solar telescopes and filters for both amateur and professional astronomers. We were saddened to learn of David's death on 13 January of 2005.

VATICAN OBSERVATORY

Something New in the Solar System

Early in 2004 astronomers announced the discovery of the most distant object ever seen within our solar system. They named it Sedna in honor of the Inuit goddess of the sea, who is thought to live at the bottom of the frigid arctic ocean. Roughly half the size of Pluto, Sedna has an eccentric orbit that brings it to within 76 AU of the Sun and as far away as nearly 1000 AU. In comparison, Pluto gets as close to the Sun as 30 AU and as far away as 50 AU. The existence of Sedna is fueling speculation that perhaps objects larger than Pluto still remain to be discovered in the distant edges of the solar system. The discovery also has scientists rethinking if tiny frozen objects like Pluto and Sedna are really planets. To clarify these issues, the International Astronomical Union created a Working Group to determine the minimum size of a planet, and Vatican Observatory astronomer Guy Consolmagno has been appointed to this Working Group. In December 2004, Consolmagno and colleagues Steve Tegler from Northern Arizona University and Bill Romanishin from the University of Oklahoma observed Sedna with the VATT to determine its color and rotation rate.



Tiny, frozen Sedna is barely visible in this image taken with the VATT. (Photo by Guy Consolmagno, S.J., Steve Tegler, and Bill Romanishin)

Personnel News

Richard J. Murphy, S.J., upon completion of seven years as Superior of the Jesuit Community of the Vatican Observatory in Tucson, Arizona, has returned to his Jesuit Province of Chicago to take up once more his pastoral ministry there. James J. Bowes, S.J., of the New York Jesuit Province has been named new Superior.

Luigi Lori, after 33 years of service at the Observatory at Castel Gandolfo, has arrived at the age of retirement according to Vatican regulations. He has accepted a one-year renewable contract and so will continue for the present his dedicated service among us.

Matthew Nelson, who had been a loyal “friend of the telescope” for the last eight years and whose computing expertise had recently made the environment at the Vatican Advanced Technology Telescope (VATT) considerably more observer-friendly, departed for the University of Virginia in June. Dan McKenna has taken over as VATT Project Manager. Dan is no stranger to VATT, for his wide-ranging engineering skills contributed greatly to the success of the telescope's upgrade that became

known as “the Kresge project.” He then spent some time with the Large Binocular Telescope (LBT) at Arizona’s Mount Graham International Observatory before returning to us in the spring of 2004.

Gabriele Gionti, S.J., an Italian Jesuit seminarian in training for the priesthood, has been assigned as a stage in his training to carry out research for a one-to-two year period at the Vatican Observatory Research Group in Tucson, Arizona. Before entering the Jesuit seminary, Gionti obtained a doctorate in mathematical-physics at the International School for Advanced Studies, Trieste, Italy with a thesis on quantum gravity.

Christopher Corbally, S.J., has become the moderator for a new IRAS Discussion Group, Nature and God. He is also acting as a co-chair and the contact person for a proposed Joint Discussion at the IAU General Assembly in Prague, 2006.

Vilppu Piirola, Tuorla Observatory, University of Turku, Finland, has accepted a one-year renewable appointment as Research Astronomer at Castel Gandolfo. He and George Coyne, S.J., will continue their research on cataclysmic variable stars.

The Holy Father received the Observatory Community at Castel Gandolfo for the celebration of the Liturgy on the Feast of St. Ignatius, 31 July.

In Memoriam

We were saddened by the death on 5 January 2005 of George J. Goudreau, Sr., of Cleveland. Mr. Goudreau, along with his late wife Lenore, was a generous founding benefactor of the Vatican Observatory Foundation. He went to the Lord at the age of 101.

Vatican Observatory Foundation

The annual meeting of the members and directors of the Vatican Observatory Foundation was held on 27 February 2004 in Tucson, Arizona. The following were elected to serve as members and directors for a three-year period: CHRISTOPHER J. CORBALLY, S.J., BEN DALBY, PAULA D’ANGELO, MICHAEL N. FIGUEROA, PAUL M. HENKELS, CHRISTOPHER P. HITCHCOCK, and WILLIAM R. STOEGER, S.J. BRENDAN THOMSON replaced JOHN B. HOLLYWOOD, S.J., as chair of the Audit and Finance Committee. MICHAEL N. FIGUEROA became a member of the Development Committee.

(By letter of 3 December citing personal reasons, Mr. PAUL M. HENKELS tendered his resignation from the Board of Directors. We wish to take this occasion to thank him for his years of dedicated service to the Foundation.)

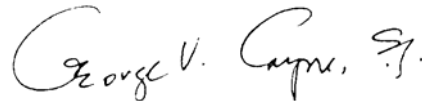
On the day preceding the annual meeting, members of the Observatory staff conducted a seminar to present their research in a popular forum to friends of the Observatory and members of the Board;

VATICAN OBSERVATORY

on the day after the meeting, the same group was accompanied on an excursion to the Mt. Hopkins Whipple Observatory, where the MMT Telescope is located. Dan Brocius and Dan Blanco kindly acted as guides.

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*. A Capital Campaign has been inaugurated with ROCCO L. MARTINO as Chairperson.

Once again through the efforts of BRENDAN D. THOMSON, Board Member, an official Vatican Observatory calendar for the year 2005 has been produced with the theme "Poets and Astronomers Unite." The calendar reflects on the timeless expressions of many poets about the universe and is illustrated with the photographic expressions by many young astronomers, graduates of the Vatican Observatory Summer Schools.



George V. Coyne, S.J., Director

I. Astronomical Research

Theoretical Studies, Astrophysics, and Cosmology

STOEGER and ARAÚJO (Universidade Federal do Rio de Janeiro) are still in the process of completing their project of solving the Einstein field equations in observational coordinates with cosmological data functions for general perturbations to a Friedmann-Lemaître-Robertson-Walker (FLRW) background, with and without a cosmological constant. They then plan to apply this approach to various data sets as well as to investigate how this can be used to reformulate the description of anisotropies in the cosmic microwave background radiation.

STOEGER and RIBEIRO (Physics Institute, Universidade Federal do Rio de Janeiro) are extending their critical analysis of galaxy luminosity functions in Einstein de Sitter (flat) cosmologies without a cosmological constant to FLRW cases with a cosmological constant. STOEGER has been setting up the procedures for fitting Lemaître-Tolman-Bondi (LTB) cosmological models with a cosmological constant to cosmologically relevant data: luminosity distance and galaxy number counts. This essentially extends the earlier work on FLRW models to more general situations. Though there is strong evidence that our universe is FLRW, or almost-FLRW, on the largest scales, it is not clear that it is so on intermediate cosmological scales. This is a first step in seeing how one can use data to determine the best-fit cosmology on such scales, and hopefully to determine the smallest length scale on which the universe is almost-FLRW.

With ELLIS and KIRCHNER (Department of Mathematics, University of Cape Town), STOEGER has continued work on physical and philosophical issues concerning ensembles of universes and their use in various cosmological contexts, particularly in understanding the processes which were important in the very early universe. This work was described in more detail in the 2003 Annual Report.

STOEGER and colleagues at the University of Cape Town continue their projects related to the conditions for and constraints on inflationary epochs (briefly described in the 2003 Annual Report), as well as a re-examination of number of independent observational cosmological parameters one has available in cosmic microwave background anisotropy measurements. This work is directly connected with the issue of how well that data can constrain cosmological models.

GIONTI, newest member of the Vatican Observatory Research Group (see Personnel News), is working on the problem of a first order gauge-invariant approach of Regge calculus as a discrete theory for quantum gravity. This research is a continuation of the work he started for his PhD thesis at the International School for Advanced Studies, Trieste, Italy.

In collaboration with the group of mathematicians of Warsaw Technical University, HELLER continued the program concerning applications of noncommutative geometry to physics. A model has been constructed unifying some aspects of general relativity and quantum mechanics. It exhibits an

VATICAN OBSERVATORY

interesting property of being non-local: on the fundamental level (below the Planck threshold), all local concepts are meaningless and, consequently, there is no time and no space (in their usual meaning as sets of points and instants). Nevertheless, dynamics is possible. The role of time is played by a one-parameter group, called modular group. It depends on the state of the system being considered. A rather unexpected property of the model is that this dynamics has a strong probabilistic character. General relativity and quantum mechanics are recovered as “limiting cases.”

Extragalactic Research

KENNICUTT (Steward Observatory), FUNES, LEE (Steward Observatory), SAKAI (University of California, Los Angeles), TREMONTI (Steward Observatory), and VAN ZEE (Indiana University) were awarded more than 100 hours of observing time with the Galaxy Evolution Explorer (GALEX). This orbiting space telescope, launched April 28, 2003, is observing galaxies in ultraviolet light across 10 billion years of cosmic history in an effort to map the history of star formation in the Universe. The goal of the team’s observing run is to obtain ultraviolet imaging for a volume-limited sample of spiral and irregular galaxies within 11 Mpc of the Milky Way. The parent survey for this investigation is the 11 Mpc H-alpha Survey, a deep H-alpha and R-band imaging survey of 340 spiral and irregular galaxies within 11 Mpc. The imaging was obtained on more than 80 nights of observing in the years 2000-2003 on the VATT (Mt. Graham, Arizona), the Bok 2.3m Telescope (Kitt Peak, Arizona), and the CTIO 0.9m telescope (Cerro Tololo, Chile). The data that GALEX is obtaining will be combined with the complete H-alpha and R-band imaging. The goal of this combined investigation, known as the 11Mpc H-alpha and Ultraviolet Galaxy Survey (11HUGS), is to study the demographics and star formation properties of nearby galaxies. The research team’s survey is a Legacy program of the GALEX mission. Such programs are expected to use GALEX to perform major observing programs that will enhance significantly the overall scientific contribution of the mission.

