

THE VATICAN OBSERVATORY
1998 ANNUAL REPORT

Staff & Directors

From Director

Editor: Elizabeth J. Maggio

Cover: To Understand. To Share.

The Vatican  Observatory



To
Understand.

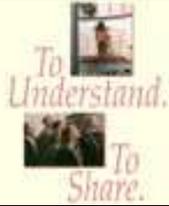


To
Share.

1998 Annual Report

Sabino Maffeo, S.J., Vatican Observatory Vice Director for Administration, demonstrates a telescope to Italian Girl Scouts visiting observatory headquarters at Castel Gandolfo. Tours are part of the Vatican Observatory's commitment to share astronomical discovery through its many public outreach programs. This commitment is summarized by the theme of this year's annual report: "To understand. To share."

Cover Artist: **Dave Fischer**



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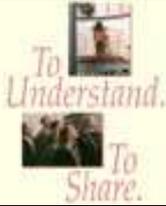
Vatican Observatory
Annual Report 1998



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Editor: Elizabeth J. Maggio
Cover Artist: Dave Fischer



From the Director

Cover

From the Director

Educational Outreach and Public Service

At various times in our annual reports I have used this section to feature one of the principal activities and achievements of the Observatory. These have included research with the Vatican Advanced Technology Telescope and the Observatory's role in the birth of the Mt. Graham International Observatory; the search for meteorites in the Antarctic; engagement in the dialogue between religion and science; the Summer Schools in astrophysics for young scholars from around the world, etc. This year I would like to speak of an important aspect of the Observatory's work that is sometimes hidden in this report because it is diffused throughout the various sections. I refer to the substantial amount of time and effort that Observatory staff members devote to educational outreach and public service.

As far back as 1991 the Observatory, in collaboration with Kino Learning Center, Inc. of Tucson, Arizona, produced a booklet entitled *Long Eyes on Space: Astronomy and You* for use in grades K to 6. Since then we have continued to dedicate considerable resources to public education at many different levels. These activities include guiding visits to the Observatory's headquarters at Castel Gandolfo, Italy, and to the Mt. Graham International Observatory in Arizona where the Vatican Advanced Technology Telescope is located; talks to elementary-school students; the preparation of resource material for teachers; lectures at public planetaria and science centers; contributions at science-fiction conventions; teaching adult-education courses; interviews with journalists and radio and television producers; science education for journalists; and public discussion of the interaction between science and religion. Noteworthy are the Vatican Observatory Foundation Seminars, which provide the Foundation's Board of Directors and friends two days of leisurely presentations by staff members who discuss the research carried out at the Observatory.

Many of the activities described above can be found in section III (Observatory and Staff Activities) of the annual report. In reviewing past reports I find that during the past two years members of the Observatory staff have given more than 100 public lectures and about 60 interviews to various news media in North America, Italy, Spain, and South America. It is of interest to note the variety of topics that have been covered in these lectures and interviews: the conditions for life elsewhere in the universe; the presence of water on other planets in the solar system; collisions in the planetary system and especially on the Earth; the formation of planets around other stars; the evolution of the universe and the appearance of life in it; the Galileo case; science and religion; as well as the history of the Vatican Observatory, the Vatican Advanced Technology Telescope, and the next generation of the world's largest telescopes.

It was through the Observatory's initiative that a series of conferences have been organized under the heading of "The Inspiration of Astronomical Phenomena." These conferences bring together artists, literary figures, architects, historians, scientists, etc. to exchange ideas on the way that astronomy has influenced the various aspects of human culture.

The Observatory's activities in educational outreach and public service are our way of sharing with others--no matter their age or background--the excitement of carrying out scientific research. We have come to realize that an amazing thing happened with the birth of modern science in the seventeenth and eighteenth centuries. We scientists were able, by the use of physics and mathematics, to put the universe in our heads. We have become so accustomed to what occurred since that time that some of us have ceased to marvel at this magnificent happening. In us the

universe has become self-reflective. We are the product of 15 billion years of an expanding, evolving universe and 3 billion years of an inevitable organic evolution from primitive living organisms to beings with the most complex entity known to exist: the human brain. It is a pleasure for us to share with the public what we have learned and to help bring back that sense of marvel to science.

Research Highlights

MYSTERY ASTEROIDS Back in the 1940s scientists theorized the existence of a family of asteroid-sized objects that orbit the sun beyond Neptune, but it was only in the early 1990s that they were able to observe these elusive celestial bodies, called Edgeworth-Kuiper Belt Objects. They are so faint that it will take the next generation of giant telescopes to unravel their mystery. In the meantime, though, Vatican Observatory scientists have teamed up with colleagues from the University of Notre Dame to conduct a preliminary survey with the Vatican Advanced Technology Telescope, taking advantage of the telescope's excellent optics and the dark skies at its Mt. Graham site that make it possible to study such dim objects.

A PIECE OF THE MOON Remember the six weeks in 1996 that Vatican Observatory astronomer Guy Consolmagno spent scouring the East Antarctic Plateau for pieces of space rock with the National Science Foundation's Antarctic Search for Meteorites (ANSMET) program? The team brought back a cache that is being examined at the NASA Johnson Space Center, Houston, where one meteorite was found to be unlike the others. Most meteorites come from asteroids, but this one is identical to samples of moon rock brought back by the Apollo astronauts. Only a dozen other lunar meteorites have ever been found.

Personnel News

After many years of preparation, José Gabriel Funes, S.J. is entering what we expect will be his final year of studies for his doctorate in astronomy at the University of Padua, Italy. He is destined by his religious superiors to join the staff of the Observatory. Funes has already participated in many of the activities of the Observatory and has carried out observations with the Vatican Advanced Technology Telescope. In anticipation of his joining the staff we present some of his research in this report.

In Memoriam

We were saddened by the death on 23 July of Fred A. Lennon, a dear friend of the Vatican Observatory for more than a decade; a major benefactor; and an active member of the Board of the Vatican Observatory Foundation since its inception. By his express wish, the Alice P. Lennon Telescope, an integral part of the Vatican Advanced Technology Telescope complex on Mt. Graham, Arizona, is named for his wife. In 1992 His Holiness John Paul II named Fred A. Lennon a Knight of the Order of Saint Silvester. He will be sorely missed by all who witnessed his dedication to the work of the Vatican Observatory.

Vatican Observatory Foundation Annual Meeting

The annual meeting of the members and directors of the Vatican Observatory Foundation was held in Tucson, Arizona, on 27 February 1998. The following were elected to serve as members and directors for a three-year period: CHRISTOPHER J. CORBALLY, S.J., PAUL M. HENKELS, CHRISTOPHER P. HITCHCOCK, WILLIAM R. STOEGER, S.J., and CHARLES W. POLZER, S.J. Additionally, PAUL M.

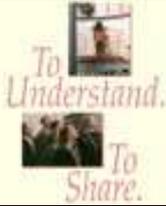
HENKELS was elected treasurer of the Foundation. The other officers were reelected for another one-year term. The Foundation's Executive Committee, acting in the name of the Board, met on 24 February, 8 October, 5 May, and 1 December.



(l. to r.) Cardinal Francis George of Chicago, Vatican Observatory Director George V. Coyne, S.J., and James McGee, chair of the development committee of the Vatican Observatory Foundation. (photo by Barbara Jones)

The Foundation is conducting [a development campaign](#) to raise funds to support further technological advances in the Vatican Advanced Technology Telescope and to establish an endowment for two postdoctoral fellowships. As part of this campaign, Cardinal Francis George of Chicago graciously held a reception at his residence at which I had the opportunity to present a slide-illustrated program on the Observatory's work and its facilities at Castel Gandolfo, outside of Rome, and in Arizona.