In order to study the ionized-gas distribution and star formation properties in elliptical galaxies with dust lanes, FUNES and KRALL (Boston College) have started an observational program to obtain H-alpha and UBR images with the VATT. With NGC 5128 (Centaurus A) as a prototype, this class of galaxies is characterized by a dust lane silhouetted against the stellar body. These objects are active galaxies with powerful radio sources. In some of them, the mass of the supermassive black hole has been determined. It appears that these galaxies have undergone a major merger event at some point in their evolution. The preliminary analysis of the H-alpha images shows that the observed galaxies have a disk of ionized gas.

VILLEGAS and MINNITI (Pontifical Catholic University of Chile) with FUNES continue the study of the nearest giant elliptical galaxy, NGC 5128 (Centaurus A). Using Hubble Space Telescope archival images, they resolved individual stars in two young globular clusters centered in the giant HII region (Sersic 13) on the dust lane of NGC 5128. The resolved stars have masses greater than 50 solar masses and ages less than 4 million years. These results are consistent with the scenario where the clusters are gravitationally bound and will merge in about 10-100 million years.

In recent years several research programs have established correlations between the mass of the supermassive black holes and the global properties of galaxies, such as the luminosity (mass) of the spheroidal component, the velocity dispersion of the same component, and the dark matter halo. Considering the previous studies, CASTILLO (Universidad Nacional Autonoma de Honduras) under the direction of FUNES is studying the possible correlations between the mass of the supermassive black holes and other properties of galaxies, such as nuclear activity, maximum of the rotational velocity, shape of the rotation curve, star formation rate in the central regions, X-ray luminosity, environment of the host galaxy, and its evolution. This project is part of CASTILLO'S master thesis.

In collaboration with BARBIERI (Department of Astronomy, University of Padua), OMIZZOLO continues his research on the light curves of quasars from data obtained by scans of the photographic plates in the Observatory's archives at Castel Gandolfo (see section II. Instrumentation and Technical Services). From scans made at the Asiago Observatory, historical light curves of four quasars have been obtained.

With RAFANELLI (University of Padua), OMIZZOLO continues research on Seyfert galaxies and has been able to obtain excellent data from observations with the VATT.

The Galaxy and Galactic Objects

The Nearby Stars (NStars) project, to obtain spectra, spectral types, and basic parameters of the 3600 stars within 40 parsec of the sun and earlier than M0 spectral type, has virtually completed its observational program, with only a few spectra in the very northern hemisphere remaining. 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. This year they have been concentrating on the classification and analysis of the data from the southern hemisphere. Among the results are preliminary statistics for A-type stars in two subsets of the data, one from the northern and one from the southern hemisphere. The percentage of peculiar to normal stars (11%) is a little higher than for previous studies (about 7%), but this may just reflect the success of identifying peculiarities from this project's high signal-to-noise spectra. Observed and derived data from this project are being released on the project's website: <http://stellar.phys.appstate.edu>.

In the continuing investigation with STRAIZYS and collaborators (Vilnius, Lithuania) of heavily reddened stars in clusters and of peculiar stars, CORBALLY has included the Aquila Rift dark clouds in a spectroscopic observing program that complements initial Vilnius 7-color photometry and classification. He has also finished classifications of 30 stars in the Aries dark cloud. Among these are two previously identified as T-Tauri stars and two that are new candidates for such stars. The spectroscopy is helping complete a distance and extinction study for these star-forming regions of the Galaxy.

VATICAN OBSERVATORY

The Strömvil Photometric System can provide data to classify all the types of stars even if reddened by interstellar dust. For Milky Way studies of galactic and globular star clusters BOYLE, assisted by co-observers PHILIP (Union College, Schenectady, New York), ZAMBRANO (Metropolitan University, San Juan, Puerto Rico), and LAUGALYS and BARTASIUTE (Vilnius University, Lithuania), made the CCD exposures in the Strömvil filters at the VATT in March, June, and October. JANUSZ (University School *Ignatianum*, Krakow, Poland) is contributing automated, iterative methods for the CCD processing so that the optimum photometry can be derived for accurate stellar classification. The June VATT run was centered on the Cygnus field defined for the Kepler Space Mission, which will be capable of detecting earth-sized planets orbiting G-dwarf stars.

A workshop on Strömvil Photometry, organized by BOYLE at Castel Gandolfo in July, brought together collaborators PHILIP, JANUSZ, KAZLAUSKAS, LAUGALYS, CERNIS (Vilnius University, Lithuania), SMRIGLIO (University of Rome), and ZAMBRANO. They discussed and worked on the various aspects of this research project. BARTASIUTE and LAUGALYS are observing 400 stars with the Vilnius Photometer on the 60-in. and 40-in. telescopes of the University of Arizona on Mt. Lemmon to complete this fourth run (October - February) for calibration stars in the Strömvil System. STRAIZYS (Vilnius University, Lithuania), awarded the Chretien Grant, is funding this aspect of the research.

BOYLE and LAUGALYS are continuing the project with STRAIZYS and KAZLAUSKAS by making further CCD observations in the Vilnius Photometric System with VRBA (U. S. Naval Observatory, Flagstaff, Arizona) on the USNO 40-in. telescope. This observational work is producing initial results of photometric parallaxes of reference stars in support of the USNO optical CCD parallax program.

In collaboration with COYNE, PIROLA continues work on cataclysmic variable stars. AM Her binaries (polars) consist of a highly magnetic ($B = 20\text{-}100$ MG) white dwarf and a low mass red dwarf component that fills its critical Roche lobe. A stream of matter from the red dwarf is channeled along the field lines and flows onto the white dwarf surface through accretion columns. The effective temperature of the accretion shock is 10-40 keV. AM Her objects are also prominent X-ray sources. The mildly relativistic electrons of the hot magnetized plasma emit strongly polarized cyclotron radiation in the optical and near-infrared. Polarization of the observed light provides information that is useful for determining the geometry of the system, e.g., orientation of the spin and magnetic axes, and the spin period of the white dwarf. Phase-dependent polarization variations observed in different wave-bands (UBVRI) enable us to determine the location and geometry of the cyclotron emission regions on the white dwarf. The wavelength dependence of the polarized and total fluxes helps in estimating the physical parameters in the accretion region and the shock front. For field strengths $B = 20\text{-}100$ MG, the cyclotron fundamental wavelength is in the near infrared, and what we observe in the optical are higher harmonic overtones ($n = 2\text{-}15$). The dependence of the circularly and linearly polarized fluxes on the angle between the line of sight and the field is characteristic for each harmonic number and for a given effective temperature and electron density. Based on multicolor photopolarimetric and spectropolarimetric observations, the aim of this work is to develop and improve the physical and geometrical models for highly magnetic interacting binaries, their magnetic fields, and cyclotron emission regions.

In collaboration with Tuorla Observatory (University of Turku, Finland), PIROLA has studied the polarimetric variability of W Ser type binaries and developed new computer codes for the modeling and the interpretation of the observations. These binaries, known also as “active Algols,” are massive systems in a brief stage of interaction with a high rate of mass transfer. Linear polarization produced by scattering of light by free electrons carries important information about the density and structure of the circumstellar envelopes in these systems. In particular, the phase-locked pattern of polarization variations yields estimates of the orbital inclination, which is needed for reliable mass determinations for the binary components.

Planetary Sciences

Meteorite Studies

- *Meteorite Physical Properties:* Among the most fundamental physical characteristics of any planetary body are its density and porosity. These data provide insight into the body’s accretion, evolution, impact history, mineralogy, internal strength, and structure. The density and porosity of meteorite groups are fundamental ground truth for the composition and structure of asteroids. CONSOLMAGNO and BRITT (University of Central Florida) continued their ongoing project of measuring and compiling a database of meteorite density measurements and exploring the implications of these data for future meteorite and asteroid studies.

Many ordinary chondrites arrive as part of a shower of meteorites: a third of all ordinary chondrite falls listed in the standard meteorite catalogues have three or more recovered pieces. A common assumption is that these meteorite-strewn field samples represent fragments of a larger stony mass that broke apart in the Earth’s atmosphere. Thus one way to examine the homogeneity of material in meteoroids is to examine the physical properties of many individual samples (whole rocks where possible) of a given meteorite fall.

Such physical parameters include meteorite density and porosity, and meteorite magnetic susceptibility. Previous to this year’s work, our density database had 22 ordinary chondrites with five or more density or porosity measurements. The magnetic susceptibilities for the Vatican ordinary chondrite collection, measured previously by ROCHETTE (CEREGE, Aix-en-Provence, France), contained most of the smaller stony samples including three showers (Holbrook, Pultusk, and Mocs) with numerous samples measured for magnetic susceptibility. Unfortunately, the samples measured for susceptibility were generally different, smaller samples than those measured for density.

To fill this gap, the Observatory this past summer hosted MACKE (St. Louis University), a young Jesuit brother presently in formation who had studied meteorites at Washington University prior to entering the Jesuits. He and CONSOLMAGNO collaborated to measure the grain and bulk densities of 173 meteorite samples, tripling the number of Vatican meteorites so measured. This data set will serve as a rich source for future analysis of meteorite properties. Key to the success of this project was the use of a new helium pycnometer loaned to the Observatory by BRITT.

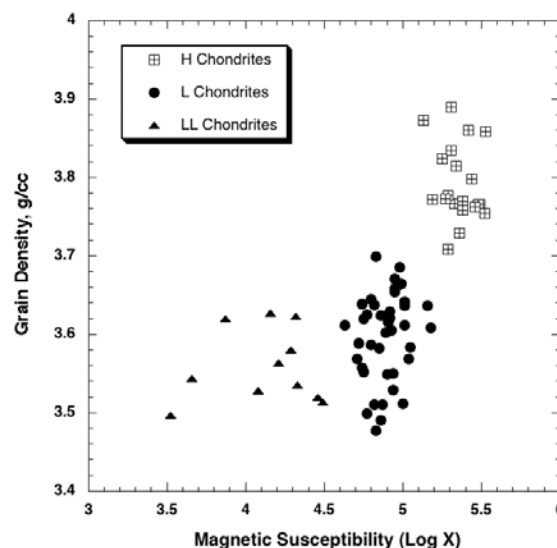
VATICAN OBSERVATORY

The measurements confirmed the pattern that showers such as Holbrook, Pultusk, and Mocs cluster both in density and magnetic susceptibility. A few outliers in both properties do exist among the sample set; it was notable that meteorites with discordant magnetic properties also had grain densities inconsistent with their classification. This may be evidence that these meteorites had been mislabeled at some point in the history of the collection.

More striking, however, was the result that grain density and magnetic susceptibility are strongly correlated even for non-shower meteorites. For fresh samples, these two measures can unambiguously separate the H, L, and LL classes of ordinary chondrites, a classification that previously required time-consuming and sample-consuming analysis, either with very expensive microprobe equipment or by highly skilled analysis with optical microscopes. Thus this new technique represents a powerful new tool for the rapid, accurate classification of extraterrestrial material. It promises to be a fast, non-destructive, and reliable way of characterizing (or confirming) the classification of meteorite samples within a collection. And it allows the rapid characterization not only of meteorites but also of returned samples from asteroid missions without any contamination or loss of material.

- *Meteorite–Asteroid Connection:* Connecting a given meteorite type with a particular asteroid class is usually done by comparing the meteorite chemical/mineralogical composition to the spectral reflectance properties of the asteroid surface. While this has tremendously advanced our understanding of meteorites and led us to identify possible asteroidal parent bodies, it suffers from several difficulties. As spectroscopists realize (but meteoriticists sometimes forget), the spectra of an asteroid characterizes only the top few microns of surface material. As meteoriticists realize (but spectroscopists sometimes forget), meteorites are often breccias and not always uniform in composition.

Thanks to space missions, observations of asteroid satellites, observations of asteroid mutual gravitational events, and radar observations, there is now a rapidly increasing data set for asteroid bulk densities. These data, along with data on grain densities of analogue meteorites, provide significant insight into asteroid porosity and internal structure. To date, these data are only available for larger asteroids (several kilometers diameter), but recent discoveries of satellites around small Near-Earth Asteroids and the imminent arrival of the Japanese Hayabusa spacecraft to the 500-meter asteroid Itokawa now expand these result to objects that may be characteristic of individual components. Results to date by BRITT and CONSOLMAGNO indicate that all but the largest asteroids have significant macroporosity, suggesting that they are either heavily fractured bodies or loose rubble piles.



Measuring meteorite grain density and magnetic properties is a rapid, non-destructive, and inexpensive way to sort out the three major classes of ordinary chondrites.

This macroporosity also makes it difficult to characterize an asteroid by its density alone. However, the density-magnetic susceptibility classification technique described above for meteorites offers the prospect that future missions to asteroids can use measurements of asteroid density and interactions with the ambient solar magnetic field to characterize the material present throughout the asteroid, not merely the material on its surface. BRITT and CONSOLMAGNO are beginning to explore the possibility of devising space-qualified instruments that can perform these measurements on the surface of an asteroid.

- *Meteorite Fabric and Impacts:* CONSOLMAGNO and STRAIT (Alma College, Michigan) have continued their study of microcrack porosity in meteorites using a computerized point-counting system to learn about the formation and evolution of meteorites and their parent bodies. Using the new density database collected by MACKE and CONSOLMAGNO (described above), a comprehensive comparison between the porosity of hand samples and the presence of microcracks in thin sections made from those hand samples can finally be made.

STRAIT and CONSOLMAGNO also looked at a suite of meteorite samples centered around a common mineralogy, using basalts as representative of most types of bodies, to evaluate if microcrack porosity varies with planet of origin. This ongoing work seeks to answer several fundamental questions: Can one see a different kind of porosity in unequilibrated versus equilibrated chondrites? Do non-chondritic meteorites look less or more cracked than ordinary chondrites? What do non-chondritic breccias like mesosiderites or howardites look like?

Microcrack porosity in meteorites, though greater than that seen in terrestrial samples, does not appear to be correlated with meteorite type, and thus it may have its origin in a process common to all meteoritic material. One such process is the impact environment that shaped the bodies on which the meteorites formed and from which they were ejected. The subsequent decompression following passage of a shock wave through the material is a very likely source of this porosity. This insight led CONSOLMAGNO to a collaborative effort with WEIDENSCHILLING (Planetary Science Institute, Tucson) and DE CARLI (SRI, Menlo Park) to examine the conditions in the early solar system when such shock environments could have led to the compaction and lithification of the meteorites.

One such effect may be seen in a possible connection between such impact events and the orientation of non-spherical chondrules in chondrites; an examination of the relationship between that orientation, anisotropy in magnetic susceptibility, and meteorite porosity is the subject of ongoing work by GATTACCECA and ROCHETTE (CEREGE, Aix-en-Provence, France) DENISE (Natural History Museum, Paris); CONSOLMAGNO; FOLCO (University of Siena, Italy), and ZANDA (Rutgers University, New Jersey).

- *Meteoroid Bulk Density:* The mean bulk density of small meteoroids remains a poorly measured quantity. Based on photographic observations of large (gram-sized) meteoroids and the theory of quasi-continuous fragmentation, previous workers have estimated the average bulk density of meteoroids to be near 3.3 g/cc, with values for individual meteoroids ranging from 1 to 8 g/cc. These high values are close to the density of solid-iron and stony meteorites, but they have been shown to

VATICAN OBSERVATORY

contradict theoretical expectations. In contrast, a competing theory applied to 370 meteors with a magnitude range between +2.5 and -5 mag found low values for the density of meteoroids in a similar mass range; for sporadic meteors, an average density of 0.8 g/cc has been found, while the density for individual meteoroids ranges from 0.1 to 4.5 g/cc.

To test these theories, KIKWAYA, BROWN (Western Ontario University), and HAWKES (Mount Allison University, New Brunswick) have begun a study of the bulk density of smaller (milligram) meteoroids, using the single-body model applied to low-light-level television (LLTV) observations. They gather data from two observing stations separated by 50 km: one station uses a digital, gated image intensifier coupled to a megapixel CCD detector, while the other station uses an image intensifier coupled to a video-rate CCD. The gated sensor permits high temporal snapshots (0.5 millisecond) of meteors that can then be combined with the LLTV systems at the second site to define both the trajectory and velocity of the meteoroid to high precision. The goal is to detect significant deceleration in a sample of both shower and sporadic meteors. Absence of significant wake in the gated images is used as a criterion to select those meteors for which fragmentation is not important and thus application of the single-body model is most appropriate. This work is ongoing and will constitute a part of KIKWAYA's PhD dissertation at the University of Western Ontario.

- *X-Rays and Meteorites*: Material derived from the interstellar medium, injected from a supernova remnant or AGB star, or made via spallation by relativistic baryons in the solar nebula can all contribute isotopically anomalous material to the solar nebula. The local spallation of material by an energetic young Sun is an attractive source of short-lived radionuclides (Be-7, Be-10, Al-26, and Ca-41) inferred to have been present in various calcium-aluminium-rich inclusions, gas-rich grains, and chondrules. In situ spallation requires MeV particle fluences of roughly a hundred thousand times the levels of contemporary cosmic ray and solar energetic particle fluences; but X-ray observations of the flaring levels of pre-main sequence stars can give direct empirical constraints on the viability of the spallation model.

The high sensitivity and resolution of the Chandra X-ray Observatory launched in 1999 has led FEIGELSEN (Penn State), WOLK (Smithsonian Astrophysical Observatory), and CONSOLMAGNO to characterize the magnetic flaring of solar-mass pre-main-sequence stars to see if these flares could produce the observed isotopic anomalies in meteorites.

These stars, observed especially in the Orion Nebula Cluster where ~1000 stars with ages ~0.5-2 Myr are concentrated in a single field, are analogues of the early Sun. Two 12-hour exposures made in 1999 and 2000 show that the X-ray luminosity of a complete sample of 43 stars with masses within 30% of the Sun's mass in the Orion Nebula Cluster in the 0.5-8 keV band is a thousand times above the average active Sun level today. Twenty-eight of these stars varied from day to day, indicating that the energy seen was being emitted as flares. While it is difficult to distinguish individual flares from quiescent levels with these short exposures, we estimate that one such energetic flare occurs every 1-2 days in pre-main sequence solar analogs. This is 30 times stronger and 300 times more frequent than seen in the contemporary Sun.

Such flares in the Sun today emit not only the X-rays that Chandra observes, but also copious amounts of high-energy particles that could be responsible for some meteorite isotope anomalies. For the young solar-like stars, the estimated enhancement in MeV proton fluences is 10 times the X-ray fluence, or a total of a hundred thousand times above present-day solar energetic particle levels. This is consistent with the levels needed to produce some of the observed isotope anomalies.

All young solar analogs exhibit huge elevations in magnetic flare levels, with estimated baryon fluences consistent with the requirements of a nebular spallogenic origin for several short-lived meteoritic isotopic anomalies. These are supported by radio continuum studies of enhanced gyrosynchrotron emission in pre-main-sequence stars. However, the location and geometry of the flaring magnetic fields is uncertain, and additional model assumptions must be made to assure that the flare particles efficiently impact nebular solids to produce the observed distribution of isotopic anomalies.

Lunar Studies

Lunar meteorites may have sampled material more representative of the bulk lunar surface than the nearside regions sampled by the Apollo and Luna missions. Lunar highland meteorites tend to be more anorthosite-rich, and poorer in the melt residue component, than their Apollo analogues. Continuing work reported last year, RUSSELL, JEFFRIES (Natural History Museum, London), and CONSOLMAGNO have now measured the Rare Earth Element (REE) composition of clasts from three lunar meteorites; modeled the original melt composition from which the clasts and relict crystals formed; and compared these results with previous work on the Apollo ferroan anorthosite (FAN) suite. The meteorites included *Dar Al Gani (DaG) 400*, a lunar highland regolith breccia, composed of melt fragments embedded in a poorly crystalline, dark matrix; *Dhofar 081*, a fragmental breccia with a glass- and melt-rich matrix and abundant vesicles; and *Northwest Africa (NWA) 482*, a light colored anorthositic impact melt breccia composed of 80-90% plagioclase including relict mm-scale plagioclase grains, with minor olivine and pyroxene, cross-cut by glassy impact melt veins.