George V. Coyne, S.J., Director



Staff and Directors

Vatican Observatory Staff

The following are permanent staff members of the Vatican Observatory, Castel Gandolfo, Italy, and the Vatican Observatory Research Group (VORG), Tucson, Arizona:

GEORGE V. COYNE, S.J., Director
RICHARD P. BOYLE, S.J.
JUAN CASANOVAS, S.J.
GUY J. CONSOLMAGNO, S.J.
CHRISTOPHER J. CORBALLY, S.J.,
Vice Director for VORG
SABINO MAFFEO, S.J.,
Vice Director for Administration
MARTIN F. McCARTHY, S.J.,
President, National Committee to
International Astronomical Union
RICHARD J. MURPHY, S.J.,
Administrator VORG
ALESSANDRO OMIZZOLO
WILLIAM R. STOEGER, S.J.
ANDREW P. WHITMAN, S.J.

Adjunct Astronomers:

EMMANUEL M. CARREIRA, S.J.
MICHAEL HELLER

Vatican Observatory Foundation Board of Directors

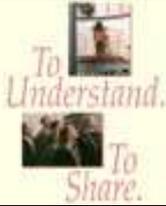
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RICHARD P. BOYLE, S.J., Second Vice President
WILLIAM R. STOEGER, S.J., Secretary
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FAITH VILAS



Astronomical Research

Cover

Theoretical Studies, Astrophysics, and Cosmology

During the past year significant progress was made by STOEGER and ARAUJO (Department of Mathematics, University of Brasilia, Brazil, and the Vatican Observatory) with help from MAARTENS and HUMPHREYS (School of Mathematical Sciences, University of Portsmouth, Portsmouth, UK). They have completed their analysis of the exact spherical symmetric Einstein field equations in observational coordinates, showing how these equations can be integrated using data functions representing observer area distance and galaxy number counts given as functions of redshift. They are presently reexamining the freedom of the fluid-ray tetrad as a prelude to correcting and completing the integration of the generally perturbed field equations in observational coordinates and to finishing their analysis of the calculation of cosmic microwave background radiation anisotropies in observational coordinates.

STOEGER, HELMI (Sterrewacht Leiden, University of Leiden, The Netherlands) and TORRES (Departamento de Fisica, Universidad de La Plata, Argentina) are nearing completion of their weak-field treatment of averaging in cosmology. Their work focuses on averaging over perturbed Friedmann-Lemaître-Robertson-Walker space-times and comparing their technique and results with those of other suggested approaches. They have been able to demonstrate the "almost covariance" of their procedure.

LISKA (Swedish Institute of Space Science, Söförs), in work with PACHOLCZYK (Steward Observatory) and STOEGER, has completed his statistical analysis of the rapid X-ray variability of Seyfert I galaxies, demonstrating that it does possess a definite low-level deterministic component, almost certainly originating in the sources themselves, as well as both transient and persistent tones and "chirps," indicating quasi-periodic phenomena in the source with periods between 20 and 400 seconds. LISKA has also demonstrated the signature of purely random, indeterministic signals in his wavelet ampligrams, and he has shown how weak deterministic components modify these. This work has strongly supported the conclusions concerning the Seyfert I X-ray variability data. On the basis of this work, PACHOLCZYK and STOEGER, with LISKA, have nearly completed their scenario for explaining such rapid X-ray variability, using the superposition of luminosity building blocks. These could be either magnetic flares developing in accretion disks around the central black holes that dominate Seyfert nuclei or X-ray bursts emanating from smaller black holes, traveling at high velocities in a central black hole cluster, as they puncture the accretion disks of the large central black hole or neighboring smaller black holes. PACHOLCZYK and STOEGER are completing the details of the physics of such proposed bursts, including the super-Eddington energy release (relative to the smaller black holes), and the degradation of the original gamma-ray release to X-rays via photon-photon pair production on the surrounding X-ray intracluster background.

STOEGER and JUST (Department of Physics, University of Arizona), along with JUST's graduate students, continue their fundamental work in quantum field theory. In particular, they are elaborating the results of JUST's quantum induction program for avoiding infinite renormalizations. They are strengthening and confirming preliminary results concerning estimates of the mass of the Higgs particle as well as estimates of the cosmological constant, which appears to be exactly zero in quantum induction. They have also been examining issues of unitarity, locality, and the sharpness of the electron mass in field theories in general, with particular application to quantum induction itself.

HELLER has continued research on applications of noncommutative geometries to physics, in particular, to the study of classical singularities and the unification of general relativity with quantum theory. An interesting result is that, if it is assumed that the pre-Planck era (quantum gravity regime) is governed by a noncommutative geometry, it can be shown that nonlocal phenomena, actually met in

quantum mechanics, are remnants or "shadows" of the primordial noncommutativity. In this way one deduces the famous Einstein–Podolsky–Rosen effect from a noncommutative model. Noncommutative geometry describes a space with no points and no neighborhoods. The fact that two elementary particles know of each other despite the distance separating them can indeed be regarded as a trace of the original nonlocality. Further work is in progress.

Extragalactic Research

MOSS (Visiting Astronomer), working with WHITTLE (University of Virginia), is completing the analysis of results of an objective–prism, H–alpha survey of nearby clusters in an investigation of the evolution of spiral galaxies in these environments. Research in recent years with the Hubble Space Telescope has shown that distant, rich clusters of galaxies have a higher fraction of blue star–forming galaxies, which often have unusual morphology suggestive of mergers and tidal interactions. It has been suggested that an earlier population of spirals in distant clusters has been depleted by the present epoch. Based on this picture, spirals do not survive a rich environment but undergo drastic modification as they are being transformed into other Hubble types. Although this depletion process, with associated mergers and interactions, is likely to be more common in distant clusters at earlier times, it is clearly of interest to search for these same processes occurring more recently in nearby clusters.

Some 450 galaxies in 8 nearby Abell clusters have been surveyed for H–alpha emission by MOSS and WHITTLE. Additionally, some 180 galaxies in Abell 1060 were surveyed by BENNETT (University of Cambridge, UK) and MOSS. The H–alpha emission is used as an indicator of the current rate of massive star formation to compare global star formation rates between cluster galaxies and field galaxies, and thereby clarify the environmental influence on star formation. Approximately 35% of the surveyed spiral galaxies are detected in emission, of which half show extended disk–wide H–alpha emission typical of normal spirals. The remainder exhibit centrally concentrated emission that appears to be tidally induced by near–neighbor interaction, and possibly also by perturbation by the overall cluster field and by higher speed "harassment" interaction between galaxies. There is an enhancement of tidally induced star formation in cluster spirals compared to spirals in the field, with a number of early–type spirals discovered to have strong star formation, which is rare or absent in the field. A strong correlation has also been discovered between cluster mean central galaxy density and the fraction of spirals with tidally triggered star formation.

MOSS continues to collaborate with BENNETT and ARAGON–SALAMANCA (University of Cambridge, UK) in the study of broadband CCD imaging and near–infrared J and K imaging of detected emission–line galaxies. These data have provided a wealth of information on the present and past star formation in cluster galaxies, its spatial distribution, and its correlation with the properties of the galaxies and their environment.

VANSEVICIUS (National Astronomical Observatory, Tokyo, and Institute of Physics, Vilnius, Lithuania) is analyzing VATT CCD observations of the Whirlpool Galaxy, M51, made in the 7 Vilnius filters by BOYLE in January. They are attempting to determine stellar populations in M51 by analysis of precise color surface photometry.

During a working visit by MAGALHAES (Institute of Astronomy and Geophysics, University of São Paulo, Brazil) to Castel Gandolfo, he and COYNE furthered their plans for mapping the magnetic field over a large area in the Small Magellanic Cloud by polarization imaging of wide fields.

OMIZZOLO, in collaboration with CRISTIANI (Department of Astronomy, University of Padua), continues to study the evolution and the luminosity function of quasi–stellar objects (QSOs). One of the strongest pieces of evidence for an evolving universe has long been the observed evolution of the quasar population in co–moving space density. A statistically well defined sample of very bright QSOs is needed to remove the present uncertainties about the properties of the local QSO population. In this way it may be possible to disentangle the QSO evolutionary pattern. This may permit a determination of the fraction of radio–loud objects and of the optical to X–ray luminosity ratio. Some of these objects may be evolving in different ways, due possibly to different types of QSO hosts. A number of databases have been used to select candidates that will provide the high level of completeness needed to carry out a survey quickly and effectively. Such a sample should play a decisive role in determining the nature and evolution of QSOs. OMIZZOLO is studying a sample of about 800 objects, part of which are from the ROSAT catalogue of X–ray sources. With the assistance of CORBALLY, he

obtained the spectra of 43 objects in October at the 90-inch telescope of Steward Observatory on Kitt Peak; images of the same were made at the VATT on Mt. Graham. The reduction of these data and of others obtained at La Silla by CRISTIANI is proceeding in Padua, Italy, and at Garching, Germany.

FUNES (University of Padua), in pursuit of his doctorate, continues research on the kinematics of ionized gas in disk galaxies. From emission lines in spectra taken with the 3.6-m telescope of the European Southern Observatory as well as from images in H-alpha taken at the VATT of a sample of early-type disk galaxies, it was shown that there is a possibility of detecting the presence of Keplerian gaseous disks using properly equipped, optical ground-based telescopes. The peculiar bidimensional shape of the emission lines was modeled as being due to the motion of a gaseous disk rotating in the combined potential of a central pointlike mass and of an extended stellar disk. The mass of the central black-hole candidate has been derived.

The Galaxy and Galactic Objects

CORBALLY and GRAY (Appalachian State University, Boone, North Carolina) have introduced an extension of the MK System of spectral classification that enables the precise classification of pre-main-sequence (PMS) A-type stars, including most Herbig Ae stars. This classification scheme characterizes the star by a standard MK type, the presence and strength of emission and/or shell lines, and the strength of the Balmer decrement.

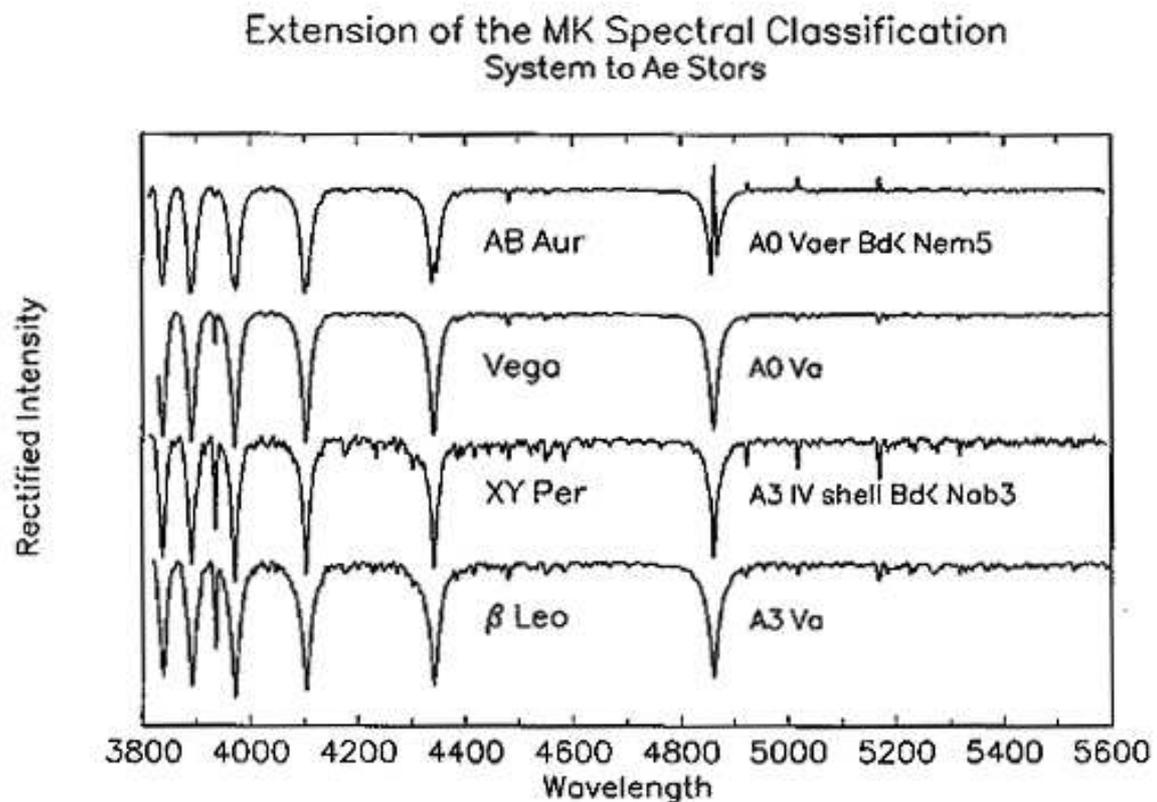


Illustration of the spectroscopic appearance of two Herbig Ae stars — AB Aur and XY Per — compared with two MK standard stars, Vega and beta Leo. Noticeable is the strong emission core in the H-beta line of XY Per. The Fe II, Ti II lines at wavelength 4923, 5016, and 5166 are in emission in AB Aur, while they are in quite strong absorption in XY per.

They used this scheme to classify and so to follow temporal spectral changes in 38 Herbig Ae stars as well as 22 PMS stars in several young open clusters. This extended system also helped them search for lambda Bootis stars among PMS A-type stars. They found one definite lambda Bootis star among

the Ae stars, and one marginal lamda Bootis star in NGC 2264. This is not significantly different from the 2 to 3% incidence of lamda Bootis stars among field A-type stars. They were led to conclude that the lamda Bootis mechanism operates over a wide range of ages from the late-PMS phase to well into the main-sequence lifetimes of A-type stars. They have been extending this study, via spectra and Strömgren photometry, to the young open clusters h and Persei.

CORBALLY has continued to obtain spectra for a list of photometrically peculiar stars provided by STRAIZYS (Vilnius Observatory, Lithuania). Observations with the Steward Observatory's 2.3-m telescope are now complete in the region between the North American and Pelican nebulae, for the reflection nebula NGC 1333, and for the open cluster IC 348. The high S/N CCD spectra are being classified to determine the specific peculiarities of the stars (three CH stars have been identified so far) and to obtain information on the properties of the dust-cloud material in which they are embedded.