Polished sections 200 μ m thick were characterized at the Natural History Museum (London) by optical and scanning electron microscope. Trace element analysis was performed by laser ablation inductively coupled mass spectrometry (LA-ICP-MS), performed in situ, with a spatial resolution of \sim 50-100 μ m. In addition, major element abundances were determined by electron microprobe for a number of clasts and matrix of DaG 400.

The REE of the anorthite crystals may represent an equilibrium between crystals and melt pre-dating the shock event that led to the formation of the matrix and mixed clasts. The wide range of REE patterns seen in the melt clasts indicates that they experienced a more complex history. The shocked melt veins of NWA 482 show REE abundances that are virtually indistinguishable from the NWA 482 clasts. This suggests that the heating event which formed the veins occurred so quickly that the REEs were not redistributed over the \sim 50 μ m scale of the shock veins.

The researchers conclude that all but a few relict anorthite grains were either partially or completely melted by the shock events experienced by these rocks. Depending on the initial mineralogy and textures, the shock events either produced clast material (some of which was transformed completely into the shock melt) or completely melted the material that became the matrix. The sample then

VATICAN OBSERVATORY

cooled so quickly that no trace element equilibration between any of these phases (or the relict anorthites) could take place. Thus it appears that the matrix, the clasts, and the anorthite grains represent at least three distinct components from the original rocks whose crystal structure was destroyed in the shock events, but whose trace element chemistry remains essentially unaltered.

Kuiper Belt Objects

ROMANISHIN (University of Oklahoma), TEGLER (Northern Arizona University), and CONSOLMAGNO continued their measurement of BVR colors of Kuiper belt objects and centaurs. With the measurements of the past year, they have now measured the colors of more than 100 such objects. The new results continue to confirm the patterns reported.

TEGLER, ROMANISHIN, and CONSOLMAGNO also produced optical photometry of the Centaur 5145 Pholus during 2003 May and 2004 April using the facility CCD camera on the 1.8-m Vatican Advanced Technology Telescope on Mt. Graham, Arizona. They found a double-peaked light curve, indicative of a spinning, irregularly-shaped object; the derived rotation period was 9.980 ± 0.002 hr. The light curve had an amplitude of 0.60 magnitude, significantly larger than amplitude determinations of 0.15 magnitude seen in 1991 and 0.39 magnitude by Buie and Bus and Farnham.

The three observed amplitudes, measured over 15 years, means that we have now seen this body as the relative orientation of its spin axis towards the Earth changes as Pholus orbits around the Sun. From measuring these changes, an amplitude-aspect model can be used to derive the shape and spin pole positions of Pholus. If we assume an albedo of 0.04, we find Pholus has dimensions of 307 x 161 x 145 km. This is consistent with the equilibrium shape of a very low density body.

By comparing the blue to red colors of the body as it spins, the researchers find that the color variation over the surface of Pholus must be smaller than 0.06 magnitude (i.e., much smaller than the range seen across different members of the Centaur and KBO populations). Likewise, comparing these colors to measurements taken over the past 15 years, there is no evidence for any color variation between the northern and southern hemispheres of Pholus. These Pholus observations add to the growing body of evidence that individual Centaurs and KBOs exhibit homogeneous surface colors. Hence, gray impact craters on radiation-reddened crusts are probably not responsible for the surprising range of colors seen among the Centaur and KBO populations.

History and Philosophy of Science; Interdisciplinary Studies

CARUANA was a panel member in a round table conference held at the Pontifical Gregorian University on 11 December 2003 and organized by the journal *Gregorianum*. Entitled *Quaestio Disputata: Philosophia et Scientiae*, the panel involved four main contributions dealing with how science and philosophy interact. Between February and March, he gave 10 hours of advanced lectures on philosophy and cognitive science at the Gregorian University. These lectures will be published in the form of a long article. He completed his research on the impact of Albert Einstein's special theory of relativity on some central issues in philosophy of religion. The resulting paper, "God's Eternity and Einstein's Special Theory of Relativity," is forthcoming in the 2005 special issue of the

journal *Revista Portuguesa de Filosofia* to commemorate the centenary of Einstein's 1905 paper on special relativity.

For his BA Degree in Philosophy at the Institute of Philosophical Studies *Aloisianum* in Padua, GIONTI prepared a thesis on the meaning of space and time by comparing philosophical and physical theories. Following the work of an Italian philosopher of science, Mauro Dorato, he showed the great utility that Kant's transcendental philosophy has in the interpretation of the concepts of space and time given by the theory of special and general relativity of Albert Einstein. He has advanced this analysis to study the concept of space and time as they emerge in an approach to quantum gravity. The framework of transcendental philosophy has allowed an interpretation of the *a priori* concept of space and time based on an ontology coming from the physical theory of quantum gravity assumed as fundamental.

HELLER is studying the history of cosmology, in particular, cosmological models with closed time. He is also investigating structuralism in the philosophy of mathematics and of physics.

STOEGER continues research and writing on the theology of creation, drawing from reflections on cosmology and the other natural sciences. Along with COYNE, RUSSELL (Center for Theology and the Natural Sciences [CTNS], Berkeley, California), and MURPHY (Fuller Seminary, Pasadena, California), he is involved in organizing a new series of Vatican Observatory-CTNS research conferences on "Scientific Perspectives on the Problem of Evil." The first conference, which will focus on what fundamental physics and cosmology have to contribute to our understanding of this issue, will be held at Castel Gandolfo 11-18 September 2005.

STOEGER has also begun some exploratory research with OLOWIN (St. Mary's College, Moraga, California) on the future of the human species, and of intelligent, conscious life beyond our species.

CASANOVAS continues his research in the history of astronomy, especially on the Gregorian reform of the calendar and on spherical astronomy.

II. Instrumentation and Technical Services

Vatican Advanced Technology Telescope (VATT)

The highlight of work at the VATT during 2004 was the replacement of the guide camera and the addition of new software by NELSON, with the help of SWIFT. The new software represents a substantial change in ease of use for the observer, both in setup and operation. Functionality has been added, and all of the tasks involved in guiding (catalogs, stages, autoguiding, etc.) have been brought into one computer window. The guide camera replacement resulted in improved response from more-reliable hardware. This is also true of the finder camera replacement. The dome tracking control has been switched to an encoder from a mechanical sensor, thus relieving observers of a regular worry. Other engineering changes to the Telescope Control System focused on removing old

VATICAN OBSERVATORY

software and unifying efforts under a single operation.

Several projects are in the engineering stage for the VATT. One by McKENNA and FRANZ is to mount an infrared sky temperature sensor and a sky brightness monitor (SBM) on the secondary mirror tube. The SBM will automate obtaining the “twilight flats” that are used to calibrate the CCD camera. Considerably improved efficiency is expected for this process, which now depends on the skill of the observer. A prototype monitor has been tested, and the mechanical drawings and initial documentation have been produced for the device. Another project, started by NELSON and being continued by McKENNA and FRANZ, is to upgrade the motor stages in the guide box (x, y, focus, filter wheel) with new motors and added optical encoders. Currently these stages are prone to fail at the lower winter temperatures.

BOYLE, chair of the VATT Allocation Committee with CORBALLY and COYNE, schedules the observing runs on the VATT. This is done on the trimester in synchronization with the University of Arizona Telescope Allocation Committee. In addition to Vatican Observatory astronomers, regular observers at the VATT include astronomers from the University of Notre Dame, Wheeling Jesuit University, New Mexico Institute of Mining and Technology, University of Virginia, the University of Arizona, Arizona State University, and Northern Arizona University.

Mt. Graham Fire

In late June 2004, lightning strikes ignited two separate wildfires in the Coronado National Forest southeast of Safford, threatening the VATT and two other telescope facilities at the Mt. Graham International Observatory (MGIO). Danger from the combined fires, known as the Nuttall Fire Complex, peaked over the 4th of July weekend. By the time firefighters had the situation under control in mid-July, the fires had charred nearly 30 thousand acres, required a workforce of 913 people, and accrued more than \$10 million in firefighting costs. In the end, fire damage to property in the affected area was minimal. The VATT was ready for an observing run on 24 July. The telescope and housing had not been damaged, not even by smoke, a tribute to the skill and



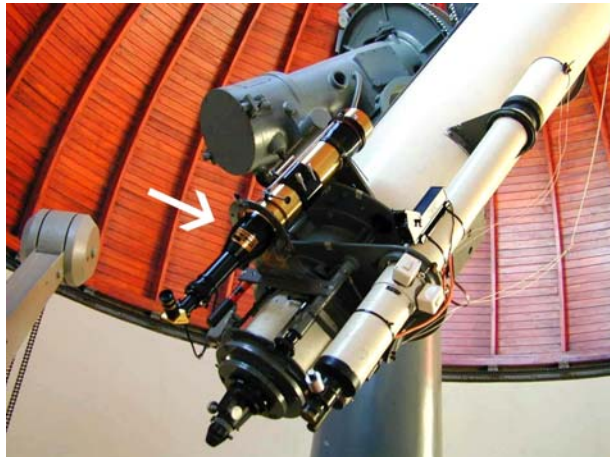
Firefighters used back burns to block wildfire flames from reaching the Mt. Graham telescopes. Smoke from the back burn seen here was only 150 yards from the VATT (at left in back). (Photo by Lance Lines)

dedication of the firefighting personnel, which included the MGIO crew, and the University of Arizona Police Department's Mt. Graham Division.

Instrumentation

MAFFEO assisted the Italian firm Astromecanica in upgrading the guiding system of the Zeiss visual telescope at Castel Gandolfo. He also installed on the Zeiss the new Coronado Solar Telescope donated to the Observatory by David Lunt and Geraldine Hogan of Coronado, Inc., Tucson, Arizona. (See From the Director.) The new telescope is the company's SolarMax 90, the largest H-A telescope to be mass-produced. It is used in installations around the world, from private to professional observatories.

At the request of the Vatican Museums, for their project to prepare a *Central Catalogue of Cultural Treasures*, MAFFEO has completed an inventory of the ancient instruments in the Vatican Observatory's possession.



Arrow points to the Coronado Solar Telescope mounted on the Vatican Observatory's Zeiss visual telescope in Castel Gandolfo. (Photo by Sabino Maffeo, S.J.)