STAGG (Mount Royal College, Calgary) has reduced *UBVRI* magnitudes obtained from the VATT for several fields at the North Galactic Pole (NGP). Part of his computations used a specially written, differential corrections technique to account for variable image size from seeing effects. In a preliminary analysis of the magnitudes and colors, CORBALLY compared the data with two recent CCD studies of the NGP and selected about 10 candidate G-dwarf stars for further spectroscopic observations. GARRISON (David Dunlap Observatory, University of Toronto) and RUEGER (Diocese of Brooklyn) are collaborating in this project.

ABT (National Optical Astronomical Observatories, Tucson) and CORBALLY are preparing for publication a full report on the 265 candidate Trapezium systems that they have observed photometrically and spectroscopically in previous years.

BOYLE and PHILIP (Institute for Space Observations and Union College, Schenectady, New York) made CCD observations at the Vatican Advanced Technology Telescope (VATT) in March and September with the 7 filter Stromvil Photometric System on open and globular clusters for their long-term investigation of stellar populations in the galactic disk and star clusters. To calibrate these data for accurate photometry, STRAIZYS and KAZLAUSKAS (Vilnius Observatory, Vilnius, Lithuania) have provided photoelectric photometry of stars in some of their fields.

DASGUPTA and SMRIGLIO (University of Rome) are processing VATT CCD observations taken by BOYLE with the 7 Vilnius filters on the old open cluster M67 and other stellar fields.

RUEGER (Diocese of Brooklyn), in collaboration with BOYLE, is processing multicolor CCD observations of the Crab Nebula made by them at the VATT.

Planetary Sciences

Meteorite Science

Work by CONSOLMAGNO on analyzing meteorite densities and porosities continued through 1998. This included further measurements of meteorite bulk density; the collection and analysis of unpublished and literature density data; and the first attempts to understand the implication of this research on the physical history of meteorites.

Most notable among the samples measured this year was the unusual Portales Valley meteorite, which was recovered soon after it fell in New Mexico on 13 June. In collaboration with KRING, D. HILL, GLEASON, and BRITT (University of Arizona), CONSOLMAGNO measured the density of seven large pieces, ranging in mass from 73 g to 1.5 kg. Though the average density of this meteorite is similar to that of a typical H chondrite, individual pieces had densities ranging from 2.45 to 4.75 g/cm³. This unusually large range matches the observed large-scale heterogeneity in the metal content of this meteorite, indicating that it may have been heavily shocked and metamorphosed deep within its parent body.

CONSOLMAGNO and BRITT used both Vatican data and that of many other authors to construct a comprehensive computer database of meteorite densities and porosities. With these other authors,

especially PESONEN (Finnish Geological Survey) and FLYNN (SUNY Plattsburgh, New York), preparations are underway to publish this database in electronic form. In addition, the Vatican method of measuring meteorite bulk densities with glass-bead powders has been adopted by ROBINSON (Northwestern University) and others, who have consulted with the Vatican group on details of the measurement technique.

Meteorites contain minerals, like metallic iron, that may not be stable in Earth's water- and oxygen-rich atmosphere. Understanding how terrestrial conditions can weather these rocks can help correct for this weathering and make it possible to reconstruct the original structure of these meteorites. As reported in previous annual reports, work by BLAND (Open University/British Museum of Natural History) and CONSOLMAGNO suggests that the first, rapid stage of weathering proceeds by filling pore space with weathering products. This idea has now been confirmed, with the further assistance of RUSSELL (British Museum of Natural History), by examining thin sections of meteorites with different degrees of weathering using optical and electron microscopy, at magnifications of up to 1000x.

In these images, pore spaces can be easily traced out as a network of cracks only a few thousandths of a millimeter wide. As weathering proceeds, veins of material rich in iron and chlorine, but poor in nickel—as expected for weathering product—extend from nickel-iron grains into this network of cracks. Fresher meteorites have their cracks only partially filled, while older meteorites have the cracks completely filled. Future analysis will measure the volume of these veins and compare this with the measured porosities of these meteorites.

Even after correcting for weathering effects, CONSOLMAGNO, BRITT, and STOLL (Oakland, California) have noted that ordinary chondrites have generally uniform and relatively low porosity; they have begun to use these data to test various ideas for how meteorites were formed. Typical terrestrial conglomerate rocks have porosities of 30%, while meteorite porosities average only 10%. What compacted the meteorites? Impacts clearly play a major role, but laboratory results on how shock compresses rock cannot be completely reconciled with the meteorite data. An alternate theory supposes that today's meteorites originated in the cores of primordial, very large asteroids, which have since been broken up and dispersed.

Finally, the analysis at NASA Johnson Space Center, Houston, of the meteorites returned by the 1996 Antarctic Search for Meteorites (ANSMET) program, which included CONSOLMAGNO (see last year's annual report), indicates that one of the samples, EET 96008, is an extremely rare type of meteorite: it is identical in mineralogy, structure, and chemical isotope abundances to samples of the Earth's Moon that were returned by the Apollo program. It is presumed that EET 96008 was ejected by an impact from the lunar surface into an orbit that eventually carried it to Earth. EET 96008 is only the thirteenth lunar meteorite discovered.

Telescope Observations of Planetary Objects

In May RETTIG (University of Notre Dame) inaugurated the Notre Dame-VATT partnership with an observing program aimed at measuring the broad colors of Edgeworth-Kuiper Belt (EKB) Objects and the irregular moons of outer solar system planets. The EKB objects are a family of asteroid-sized objects orbiting beyond Neptune. They were first theorized to exist as far back as the 1940s by Edgeworth and Kuiper, but they have only been observed since the early 1990s. At magnitude 20 and fainter, they are in fact fainter than most Milky Way stars; it is generally agreed that detailed studies of such objects will require use of the new generation of very large telescopes, such as the Keck in Hawaii and the Large Binocular Telescope (LBT) now under construction on Mt. Graham, Arizona. However, thanks to the excellent optics of the VATT and the dark skies at its Mt. Graham site, the B, V, and R colors of objects as faint as 22nd magnitude can be obtained, allowing a preliminary survey of such objects to proceed.



Vatican Observatory astronomer Christopher Corbally, S.J. (l.) and Terrence Rettig of the University of Notre Dame at the Vatican Advanced Technology Telescope.

Joining RETTIG in this project were TEGLER (Northern Arizona University) and ROMANISHIN (University of Oklahoma), who were the first to report a separation of EKB objects into two distinct color classes, and CORBALLY and CONSOLMAGNO from the Vatican Observatory.

One strategy for understanding EKB objects is to look at Pluto and the irregular moons of the outer planets, which may represent captured EKB objects. Two such moons were recently discovered orbiting Uranus, and during the May observing run, the first set of colors for these moons were obtained. In September RETTIG and CONSOLMAGNO also obtained colors for Nereid, Neptune's irregular moon; Phoebe, the irregular moon of Saturn; and six of Jupiter's eight irregular moons.

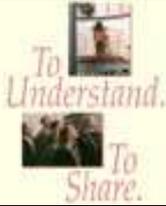
Dark, C-type asteroids (like Mathilde, imaged by the NEAR spacecraft in 1997) may be dark because they are rich in carbon, like the CM and CI class meteorites; or they may be rich in magnetite, like CV meteorites; or they may simply be ordinary chondrite material that has been blackened by shock, like many meteorites in the Vatican collection. A diagnostic test is to look for the characteristic infrared absorption features of silicates, which are present in ordinary chondrites but rarer in carbonaceous chondrites. To search for them, BRITT and CONSOLMAGNO observed several such asteroids with the NASA Infrared Telescope Facility on Mauna Kea, Hawaii, in March.