The box and all internal mechanical components of the VATT's medium-resolution optical spectrograph (VattSpec) have been fabricated by Astronomical Consultants & Equipment, Tucson. The wiring of its control elements is in progress. An initial set of reflection gratings and a blank flat have been purchased in anticipation of first tests on the spectrograph. This project falls under the guidance and monitoring of CORBALLY, CROMWELL, McKENNA, and NELSON, along with HARMER (National Optical Astronomy Observatories).

The Imaging Technology Laboratory at the University of Arizona delivered a 4Kx4K CCD camera to the VATT. McKENNA and FRANZ are making an adaptor to the current 2Kx2K camera shutter for it. A high-speed shutter is under development.

OMIZZOLO has completed the scanning and digitalization of about one-quarter (1100 plates) of the Observatory's Schmidt direct plate archive. He is developing a program to automatically extract data from the Schmidt spectral plates. As reported in Section I. Astronomical Research, Extragalactic Research, he has together with BARBIERI (University of Padua) been able from the scanned data to construct light curves over time for selected quasars.

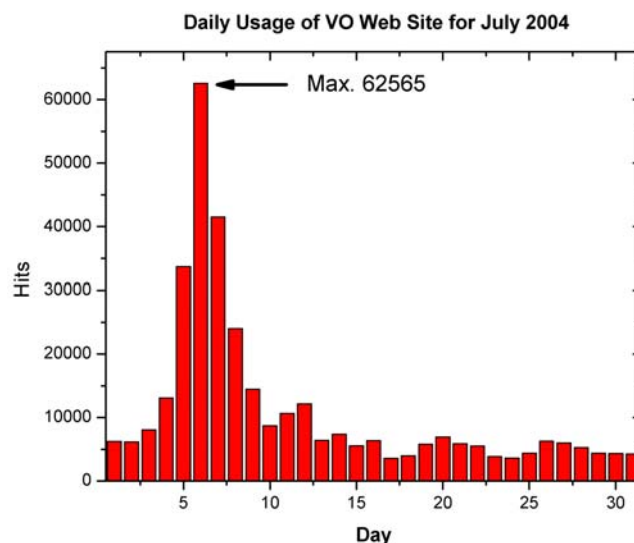
Guest Housing

VATICAN OBSERVATORY

The Vatican Observatory's Jesuit Community in Tucson, Arizona, with the assistance of the Vatican Secretariat of State, has purchased an additional residence adjoining the current Tucson residence. The new residence will serve principally to host visiting scientists who come to collaborate on research with the staff astronomers.

Cyber Activities

CORBALLY and PELETIER (Nottingham, UK) continued to maintain the website of the Vatican Observatory and the Vatican Foundation (<http://vaticanobservatory.org>), updating it with such items as the Annual Report, Newsletters, Summer School announcement, alumni details, and VATT observer information. The website's usual rate of about 7,000 hits per day, spiked to nearly 63,000 on July 6, a measure of the public concern about the fate of the VATT on Mt. Graham at the height of the wildfire threat (see graph at right).



Meteorite Collection and Laboratory

The Vatican meteorite collection and the Vatican Observatory's Meteorite Laboratory at Castel Gandolfo continued to grow and serve the meteorite community. New acquisitions in 2004 included a fragment of the unusual primitive chondrite Tieschitz and the rare unweathered Rumurutiite meteorite NWA 753. In December, the meteorite collection was enhanced by the donation of eight new specimens from John Blennard, an Arizona meteorite collector. Most notable among the donations were 18 g of Franconia, a meteorite found recently in the Arizona desert, and a small sample of the rare tektite material Irghizite. Eighteen meteorite samples from the Vatican collection were loaned to other laboratories, including the State University of New York at Stony Brook, and the CEREGE institute in Aix-en-Provence, France.

The Meteorite Laboratory was enhanced with the addition of a Meiji EMZ-5TR zoom stereo microscope and fiber optic illuminator, which allows for the close inspection and photography of whole meteorite samples. This instrument complements the previously obtained petrographic microscope, making it possible to obtain a detailed characterization of meteorite samples and candidate samples in the lab at Castel Gandolfo.

III. Observatory and Staff Activities

Vatican Observatory Conferences

From 24 to 26 June the Observatory at Castel Gandolfo hosted a symposium sponsored by the Templeton Foundation on “Purpose in Evolution.”

From 12 to 16 July under the direction of BOYLE a workshop was held at Castel Gandolfo on “CCD Processing for Photometry.”

Presentations and Academic Activities

CARREIRA • Gave two lectures at the University of Central America in El Salvador. He spoke to faculty and students about the Origin of the Universe and to the faculty of the Philosophy Department on Science and Faith. • Conducted a 10-hour course over a period of two weeks at the Catholic University in Bogota on Metaphysics and Science. • Lectured to theology students at the Universidad Javeriana on the Anthropic Principle and at the Universidad Gran Colombia on the Origin of the Universe and the relationship between Science and Faith.

CARUANA • At the Gregorian University, Rome, presented the undergraduate course “Philosophy of Science and Nature.” • At Arrupe College, Jesuit School of Philosophy and Humanities, Harare, Zimbabwe, presented an undergraduate course “Philosophy of Science and Cosmology.” Also gave a public talk entitled “A Christian Evaluation of Scientific Attitudes in Ethics and Economics.” • At Piešťany, Slovakia, 28 August-1 September was one of the keynote speakers during the biennial conference of the European Jesuit Philosophers with a paper entitled “Science and Ethics: Tracing Parallels and Contrasts between Science, Relativism and Utilitarianism.”

CASANOVAS • On 23 January participated at Monte Mario (Rome) at the inauguration of the Center on Variability of the Sun. • Gave a paper at Maròstica (Veneto) on changes in the teaching of astronomy in the XVIII century in the Italian Jesuit Schools. • Lectured at San Marino on exoplanets. • Spoke at the Naples meeting of the history of physics and astronomy about the 1759 transit of Venus observed by Fr. M. Hell at Wardhuss, Finland. • Attended the celebration of 100 years of the Observatorio de l’Ebre, Roquetes, Spain, and a workshop on geophysics at Tortosa, Spain. • Lectured on Galileo in Turin and on Kepler at the Università Regina Apostolorum, Rome.

CONSOLMAGNO • Served on the NASA New Horizons panel to select candidate spacecraft missions to explore the Moon and planets. This panel met in Washington, DC, 10-13 May. • Served on the NASA Planetary Geology and Geophysics panel, meeting in Boulder, Colorado, 15-20 August, evaluating more than one hundred proposals for funding from the American space agency. • Reviewed other proposals for both NASA and the (UK) Particle Physics and Astrophysics Research Council • Delivered seminars on Color Patterns in the Kuiper Belt at the University of Arizona As-

VATICAN OBSERVATORY

teroid Lunch seminar on 12 January; at the University of Western Ontario, 28 January; at Louisiana State University, 11 March; and at the Pontifical Catholic University of Santiago, Chile, 11 August. • Presented a seminar on new ideas for the origin of the lunar crust at Loyola Marymount University on 17 February; at Louisiana State University, 12 March; and at the University of Central Florida, 22 November. • Spoke at a Science/Engineering/Math Staff luncheon at Loyola Marymount on 17 February, and presented a discussion on the Galileo Affair and its effects on the relations between Church and science at Louisiana State on 11 March. • Discussed the relationship between meteorite porosity and asteroid structure at Penn State University on 14 April; at Wagner College, Staten Island, New York on 27 April; to the Malta Astronomical Association on 5 May; at the Pontifical Catholic University of Santiago on 9 August; and at the College of Charleston on 18 November.

CORBALLY • As Immediate Past President of the Institute on Religion in an Age of Science, participated in council meetings in January at Philadelphia, Pennsylvania, and in July at Portsmouth, New Hampshire. • Gave a paper, “Characteristics of our Neighboring A-Stars,” at the IAU Symposium 224 in Poprad, Slovakia. • Participated in the Star & Planet Formation Discussion Group at Steward Observatory. • Represented the Vatican Observatory at the 15 October dedication ceremony in Tucson of the Large Binocular Telescope. • Collaborated with Steward Observatory and MGIO personnel to implement the outdoor lighting code around Mt. Graham, and represented the Vatican Observatory at the International Dark-Sky Association “Excellence in Lighting” award presented to the University of Arizona. • Continued on the Board of the St. Albert the Great Forum for science and theology at the Catholic Newman Center, University of Arizona.

COYNE • Was named a member of the Scientific Council of the Osservatorio Astronomico Scientifico “*Gian Camillo Gloriosi*,” Montecorvino Rovella, Italy. • Was a member of the Honorary Committee for the celebration at the Università Cattolica del Sacro Cuore, Brescia, Italy of the 100th anniversary of the birth of Carlo Viganò, founder of the renowned Library of the History of the Physical-Mathematical Sciences at Brescia. • Taught a course of eight lectures in cosmology in the new specialty program, “Science and Philosophy,” of the philosophy faculty of the Pontifical Gregorian University, Rome. • Participated in a round table discussion, “The Scientific Hypotheses of Teilhard Today,” at the International Conference on Teilhard de Chardin held at the Pontifical Gregorian University, Rome, 21-24 October. • Gave a talk on “Origins and Creation” as part of the series, “An Invitation to Theology,” sponsored by the School of Theology of Bergamo, Italy. • Presented a paper on “The Laws of Nature and Purpose in the Universe: An Historical Overview” at the international meeting on “God and the Laws of Nature” held at Villa Monastero, Varenna, Italy, 11-13 October. He served on the Scientific Organizing Committee for the meeting. • At the symposium “Religion and Natural Science” held at the Manreza Center, Dobogókő, Budapest, Hungary, gave a paper on the “Dance of the Fertile Universe.” • Served on the Organizing Committee for the meeting on “Value in the Sciences” of the Asociación Argentina de Cultura held 15-17 October at La Armonia (Mar del Plata, Argentina) and gave a paper on “The Meaning of Value in the Natural Sciences.” • Continues to serve on the Advisory Committee for the Cosmology Prize of the Peter Gruber Foundation and participated in the prize awards held 4 June at the Smithsonian Institution, Washington, DC. • Gave a paper at the Plenary Session of the Pontifical Academy of Sciences in November on “Discovery in the New Cosmology of Copernicus, Kepler and Galileo.” • Participated

in the meeting of the International Society for Science and Religion in Boston 18-22 August. • Taught the General Astronomy course during the spring semester in the Department of Astronomy, University of Arizona.