History and Philosophy of Science; Interdisciplinary Studies

CONSOLMAGNO has been involved in an evaluation of how well journalists report on science. A recent study conducted by SCHAEFER (Yale) suggests that errors in reporting may not be entirely with the reporters. Schaefer asked a number of professional astronomers (including CONSOLMAGNO) to review ten years' worth of reporting from *Sky and Telescope*, *Science News*, the *New York Times*, and other sources, centering on reports of advances in three specific areas: Mars, gamma-ray astronomy, and the Hubble Constant. His preliminary results suggest that inaccuracies in the reports, although real, are due more to the tentative nature of the material being announced to the press by the scientists, and less due to mistakes made by journalists reporting those results. A detailed analysis of this survey is being prepared for publication.

STOEGER's work on God and time has been published. He was recently engaged in working on several philosophical problems related to the mind-brain problem, in connection with the joint Vatican Observatory-Center for Theology and the Natural Sciences (Berkeley, California) workshop held on that subject in Krakow, Poland, in June. He is attempting to develop more adequate concepts of reducibility, emergence, and supervenience on the basis of differentiating between the laws of nature that we have constructed and laws of nature as they really function, that is, the regularities, processes, and relationships that really obtain in reality. This is also intimately connected with how one conceives the soul in a way that has definite, scientifically accessible correlates but which inevitably transcends any adequate scientific description.

STOEGER has also been involved in a project on eschatology and the natural sciences with the Center of Theological Inquiry (Princeton, New Jersey), and he continues to pursue work on articulating the issues and the resolution of the issues in that area. He has been focusing on the scientific accounts of life–ending or culture–ending catastrophes and of death as a biological phenomenon; on the impact that these accounts, along with scientific knowledge in general, has on culture and values; and the response that Christian theology can give to them.



Instrumentation and Technical Services

Cover

Instrumentation, Technical Services, and Meteorite Curation

CROMWELL, as Project Scientist of the Vatican Advanced Technology Telescope (VATT), provided scientific, technical, and managerial guidance in the activities reported below. NELSON, as on-site assistant staff scientist, took the lead in many of the developments. Contributions came from many members of the Steward Observatory Technical Division, directed by DeRIGNE, especially from BRAR, WILSON, SCHALLER and HARVEY; from Vatican Observatory scientists BOYLE and CORBALLY; and from the Mt. Graham International Observatory (MGIO) staff, directed by RATJE. The VATT was scheduled on a regular basis during the past year for astronomical research. For long-exposure, direct images, image quality was typically better than 1.5 arcsec fwhm, and under the best conditions, 0.7 arcsec, using three different methods: unguided, manually guided, and—most recently—autoguided. Enhanced performance is expected when the thermal environment of the dome is improved, and autofocus and autocollimation are implemented. Major achievements this year include revamping of the secondary-mirror positioner; fine tuning of the primary-mirror side supports to promote stable optical alignment; and development of laser methods and imaging tests for critical mechanical and optical alignment.

BOYLE, as Telescope Scientist of the VATT, trained new observers in its operation. They included: RETTIG, RHIE, and KING (University of Notre Dame, Physics Department); UGLESICH (Columbia University, New York); BURG (Arizona State University); FUNES (University of Padua, Italy); and MCINTOSH (University of Arizona).

CORBALLY used the help of CLARK (London, England) to format the home page of the World Wide Web site of the Vatican Observatory (<http://clavius.as.arizona.edu/vo>) into HTML frames. A newly installed "hit" counter shows that the site has been visited, on average, 150 times per day since late August.

BOYLE and ROSSI installed three new Pentium PC computers at Castel Gandolfo. These are networked locally and are now running LINUX/IRAF version 2.11 or Windows NT. The Vatican Internet Office is increasing the speed of the microwave link to 128 kbps. The Observatory acquired an HP OfficeJet Pro 1150C color printer from the International Center of Relativistic Astrophysics, through the courtesy of RUFFINI (Institute of Physics, University of Rome).

Thanks to the generosity of a freelance gold prospector in Arizona, the Vatican meteorite collection now has several samples of the newly discovered Gold Basin meteorite. John BLENNERT and a colleague discovered a collection of meteorites scattered across the desert while searching for gold in northern Arizona. These meteorites may have been lying on the ground, relatively untouched, for hundreds of years. It is the first "fossil" field of meteorites found outside of Antarctica. Their samples were identified as meteorites by KRING (University of Arizona), who put BLENNERT in touch with the Vatican Observatory. In July BLENNERT donated four pieces to the Observatory.

During the past year negotiations were begun with EHLMANN, curator of the Monnig Meteorite Collection at Texas Christian University (TCU) in Fort Worth, Texas, to arrange for a trade of meteorites. As a result six samples from the Vatican collection (all of them meteorites for which there are multiple samples) were traded to TCU for six meteorites new to the Vatican collection. They are the ordinary chondrites known as Atoka, Julesburg, Kendleton, Leedey, Richardton, and Saratov, as well as a large, etched slice of the iron meteorite known as Glen Rose. The latter is now on display in the meteorite collection at Castel Gandolfo.

Meteorites from the Vatican collection were used by BONINO (University of Turin) for studies of

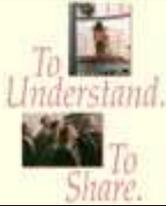
magnetic remanence and solar–system magnetic fields, and by KITTS and FEGLEY (Washington University, St. Louis) for studies of trace elements in basaltic achondrites.

As part of an ongoing effort to make its collection more accessible to researchers worldwide, the Vatican Observatory has begun to prepare microscope thin sections of its more unusual and rare holdings. These sections will also make it possible for Vatican researchers to analyze these samples with the sophisticated (and very expensive) equipment found in other laboratories around the world.

These thin sections, which are 10–micrometer–thin slices of a sample mounted on a microscope slide, can be transported far more easily and more safely than larger samples. With them, researchers do optical microscopy as well as electron microscope and microprobe analysis of the mineralogical and chemical nature of the samples. Such analysis provides a detailed history of the rock. It also has the advantage of being essentially nondestructive.

The thin sections are being prepared in the laboratory of the British Museum of Natural History, London, with the assistance of GRADY, curator of meteorites there. Two slides are being made from each sample: one for the Vatican Observatory, and the other for the British Museum of Natural History in payment for their work. To date, fifteen meteorite samples have had thin sections prepared. These new slides have been added to the dozen very old ones already in the Vatican collection.

A new system for sorting and storing the Vatican meteorite collection was installed this past year. Each sample is now kept in an individual container, labeled according to the information in the new computer database (as described in previous annual reports). During this installation, a new inventory of the meteorites was done, so that the computer database has now been directly compared against the samples physically present. Work has also begun on the much larger task of entering complete descriptions of each sample into the database. With a collection of over one thousand samples, this is a long–term project. The eventual goal is to produce a new, more complete catalog of the collection, including an on–line version for the use of other researchers worldwide.



Observatory and Staff Activities

Cover

Conferences

Together with the Center for Theology and the Natural Sciences, Berkeley, California, the Vatican Observatory held the fourth in the series of research conferences that the two institutions are organizing on the theme of "Scientific Perspectives on Divine Action." The meeting, held in Pasierbiec, Poland, from 21–27 June, dealt with the topic: *Brain and Mind: Neuro-Biology and Brain Research*. HELLER chaired the local organizing committee, and STOEGER served on the scientific organizing committee. COYNE and CORBALLY also participated in the meeting.

A working group on the Church and Science was organized by the Observatory at Castel Gandolfo 12–18 September. Seven scholars in the history and philosophy of science gathered to evaluate the outcome of the Church's recent activities toward a dialogue with modern science. Special emphasis was given to the work of the Galileo Commission, constituted by John Paul II in 1981 and terminated in 1992.

Under the leadership of IMPEY (Steward Observatory, University of Arizona), alumni from all of the six Vatican Observatory Summer Schools, which have been held since 1986, were invited to participate in an International Symposium on Astrophysics Research and Science Education held 14–21 June at Rocca di Papa (Rome), Italy.

Participants at the International Symposium on Astrophysics and Science Education relax in Castel gandolfo's piazza.



Eighty participants from thirty-three different countries attended. Over the past decade, the Vatican Observatory Summer Schools have helped to create a worldwide community of young scholars in astronomy and astrophysics. Their research extends over a wide range, from the discovery of extraterrestrial solar systems to exploring the question of whether the universe is open or closed. Many of these former students have become recognized experts in their fields, and the symposium provided an opportunity for them to share their research results with one another. The meeting also addressed the concerns and issues of science education around the world. Group discussions were held on the particular problems of research and education in developing countries, on strategies for encouraging women into science, and on ways to facilitate international collaborations. The proceedings of the symposium are being prepared for publication.

The Observatory is organizing an international conference on "Galaxy Disks and Disk Galaxies" to be held 12–16 June, 2000, at the Pontifical Gregorian University, Rome. The scientific organizing committee is being cochaired by BERTOLA (Department of Astronomy, University of Padua, Italy) and

RUBIN (Department of Terrestrial Magnetism, Carnegie Institution of Washington, USA). Members of the local organizing committee include COYNE and OMIZZOLO along with CORSINI and FUNES (Department of Astronomy, University of Padua, Italy).

An official invitation has been extended by the Observatory to the Meteoritical Society, the premier international organization dedicated to the study of meteorites, to hold its 64th annual meeting in September 2001 at the Pontifical Gregorian University, Rome. The Society accepted this invitation at its annual meeting in Dublin, and preparations for the meeting have begun. CONSOLMAGNO will serve as the chair of the local organizing committee, assisted by COYNE and MAFFEO.

The Observatory will be a co-host of the 1999 annual meeting of the Division for Planetary Sciences of the American Astronomical Society, to be held in Padua, Italy, under the chairmanship of BIANCHINI (University of Padua.) CONSOLMAGNO has been appointed chair of the program committee.

Through the efforts of MAFFEO, the Observatory continues to collaborate with the Golden Age University of Ariccia, Italy, in the presentation of lectures on astronomy. In addition to MAFFEO, CASANOVAS, CONSOLMAGNO, COYNE, and OMIZZOLO have given lectures.

Presentations and Academic Activities

CASANOVAS 27 March gave a seminar at the University of Campobasso, Italy, on "Mathematics in Early Astronomy." Presented a paper on "Riccioli and Kepler" at the international meeting held 15–16 October at Ferrara to celebrate the 400th anniversary of Riccioli's birth, and served on the scientific organizing committee for this meeting.

CONSOLMAGNO Presented a talk 12 February on meteorite densities and porosities, and their implications for asteroid structure, to the weekly Asteroid, Comets, and Meteorites luncheon seminar sponsored by Steward Observatory and the Lunar and Planetary Laboratory at the University of Arizona, and by the National Optical Astronomy Observatories (NOAO). Gave a talk on meteorite and asteroid densities and structure on 4 March at the University of Hawaii Institute for Geophysics and Planetology. During that visit he consulted with BELL and KEIL (University of Hawaii) and GRADIE (TerraSystems, Inc.). On 15 April presented a slide show, "Visitors to An Alien World: Searching for Meteorites in Antarctica," at the weekly physics seminar of the Fermi National Accelerator Laboratory in Batavia, Illinois. Presented a paper at the inaugural internal seminar of the Lunar and Planetary Laboratory of the University of Arizona, 18–20 May. 1–3 December presented his work on meteorite densities and structure and participated in discussions with STRAZZULLA (Astrophysical Observatory of Catania, Italy) and his group, which does laboratory experiments concerning the effects of radiation damage on materials in space. Paid a working visit 14–17 May to Oakland, California, to discuss with STOLL their work on meteorite porosity and structure.

Appointed in the spring to the program committee of the 1998 Division for Planetary Sciences meeting in Madison, Wisconsin; he was named chair of that committee for the following year's meeting in Padua, Italy. Traveled to Madison on 15 August for a meeting of the 1998 committee; hosted a meeting in July at Castel Gandolfo with members of the 1999 organizing committee; and traveled to Turin and Padua in November to meet further with the organizing committee. The visit to Turin also provided an opportunity to meet with colleagues at the University of Turin, including BONINO and TANGA.

In June, July, and November, made three working visits to the meteorite collection at the British Museum of Natural History (BMNH), London, as part of an ongoing collaboration. The last trip was coupled to a visit 9 November to the Open University in Milton Keynes, where he was hosted by FRANKI and PILLINGER, and gave the presentation "Meteorite Porosities and Asteroids Structure" to the Planetary Sciences Research Laboratory. Work at the meteorite collection included preparation of thin sections with GRADY (BMNH); examination of those thin sections with an optical microscope and scanning electron microscope with RUSSELL (BMNH); and investigation of weathering of meteorites in collaboration with BLAND (Open University/BMNH).

CORBALLY Continues to serve on the Council of the Institute on Religion in an Age of Science and was reappointed to Vice President for Science. He attended council meetings in January in Boston, and in July in Portsmouth, New Hampshire. He was a responder at the Tallahassee Winter Templeton

Course Program Conference, 2–6 January, and led a discussion on "Divine Action in the Evolution of the Universe and of Life."

14–18 April paid a working visit to the Department of Physics and Astronomy, Appalachian State University. Participated in the consultation of the International Astronomical Union's Working Group on Spectroscopic Data Archives, held at l'Observatoire de Haute Provence, France, 1–3 October. In May was a member of the preliminary oral examination committee for Jian Liu, Steward Observatory, University of Arizona.

COYNE On the occasion of the plenary session of the Pontifical Academy of Sciences, attended a reception held 26 October at the residence of the Ambassador to the Holy See from the United States to honor personnel from NASA participating in the Academy meetings, including Dr. Jeffrey A. Hoffman, astronaut and NASA European representative. As a member of the Council of the Pontifical Academy of Sciences, attended Council meetings on 25 May and 1 September.

17–18 February participated in the meeting, held at Stanford University, of the Governing Board of the International Center for Relativistic Astrophysics (ICRA), of which the Observatory is a member. On 2 July attended the inauguration of the new international coordinating center of ICRA at Pescara, Italy. He also participated on 27 May at the Council Meeting of the Pontifical Commission for Vatican City; MAFFEO represented the Observatory at the Council Meeting of 5 November. Became a corresponding member of the Geymonat Institute for the History and Philosophy of Science, Milan. On 30 April attended the awards program of The Franklin Institute, Philadelphia.

HELLER Presented a paper on "The Human Person and the Space of Dialogue between Science and Theology" at the 7th European Conference on Science and Theology on "The Person: Perspectives from Science and Theology," held 31 March–5 April at Durham, UK. At the conference on "Particles, Fields and Gravitation" held 15–19 April at Lodz, Poland, he presented a paper, "Einstein–Podolsky–Rosen Experiment from Noncommutative Geometry." At the 5th Krakow Methodological Conference, "Unity of Science–Unity of the World?" held 6–8 May in Krakow, he presented a paper, "Beauty as a Criterion of Truth."