FUNES • Taught a course on “Star Formation in Galaxies“ to graduate students at the Instituto Nacional de Astrofísica Óptica y Electrónica in Puebla, Mexico. He also gave a seminar on his extragalactic research on the elliptical galaxy NGC 5128 (Centaurus A). • Taught the General Astronomy course during the fall semester in the Department of Astronomy, University of Arizona.

HELLER • On 22 April in Bratislava, Slovakia, gave a paper on “Ultimate Explanations in Cosmology.” • In Paris on 30 April at the Symposium: The Question of God and the Laws of Nature presented a paper on “Laws of Physics and the Mind of God.” • In May, organized at Kraków, Poland a symposium on “Information and Understanding.” • Gave a paper on “Man in the Cosmos” at the IV International Humboldt Conference in June at Kraków. • Gave a paper on “Discovering the World Structure as a Goal of Physics“ at the Plenary Session of the Pontifical Academy of Sciences in November. • Taught a course of ten lectures in mathematical methods in the natural sciences in the new specialty program, “Science and Philosophy” of the philosophy faculty of the Pontifical Gregorian University, Rome.

OMIZZOLO • Gave a paper on “Variations of the Constants in the Laws of Physics,” at the conference “God and the Laws of Nature,” at Varenna, Italy. • Presented a series of talks on cosmology and the science-faith dialogue in Padua and in Venice. • Spoke of the program for the digitalization of the plate archives of the Vatican Observatory and Italian observatories at a meeting in Volterra, Italy.

STOEGER • Team-taught the course “Science and Theology” with LINDELL (Department of Molecular and Cellular Biology, University of Arizona) in both the fall and spring semesters. • Continues as Chairperson of the St. Albert the Great Forum Board at the Catholic Newman Center, University of Arizona. • Also serves on the Board of Trustees, Brophy Preparatory High School, Phoenix, Arizona and on the Board of the Center for Theology and the Natural Sciences (CTNS), Berkeley, California. He was appointed Chairperson of the CTNS Board. • Is a member of the committee at Steward Observatory, University of Arizona, committee for implementing the three-year Templeton Foundation Grant on “Astrobiology and the Sacred.” • From 2 to 6 January participated in the International Symposium, “Modern Science, Values, and the Quest for Unity,” at the Regal Hotel in Mahabaleshwar, Maharashtra, India. He presented an invited lecture entitled “Science, Cosmology, Theology and Critical Realism.” After the meeting he lectured at a class on “Theology and Science” at De Nobili College in Pune. • From 17 to 20 March, attended the meeting of the National Optical Astronomy Observatories on “Dark Energy” at the Tucson Omni Resort, Tucson, Arizona. • Visited St. Mary’s College, Moraga, California 4-7 April to begin interdisciplinary work with OLOWIN (Physics Department) on issues relating to the transhuman future. • Attended the Sir John Templeton Foundation meetings in Paris, France, from 29 April to 5 May to discuss various issues related to religion and science, and participated in the Templeton Prize celebrations there and at Buckingham Palace, London, England. He coordinated the nomination of this year’s Templeton Prize winner, ELLIS (University of Cape Town, South Africa). • Participated in the annual convention of the

VATICAN OBSERVATORY

Catholic Theological Society of America (CTSA) in Reston, Virginia, 10-13 June. He was the convener of the Theology and the Natural Sciences Group session for the CTSA. At that session he also gave a presentation on “The Neurosciences and Philosophy: Consciousness and the Soul.” • Attended 18-24 July the International Conference on General Relativity and Gravitation, GRG17, at the Royal Dublin Society, Dublin, Ireland. While there, he also visited HOGAN and O’SHEA at University College Dublin and discussed possible research collaboration with them. • In November participated in the O. C. Tanner Symposium, “Religion and Culture: Spiritual Imperatives in Contemporary American Life” at Utah State University, Logan, Utah. He gave an invited lecture there, “Cosmology, the Laws of Nature and Divine Action,” and was a panelist on “Spiritual Imperatives and Modern Science.”

TERES • Gave a series of lectures on “The Jesuit Astronomers and their Work,” first at the Faculty of History of the Pazmany University, Hungary, and then in a tour through several Hungarian towns. • Presided over the Organizing Committee for the three-day Manreza Symposium on “Religion and Natural Science,” held at Dobogókő, Hungary, and held a preparatory conference for student participants at the symposium. • Gave lectures on the “Beginning of the Christian Era according to the Calculation by Dionysius Exiguus in the Sixth Century,” at the Institute of Astronomy at the Eotvös Lorant University in Budapest. • Also presented lectures at the Faculty of Theology of the Sapientia University in Budapest and in Székesfehérvár on “The Scriptural Account of Creation and Astrophysical Cosmology.” • Observed the transit of Venus on 8 June at Vardhø, Norway, near Lapland within the Arctic Circle. On that occasion he was invited by the Commander of the Vardøhus Fortress to give a talk on the observations of a Venus transit made at the same site in 1769 by two Hungarian Jesuits, Maximilian Hell and Johann Sajnovics, who had been invited by Christian VII, King of Denmark and Norway.

WHITMAN • Was one of the organizers of the 42nd Meeting of the Clavius Group of Mathematicians, held at Boston College 3-31 July. • Helped organize a seminar on topics in differential geometry, and gave two lectures a week during the four weeks of the meeting.

Public and Educational Outreach

On the occasion of the transit of Venus visible from Castel Gandolfo on 8 June, the Vatican Observatory hosted on the days surrounding the event two groups of nearly one hundred amateur astronomers, sponsored by *Sky and Telescope* magazine. KOCH provided local arrangements and CORBALLY and MAFFEO hosted the amateurs who brought telescopes to set up on the rooftop terrace of the Observatory, while CONSOLMAGNO and CASANOVAS gave presentations about the Vatican Observatory and the history of transits.

CARREIRA • Gave lectures in San Francisco, Cleveland, and Arlington and at the summer meeting of the Universidad Menendez y Pelayo and at a symposium of the Astronomical Society of Palencia on the origin of the universe and on the Earth as a habitable planet. • Is a member of one of the Local Groups Network in Spain, sponsored by Metanexus and the Templeton Foundation, to develop audiovisual materials on Science and Theology at the university level.

CONSOLMAGNO • Was the featured banquet speaker at the 50th anniversary dinner of the Tucson Amateur Astronomy Association on 23 January, speaking on the history of planetary astronomy in Tucson during those fifty years • At the annual seminar of the Vatican Observatory Foundation in February spoke on the future of Mars exploration. • Spoke about the adventures of a Vatican astronomer at the Cranbrook Museum of Science, Detroit, Michigan, on 15 May; at Stonyhurst College, England, on 4 November; and at a conference of Heads of Jesuit Works held in Oxford on 5 November. • Gave a history of the Vatican Observatory to the Malta Astronomical Society on 4 May and to the University of Dallas Rome Center on 5 October. • Presented a talk, “Astronomy, God, and the Search for Elegance,” for the “Naming the Holy” program sponsored by the Catholic Chaplaincy at the University of Toronto on 27 January; at Olivet Nazarene University, Chicago, on 2 February; at Loyola Marymount University, Los Angeles, on 12 February; at Penn State University on 14 April; at Cranbrook Museum of Science, on 16 May; at the Southeast Christian Church of Louisville, Kentucky, on 11 November; and at the College of Charleston, South Carolina, on 18 November. • Reflected on the theological implications of the search for extraterrestrial intelligence with a group of Lutheran campus ministers at the Adler Planetarium in Chicago on 3 February. This informal discussion was followed by two 2-hour classes on “The Human Search for Alien Life” at the Adler Planetarium on 4 and 5 February. The first discussion covered the recent scientific history of the search for extraterrestrial life, while the second session, taught with HIGGINS (Fermi Lab, Batavia, Illinois) covered the effect of this search on the human imagination. This latter theme was revisited in a presentation to the St. Albert the Great Forum at the University of Arizona on 1 December. • Continued to give talks on astronomy and the interaction between science, religion, and the popular culture at numerous science fiction conventions. The most significant of these were four presentations and panel discussions at the World Science Fiction Convention in Boston 1-4 September. Presentations at regional conventions included a talk at the Confusion convention in Detroit on 25 January; three presentations at the Capricon convention in Chicago 31 January-1 February; and three presentations at the Windycon convention in Chicago 13-14 November. • At the invitation of the Maryland Province of the Society of Jesus gave talks entitled “The Glorious Things Done By God” at St. Joseph’s University in Philadelphia on 15 November and at Holy Trinity Parish in Washington, DC, on 16 November. • Gave the following classroom presentations: on faith and science issues to classes at the University of Toronto on 26 January; on the solar system to a Catholic K-9 home school group in Tucson on 26 March; on meteorites at Pima Community College, Tucson, on 12 April and 6 December; on faith and science issues and extraterrestrial life at Wagner College, Staten Island, New York, on 27 April; to a group of Maltese schoolchildren sponsored by the Astronomical Society of Malta on 6 May; to students of the University of Washington’s Rome Center on 10 and 15 September; and at Bishop England High School, Charleston, South Carolina, on 19 November.