STOEGER During the fall semester at the University of Arizona team–taught, with COCKE, the graduate course in general relativity in the Department of Astronomy; he presented the component on cosmology. During the same semester he participated in and gave four class lectures for the course "Science and Theology" taught by LINDELL in the Department of Molecular and Cellular Biology.

Participated in and often gave talks during the informal working seminar each week on quantum field theory run by JUST in the Department of Physics.

Served as principal host, on behalf of the Catholic Newman Center and the St. Albert the Great Forum, of the Rev. Dr. Arthur R. PEACOCKE, S.O.Sc., of the Ian Ramsey Centre, Oxford, UK, 23–26 January. On 23 January PEACOCKE delivered a Sir John Templeton Lecture, "Welcoming the Disguised Friend: Darwin and Divinity," as part of the Forum Program at the Newman Center. The next morning PEACOCKE joined the campus community for an ecumenical service at the Campus Christian Center, followed by brunch. This event was co–sponsored by Campus Christian Center and the Catholic Newman Center with Templeton Foundation support. Stoeger was chairperson of the organizing committee.

2–4 February was hosted by ZOTOV for a visit to the Physics and Mathematics Departments and the Catholic Newman Center at Louisiana Tech University. He delivered an evening lecture at the Newman Center on "Science, the Laws of Nature and Divine Action," as part of the Science and Theology Forum there. He also gave a colloquium on "Zeroing in the Cosmological Constant" to the Physics and Mathematics Departments.

Attended working meetings 20–24 February and 29 October–1 November on the Eschatology and Science project initiated by the Center of Theological Inquiry in Princeton, New Jersey. Spent the month of April on a working visit to the Department of Mathematics, University of Brasilia, Brazil, and while there worked with ARAUJO on completion of analysis of the exact spherical symmetric Einstein field equations in observational coordinates with data functions. He also continued work on several other related theoretical projects in observational cosmology.

11–14 June attended the Catholic Theological Society of America annual meeting in Ottawa, Ontario. He organized and chaired the parallel session on "Theology and the Natural Sciences" that focused on "The Johnson–Bracken Exchange. Searching for Metaphysics Adequate to Our Evolutionary Universe." He also gave a short presentation on the relevant scientific background to that discussion. In another parallel session gave one of two presentations on "Teleology in Science." 18–21 June attended a conference on research in science and theology at the University in Heidelberg, Germany. He gave a talk on the programs of the Vatican Observatory and the Center for Theology and the Natural Sciences in this area.

Continues to serve on the Boards of the Center for Theology and the Natural Sciences, and of the St. Albert the Great Forum at the Catholic Newman Center, University of Arizona. Continues as the principal editor for the series *Philosophy in Science*, published by Pachart Press, Tucson, Arizona.

WHITMAN The principal forum for his research is the Clavius Group of Mathematicians, which he co–founded in 1963 as a faith community of mathematicians. It has met every summer for six weeks for thirty–six consecutive years, and currently has a membership of twenty–four mathematicians. During the summer the Group met at Fairfield University in Connecticut and explored the following topics: Finite Automata and Regular Languages, Turing Machines and the Undecidability of the Halting Problem, Computational Geometry, A Hierarchy of Programming Languages, Seiberg–Witten Invariants for Smooth 4–Manifolds, Clifford Algebras, and Isoperimetric Hypersurfaces. He gave two lectures on "From Lie Groups to Lie Algebras" during a seminar on the "Representation Theory of Lie Algebras." STOEGER participated for one week in the Clavius Group meetings.

On 14 and 15 November he attended the regional meeting of the American Mathematical Society, which met at the University of Arizona in Tucson. During the year completed the TEXing of his notes on a visual approach to the first–year calculus using the software package *Mathematica*.

Public and Educational Outreach

NEWS MEDIA COVERAGE The Vatican Observatory was featured in several popular publications during 1998. The cover article for an issue of *Newsweek* highlighted the work of STOEGER with the CTNS, Berkeley. CORBALLY and CONSOLMAGNO were featured in an article about the Observatory in the December issue of *Astronomy*. A special issue of the National Space Society magazine, *Ad Astra*, dedicated to religion and astronomy ran an article by CONSOLMAGNO. CORBALLY, FUNES, and OMIZZOLO were featured in a story in the *Sunday Telegraph* of London.

CONSOLMAGNO Participated in the Chicago–area science/science fiction convention, Capricorn, 6–7 February. He gave presentations on the utilization of asteroid resources and the development of scientific theories for life in the oceans of Europa. He also served on panels discussing K–12 science education and the recent results from the Mars Pathfinder mission, and set up a display room of 3–D Pathfinder wall posters, loaned by BRITT (University of Arizona).

Public speaking engagements: 9 March, to the Serra Club of Tucson, a group of laymen dedicated to furthering vocations to religious life, about his experiences as a Jesuit brother and his work as a scientist in Antarctica. 11 March, a presentation to the Women's Club of St. Raphael Parish (Englewood, Florida) on "The Vatican Observatory, Science and the Church." 16 May, appeared in the San Francisco–Berkeley area on the live radio show *West Coast Live*, hosted by Sedge Thomson, to discuss his work at the Vatican Observatory.

At the annual Space Development Congress of the National Space Society (an organization of advanced amateur and semiprofessional space enthusiasts), 22–23 May in Milwaukee, gave invited papers on scientific theories for oceans and life on Jupiter's moon Europa; asteroid structure and its implications for space utilization; and his experiences collecting meteorites in Antarctica. On 4 September, spoke to the Tucson Amateur Astronomy Association on "Visitors of Another Planet: Searching for Meteorites in Antarctica." Invited to speak on 4 October at the monthly meeting of the student Space Development Society of the University of Illinois, Champaign–Urbana, where he described the evolution of theories for the presence of liquid, and possibly life, in the interior of Jupiter's moon Europa.

7 October, presented the talk, "Are Asteroids Fluffy?" to the weekly lunchtime seminar of the Adler

Planetarium in Chicago. As a member of a panel advising on the continued expansion and renovations to the Planetary Science exhibit hall at the Adler, he spent the remainder of the day consulting with FORTSON and WOLF-CHASE (Adler Planetarium and University of Chicago). Invited guest lecturer 16 October to the Philosophy 101 class at the University of Scranton where he spoke on the shared common roots and search for truth in science, theology, and philosophy.

His book *The Way to the Dwelling of Light: How Physics Illuminates Creation* (see sec. IV, Publications) was published in the fall by the Vatican Observatory. It presents an informal description of modern physics for a lay audience of religious believers. He is author of one chapter, coauthor of a second, and served as an advisor for two other chapters in *The Impact Book*, which is being prepared for publication in 1999 by McGraw-Hill in response to the premature and inaccurate announcement during the summer of a near-Earth asteroid on a possible collision course with Earth. That news and the release of two major Hollywood movies about the threat of asteroid or comet impacts renewed public interest in the subject matter. The book, which is geared to a general audience and explains the science behind the impact hazard, is edited by SUMNERS (Houston Museum of Science) and C. and J. ALLEN (Johnson Space Center, Houston), and will contain nine chapters written by experts in the field of small solar-system bodies.