CORBALLY • On 15 January gave a talk to the Sun City Astronomy Club on “Getting to Know Thy Neighbors,” and spoke on the same topic to the East Valley Astronomy Club on 10 March • Gave a talk on “Which of our neighbors is going to have a suitable planet?” at the seminar on 26 February for friends and benefactors of the Vatican Observatory Foundation. • Helped host *Sky & Telescope* visitors to Castel Gandolfo for the transit of Venus on 8 June • On 14 August, with Aileen O’Donoghue (St. Lawrence University, Canton, NY), led a faith and astronomy retreat and symposium

VATICAN OBSERVATORY

sium at the Loyola Jesuit Center, Portland OR, sponsored by the St. Agatha Catholic Church Faith and Astronomy Dialogue program. • Regularly engaged in phone and video links with the same St. Agatha Church during its monthly astronomy meetings. • Continued as an advisor to the *Earth & Sky* radio series. • Answered public enquiries by e-mail and phone. • Hosted visits to the Steward Observatory Mirror Lab at the University of Arizona and to the VATT on Mt. Graham, including visits for the Steward Observatory Business Office and the Hands on the Sun conference.

COYNE • At the annual seminar of the Vatican Observatory Foundation in February spoke on “Research Highlights of 2003 at the Vatican Observatory.” • Gave talks at the following meetings in Italy: Ariccia (Rome), at the Golden Age University, a series of three lectures on “Life in the Universe”; Naples, Science City, at the *Futuro Remoto* meeting, on “Life Perhaps Elsewhere in the Universe”; Rome, at Rotary North, on the “Dance of the Fertile Universe”; Alassio, at the *Oltre Lo Spazio* meeting, on “The Frontiers of Space”; Frascati, at the Union of Amateur Astronomers of Italy, on “The Cosmic Connection: From the Big Bang to Life’s Origins”; Pavone (Turin), on “Life in the Universe: Chance or Necessity”; Cosenza, at the *Viaggio Telecom Italia: Utopia ed Eresia* meeting, on “Galileo: A Reconstruction of the Process for Heresy”; Milan, at the *Spalle dei Giganti* series, on “Reason, Science, Spirituality and the Future”; Grosseto, at the Pari Center for New Learning, on “Science and Faith: Limits and Hopes”; Pisa, at the Cardinal Maffi and Science as a Means of Dialogue meeting, on “Cardinal Maffi and the Vatican Observatory”; Ancona, at the *Centro Studi Oriente Occidente* meeting “Ways through the Natural Sciences to God,” a paper on “Theological Implications of the Origins of Life in the Universe.” • Hosted the visit to Rome and the Vatican of the Galileo Circle of the College of Science of the University of Arizona, Tucson. • Gave the following talks in the United States: New York, at Fordham University, on “Does Galileo Still Haunt the Church?”; Tucson, to the Science Club of the Community School, Naples, Florida, on “The Evolutionary Universe”; Washington, Pennsylvania, at Washington-Jefferson University, on “The Dance of the Fertile University”; Palo Alto, California, at St. Thomas More Catholic Center, on “Life in the Universe: Chance or Necessity”; Milwaukee, at Marquette University, Jesuit Partnership of the Jesuit Wisconsin Province, on “Dance of the Fertile Universe”; Chicago, at the Adler Planetarium, commented on the presentation of the television production *Galileo’s Sons* by Alison Rose of Inigo Films, Toronto, Canada.

FUNES • At the annual seminar of the Vatican Observatory Foundation in February spoke on “Telling Merger Tales: The Story of the Galaxy NGC 5128.”

HELLER • From 9 November to 15 December gave a series of lectures on “Mathematical Methods in the Natural Sciences” at the Pontifical Gregorian University, Rome. • Gave many talks and lectures to the general public on cosmology, on philosophical aspects of science, and on science and theology.

MAFFEO • Gave talks on the history of the Vatican Observatory to the Hipparchus Association of Amateur Astronomers and to the Rotary Club of Leonardo Da Vinci Airport and to the Lions Club, Aldobrandeschi, in Grosseto. • Presented a lecture on “Angelo Secchi, Priest and Scientist” as part of the degree program in science and faith at the Rome University of *Regina Apostolorum*.

OMIZZOLO • Gave various public talks on cosmology and on the science-faith dialogue at Padua and at Venice.

STOEGER • Gave a presentation on “Cosmology, Multiverses and the Anthropic Principle” on 11 February to the East Valley Astronomy Club, at Scottsdale Community College, Scottsdale, Arizona, and on 9 July to the Sierra Vista Astronomy Club, Sierra Vista, Arizona. • Presented from September to October a series of four lectures to the parishioners of St. Thomas the Apostle Parish, Tucson, Arizona, on connecting theology with the natural sciences. The first talk was on the Vatican Observatory and the Church’s views on faith and the natural sciences. In succeeding presentations, he focused on relating cosmology and physics, evolutionary biology, and the neurosciences, respectively, to our understanding of creation, the soul, and other key theological issues. • On October 26 was a guest lecturer in the NAVA (Religious Studies Department, University of Arizona) course on “The Concept of God.” He spoke on “Cosmology, God and Creation.” • Gave a presentation “The Big Bang, Cosmology and Creation” on 17 November at the St. Albert the Great Forum of the Catholic Newman Center, University of Arizona, Tucson.

News Media Coverage

On 16 August at the Adler Planetarium, Chicago, the U.S. premier of the television production *Galileo’s Sons*, a documentary on the Vatican Observatory, was held. Produced by Alison Rose of Inigo Films, Toronto, Canada, the production has won numerous awards, including the Canadian Broadcasting Aurora Award and the Gemini Award of the Canadian Academy of Television Arts. It was presented in November at the International Documentary Festival in Amsterdam, and rights to it have been purchased by YLE Finland, by ABC Australia, and by the Hispano-America History Channel.

On 16 June the BBC Radio 4 presented a half-hour program *The Pope’s Telescope* recorded during an observing run at the Vatican Advanced Technology Telescope and including interviews with CONSOLMAGNO and CORBALLY.

CARREIRA • Spoke on the radio station of the *Universidad Gran Colombia* and on a TV program that reaches from the Caribbean to Argentina.

CONSOLMAGNO • On 11 November appeared on the Louisville, Kentucky, public radio WFPL call-in radio show *State of Affairs*; and on 17 November, on the Charleston, South Carolina, radio WTMA talk show *Radio-Free Rocky-D*. • Gave interviews to the web magazine *Astrobiology* in April; to the Catholic News Service for publication in numerous diocesan newspapers in March and June; and in the Charleston *Post and Courier* on 17 November.

CORBALLY • Provided interviews to the following media and journalists: Joe Rogers, for *The Bishop’s Radio Hour*, Diocese of Sacramento; Geoff Ziezulewicz, *The Minnesota Daily*; Joe Kolb, *Voice of the Southwest*, Diocese of Gallup; Pat Zapor, *Catholic News*, on the Nuttall Fire Complex; Gudrun Sailer, for *Swiss Public Radio*, together with BOYLE; Kris Koenig, *Coast Learning Systems*, at VATT for a telecourse project; Lucy Hornby of Energy Intelligence Group, for *Oil Daily*, concerning light pollution; Laura Lee, for *Conversation for Exploration*, together with STOEGER. • Answered questions from: Laura Bly, *USA Today*; Alice Jenner, *BBC Radio Scotland*; Frank Reddy,

VATICAN OBSERVATORY

Astronomy Magazine.

COYNE • Provided interviews to the following media and journalists: Sophie Brouillet, *La Presse*, Quebec, Canada; Frank Reddy, *Astronomy Magazine*, Milwaukee, Wisconsin; Davide Rondoni and Stefania Pedania of DUEA Films, SAT 2000, of the Italian National Bishops' Conference; Giulia Brotti of *L'Eco of Bergamo*; Silvia Rosa-Brusin of *Radiotelevisione Italiana*; Frederica Saylor of *Science & Theology News*; Stelio Montebugnoli, Simona Righini, and Giampiero Piazza of *Xilo Studios*, Bologna, Italy, for the production of the documentary *Deep Space*; Mary Shovlain and Martin Goings of *Rome Reports TV*; Vanessa Strizzi of *Radiotelevisione Italiana Uno "A Sua Immagine"*; Elaine Wacker, National Bishops Conference of Scotland; the Catholic Communication Campaign, National Conference of Catholic Bishops, USA, for the program *A Day in the Life of the Church*.

FUNES • Was interviewed by *Report on Research*, University of Arizona; *Il sole 24 ore* (Italy) on occasion of the dedication of LBT; *Diario de Cuyo* (Argentina) and *Diario de Sevilla* (Spain). • Wrote an article for the weekly news magazine *Noticias* (Argentina).

HELLER • Gave several interviews in various Polish media on science, philosophy, and their relationship to theology.

MAFFEO • In addition to various interviews to radio and television journalists, participated in a program on SAT 2000 of the Italian Bishops Conference about Jesuit involvement in the science-faith dialogue. • Gave an interview on the Spirit satellite landing on Mars to the Vatican Radio. • Was interviewed by TVP TV Poland on the Gregorian reform of the calendar and on the Vatican Observatory.

OMIZZOLO • Was featured in an article in *Il Giornale of Vicenza*, 18 April.

Conference Participation

4-8 January: Atlanta, Georgia. 203rd Meeting of the American Astronomical Society. RICHARD BOYLE, S.J., and CHRISTOPHER CORBALLY, S.J., each presented papers.

6-10 January: Phoenix, Arizona. 111th Annual Meeting of the American Mathematical Society and 88th Annual Meeting of the Mathematical Association of America. ANDREW WHITMAN, S.J., participated.

11-13 March: Tucson, Arizona. Annual General Meeting of the International Dark-Sky Association. CHRISTOPHER CORBALLY, S.J., participated.

14-18 March: Houston, Texas. 35th Annual Lunar and Planetary Sciences Meeting, GUY CONSOLMAGNO, S.J., presented one paper and co-authored another.

28 March-1 April: Moffet Field, California. Astrobiology Science Conference 2004. GUY CONSOLMAGNO, S.J., co-organized and chaired a special session on "The Ethics of Exploration."

1-6 April: Barcelona, Spain. Xth Annual European Conference on Science and Theology. JUAN CASANOVAS, S.J., and CHRISTOPHER CORBALLY, S.J., participated.

24-26 June: Castel Gandolfo, Italy. Templeton Symposium on Purpose in Evolution. GEORGE COYNE, S.J., hosted, and CHRISTOPHER CORBALLY, S.J., attended.

4-31 July: Boston College, Boston, Massachusetts. 42nd Annual Summer Meeting of the Clavius Group of Mathematicians. ANDREW WHITMAN, S.J., organized and lectured.

7-13 July: Poprad, Slovakia. 224th Symposium of the International Astronomical Union. CHRISTOPHER CORBALLY, S.J., presented a paper.

12-16 July: Castel Gandolfo, Italy. Vatican Observatory Workshop on the Strömvil and Vilnius Photometric Systems. RICHARD P. BOYLE, S.J., organized this workshop with collaborators from Lithuania, Poland, United States, Italy, and Puerto Rico.

24-31 July: Star Island, New Hampshire. Annual Conference of the Institute on Religion in an Age of Science. CHRISTOPHER CORBALLY, S.J., participated.

1-6 August: Rio de Janeiro, Brazil. 67th Annual Meeting of the Meteoritical Society, GUY CONSOLMAGNO, S.J., presented two papers and co-authored another.

16-20 August: London, Ontario, Canada. 3rd International Meteoroid Meeting (Meteoroids 2004). JEAN-BAPTISTE KIKWAYA, S.J., presented a paper.

18-22 August: Boston, Massachusetts. International Society for Science and Religion. GEORGE V. COYNE, S.J., participated.

3-4 November: Tucson, Arizona. Steward Observatory Internal Symposium. CHRISTOPHER CORBALLY, S.J., and JOSE FUNES, S.J., participated.

5-8 November: Vatican City. Plenary Session of the Pontifical Academy of Sciences on "Paths of Discovery." GEORGE V. COYNE, S.J., gave a paper.

8-12 November: Louisville, Kentucky. Annual Meeting of the Division for Planetary Sciences of the American Astronomical Society. JEAN-BAPTISTE KIKWAYA, S.J., presented a paper; GUY CONSOLMAGNO, S.J., presented a paper and co-authored two others.

IV. Publications

BARBIERI, C., OMIZZOLO, A., and ROSSI, C. "Historical Light Curves of QSOs from the Digi-

VATICAN OBSERVATORY

tized Archive of Asiago Plates,” 2004, in *AGN6 Proceedings*, in press

BARBIERI, C., BLANCO, C., BUCCIARELLI, B., COLUZZI, R., DI PAOLA, A., LANTERI, L., LI CAUSI, G., MARILLI, E., MASSIMINO, P., MOTTOLA, S. NESCI, R., **OMIZZOLO**, A., PEDICHINI, F., RAMPAZZI, F., ROSSI, C., SCLAVI, S., STAGNI, R., TSVETKOV, M., and VIOTTI, R. “Digitizing of Plate Archives of the Italian Observatories and Specola Vaticana,” 2004, *Baltic Astronomy* 13, 665-670

BARTASIUTE, S., ASLAN, Z., **BOYLE**, R. P., KHARCHENKO, N., OSSIPKOV, L., and SPERAUSKAS, J. “Studying the Stellar Populations of the Galactic Disk in the Local Cylinder,” (abstract) 2004, *BAAS*, 36, 1583

BOYLE, R. P., JANUSZ, R., PHILIP, A. G. D., and LAUGALYS, V. “Automation and Iteration Methods for Processing CCD Stellar Photometry in the Strömvil System,” (abstract) 2004, *BAAS*, 36, 1602

BRITT, D. T. and **CONSOLMAGNO**, G. J. “Meteorite Porosities and Densities: A Review of Trends in the Data,” 2004, *Lunar Planet. Sci.*, XXXV, 2108

CASANOVAS, J. “Tentativo di riforma del calendario gregoriano nel 1700,” 2004, in *Atti del XXII congresso nazionale di Storia della fisica e dell’astronomia*, eds M. Leone, A. Paoletti, and N. Robotti (Genova)

—. “The Work of N. Copernicus,” 2004, in *KOS*, July 2004, 14-19

COCCATO, L., CORSINI, E. M., PIZZELLA, A., **FUNES**, J. G., and BERTOLA, F. “Minor-Axis Velocity Gradients in Disk Galaxies,” 2004, *A&A*, 416, 507

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—. “Aliens at the Vatican,” 2004, *Geoscientist*, 14, 4-9

—. “God Under the Dome,” 2004, *Planetarian*, 33, 1

—. “Grappling with a Universe,” 2004, *Company*, 21, 27-29

—. “Jesus Was a Techie.” 2004, *America*, in press

—. “Relish the Red Planet,” 2004, *The Tablet*, 258, January 24, 6

—. “The Glorious Things Done by God,” 2004, in *Partnership* supplement to *Company*

—. Monthly columns in *The Tablet*: “Losing Faith in Frankenstein,” 2004, 258, February 28, 36

- ___ . “What’s in a Name?” 2004, *The Tablet*, 258, March 27, 36
- ___ . “Ethics and the Search for ET,” 2004, *The Tablet*, 258, April 24, 36
- ___ . “The Secrets Venus Revealed,” 2004, *The Tablet*, 258, May 22, 36
- ___ . “Paper Trail to the Planets,” 2004, *The Tablet*, 258, June 26, 37
- ___ . “The Stars in My Hands,” 2004, *The Tablet*, 258, July 24, 34
- ___ . “Sociable Nerds in Rio,” 2004, *The Tablet*, 258, August 28, 33
- ___ . “Stories of Another World,” 2004, *The Tablet*, 258, September 25, 38
- ___ . “Souvenirs from Space,” 2004, *The Tablet*, 258, October 30, 37
- ___ . “The Light of Understanding,” 2004, *The Tablet*, 258, November 27, 36

CONSOLMAGNO, G. J. and BRITT, D. T. “Bulk Density as a Probe of Asteroidal Internal Structure,” 2004, in *International Symposium on Sample Returns from Solar System Minor Bodies-The First HAYABUSA Symposium*, ISAS, Japan, Oct. 20-22

___ . “Meteoritical Evidence and Constraints on Impacts and Disruption,” 2004, *Planet. Space Sci.* 52, 1119-1128

___ . “Physical Classification of Meteorites and the Remote Classification of Asteroid Composition,” *Bull. A.A.S.* 36, 1180-1181

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CONSOLMAGNO, G. J., RUSSELL, S. S., and JEFFRIES, T. E. “An In-Situ Study of REE Abundances in Three Anorthositic Impact Melt Lunar Highland Meteorites,” 2004, *Lunar Planet. Sci.* XXXV, 1370

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___ . “L’uomo, la vita extraterrestre e l’universo in evoluzione,” 2004, *Vita e Pensiero*, January-February 2004, 117-122

___ . “L’emergere ontologico nell’universo in evoluzione,” 2003, in *Epistemología de las Ciencias: La Emergencia*, ed. L. B. Archideo (Buenos Aires: CIAFIC Ediciones 2003), 165-192

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VATICAN OBSERVATORY

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VATICAN OBSERVATORY

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V. Observatory Visitors

The Vatican Observatory at Castel Gandolfo and the Vatican Observatory Research Group in Tucson, Arizona, hosted a number of visitors during the year. Noteworthy were the number of school groups and cultural groups received by MAFFEO, assisted by KOCH, at Castel Gandolfo. These groups included the Lions Club of Latina and the Association of Friends of Teilhard de Chardin on the occasion of the International Meeting on Chardin held at the Pontifical Gregorian University.

MAFFEO hosted the Occultation Group of Italian Amateur Astronomers for a day-long meeting at Castel Gandolfo on 11 December.

As reported in Section I. Astronomical Research, ROBERT MACKE, S.J., a Jesuit seminarian of the Province of Missouri, worked during July and August at Castel Gandolfo with CONSOLMAGNO to measure the grain and bulk densities of meteorite samples.

VATICAN OBSERVATORY

LUISA ZAMBRANO, a student selected in the ten-week “Model Institution for Excellence Project” of the Universidad Metropolitana, San Juan, Puerto Rico, was tutored by BOYLE. For this project, which was directed by Juan Arratia and funded by NSF, Zambrano made CCD observations with BOYLE at the VATT and then carried out computer processing of the data at Castel Gandolfo.

During a working visit to Tucson, CHRISTOPHER KRALL, a senior student at Boston College, was tutored by FUNES in studies of the ionized-gas distribution and star formation properties in elliptical galaxies with dust lanes.

The lay staff of the Observatory at Castel Gandolfo paid a visit to Tucson, Arizona, in May 2004.

The following individuals paid working visits to the Observatory:

STANISLAVA BARTASIUTE, Vilnius University, Vilnius, Lithuania

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

RICHARD D’SOUZA, S.J., Max-Planck-Institut fuer Astronomie, Heidelberg, Germany

ROBERT JANUSZ, S.J., University School “Ignatianum,” Krakow, Poland

ALGIRDAS KAZLAUSKAS, Institute of Theoretical Physics and Astronomy, Vilnius University, Vilnius, Lithuania

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

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

FILIPPO SMRIGLIO, Department of Physics, University of Rome “La Sapienza,” Rome, Italy

KEVIN VEREEKE, Bowling Green State University, Ohio, USA

LUISA ZAMBRANO, Universidad Metropolitana, San Juan, Puerto Rico

Among other professional guests at either Castel Gandolfo or Tucson during the year were: JUAN F. ARRATIA, MIE Project, Universidad Metropolitana, San Juan, Puerto Rico; NATALIA ARTEMIEVA, Russian Academy of Sciences, Institute for Dynamics of Geospheres, Moscow; CORYN BAILER-JONES, Max Planck Institut für Astronomie, Heidelberg; ROGER BUCK, Lamont-Doherty Geophysical Observatory, Columbia University, New York; JOHN FALLON, North Dakota, USA; DAGMAR FRINTA, Visiting Scholar, American Academy, Rome; PETER LYNCH,

Visiting Scholar, American Academy, Rome; PIERRE-MARIE ROBITAILLE, Ohio State University, Columbus; INGRID ROWLAND, American Academy, Rome; BRADLEY SCHAEFER, Louisiana State University, Baton Rouge; MARTHA SCHAEFER, Louisiana State University, Baton Rouge; DAVA SOBEL, Journalist, USA.





Vatican Observatory Inauguration, September 29, 1935

Castel Gandolfo, Italy