Turn Left at Orion, his popular how-to-use-a-telescope book written with DAVIS (State University of New York Stony Brook), continued to sell strongly. It reached the top five best sellers of astronomy books for the Internet bookseller Amazon.com, and accounted for a significant fraction of all sales of astronomy books issued by Cambridge University Press. While working in London in November, he traveled to Cambridge to consult with MITTON (Cambridge University Press) to arrange final details of their plans to expand the text and accelerate production of a third edition of this book. Delivery of the text is expected in June 1999, with a probable publication date of spring 2000.

CORBALLY In May, attended the annual meeting of Discovery Park in Safford, Arizona, and saw the newly opened wildlife habitat called "Nature's Hideaway" and the railroad. On 27 October, visited the Newman Center at Eastern Arizona College, Thatcher, and later helped guide students and faculty from the college on their visit to the Mount Graham International Observatory. He hosted several other groups visiting MGIO throughout the year.

Talks: "The Universe: From Its Past to Our Prospects," at Eastern Arizona College to the Arizona Board of Advisers on 6 February, and to Sigma Xi Society at Boone, NC, on 17 April; on that same day a talk to the Physics and Astronomy departmental seminar at Appalachian State University on the "New Vatican Telescope"; 11 June, a breakfast meeting talk on the Vatican Observatory to the St. Thomas More Society, Tucson; 30 October, "The Vatican Observatory in Arizona," a presentation to the Jesuit Alumni of Arizona at Brophy College, Phoenix, following an introduction by Brendan Thomson on the history of the calendar.

Provided interviews to the following journalists: Jonathan Leake, *The Sunday Times*, London; Tim Jenkins, *Radio Ulster*, Belfast; Lyle Schnably, of Videoworkshop, who is preparing brief, science topics for *Discovery Channel*. Hosted various news media representatives interested in visiting the VATT, including Tony Ortega, writing for *Astronomy* magazine, and Ian Parker, *Sunday Telegraph Magazine*, London. Helped the following journalists: Edwin Aguire, *Sky & Telescope*, with a News Note on galaxies observed with the VATT (appeared in the April 1998 issue); Alison Rose, Grimthorpe Film, with a proposal for a video documentary on the Vatican Observatory; Lyle Jackson, *News Odyssey*; Shankar Vedantam, *Philadelphia Enquirer*; and Jan Ferris, *Sacramento Bee*.

COYNE Provided interviews to: Jane Little of BBC Radio; Raymond Arroyo and Gary Gagnon of EWTN News, USA; Brian Healy and Rita Braver of *CBS Sunday Morning*; Ian Johnston, Australian National Radio Program 3, *The Clockmaker's Handiwork*; Luigi dell'Aglio, *AVVENIRE*, Rome and Milan, Italy; Andy Papadopoulos, Film Ross, Los Angeles. Featured in the PBS program *Faith and Reason*, produced by New River Media under the direction of Margaret Wertheim and shown throughout the United States in September.

Lectures: 10-11 March, at the University of Kansas, Lawrence, "Cataclysmic Variable Stars," to the Physics Department; "Galileo, The Right to Think," to the course in European History; and "The Evolving Universe," a public lecture; on 12 March, the Templeton Lecture on "Scientific Evidence for Habitable Extra-Solar Planets: A Challenge for Religious Thought," at St. John's University, Queens,

New York; on 25 March, "Astronomy at the Vatican Observatory," to the Lecture Series of St. Francis in the Valley Episcopal Church, Green Valley, Arizona; also on 25 March, "Life in the Universe," to the Community School of Naples, Florida, during its visit to Tucson; 2–4 April, at Purdue University, Indiana, "The Emergence of Life in Cosmic Evolution," a public lecture, and "The Search for Proto-Planetary Disks," to the Physics Department; on 14 April, "Next Generation Telescopes," to the Engineer Associates of Arizona, Tucson; on 20 May, "Polarimetric Search for Planetary Disks," to the Hipparchus Group of Amateur Astronomers, Rome; on 28 May, "Birth and Death of Stars," to the Swiss Italian Electricity Board, Lugano, Switzerland; on 20 June, "Sustainable Human Development in an Evolving Universe," to the International Council of Human Duties, Trieste, Italy; on 28 September, "Modern Research in Astrophysics at the Vatican Observatory," to the friends of Cardinal Francis George, Chicago, and on 13 October to the friends of Sir Daniel Donohue, Los Angeles; on 8 October, "Stars, Galaxies and Us," to the Sun City Astronomy Club, Tucson; on 29 October, "The God of the Cosmologists," to the *Cattedra dei Non-Credenti* sponsored by Cardinal Carlo Maria Martini, Milan; on 30 October, "The Physical Conditions for the Origin of Life," to the Cultural Center S. Omobono, Cremona, Italy; on 19 November, "Life as a Cosmic Imperative," Rimes Lecture in Science, Spring Hill College, Mobile, Alabama; 21–24 November, "Possible ETs and Religion," to the Templeton Foundation Meeting on "Many Worlds: The New Universe and Its Implications for Theology," Lyford Cay, Nassau, Bahamas; and on 14 December, "The Evolving Universe," to the Amateur Astronomers' Association, Trieste and Mestre, Italy.

MAFFEO Gave an interview to Letizia Davoli, Alessandro Vittori, and Domenico Marzini of SAT 2000 TV, Italy.

STOEGER Visited St. Norbert College, DePere, Wisconsin, 19–21 March, to deliver a Templeton Lecture on science and religion; he also taught several classes while there and delivered a breakfast lecture on his personal experience as a priest and a cosmologist. 19 May, gave a lecture on cosmology, "How Did It All Begin," to participants at the Smithsonian Associates New Astronomies seminar at the Arizona Inn on 13 March, visited Loreto Catholic Elementary School, Douglas, Arizona, to celebrate Mass for the students there and to speak to the classes about astronomy and religion.

7–10 June, gave an invited paper, "Is There Common Ground in the Practice and Experience of Science and Religion" at the Science and the Spiritual Quest Conference, held at the University of California, Berkeley. 25 October, gave a lecture on "Science and Religion" at the Community Christian Church, Green Valley, Arizona. 18 November, gave a St. Albert Forum presentation on "The Mind-Brain Problem."

WHITMAN Continues to prepare the Annual Financial Report for the Centro Social Presidente Kennedy of Campinas, São Paulo, Brazil. This necessitated a month's visit to Brazil in March. In this way, the Vatican Observatory contributes to the justice and peace mission of the Church in the Third World.

International Meetings

During 1998 representatives of the Vatican Observatory took part in the following international meetings:

6–10 January: Washington, DC. 189th Meeting of the American Astronomical Society. CHRISTOPHER CORBALLY, S.J. coauthored a paper; RICHARD BOYLE, S.J. participated.

25–27 February: Havana, Cuba. Second Congress of the Cuban Society for History and Technology. JUAN CASANOVAS, S.J. gave a paper.

12–13 March: Tucson, Arizona. 1998 Steward Observatory Internal Symposium. CHRISTOPHER CORBALLY, S.J. gave a paper.

16–20 March: Houston, Texas. 29th Lunar and Planetary Science Conference. GUY J. CONSOLMAGNO, S.J. presented a paper and coauthored another.

31 March–5 April: Durham, England. Seventh European Conference on Science and Theology. CHRISTOPHER CORBALLY, S.J. gave a paper and moderated a workshop; MICHAEL HELLER

presented a paper.

27–30 April: Palermo, Italy. Italian Astronomical Society. JUAN CASANOVAS, S.J. participated.

16–17 May: Tucson, Arizona. Tenth Annual Meeting of the International Dark–Sky Association. CHRISTOPHER CORBALLY, S.J. participated.

15–20 June: Rocca di Papa (Rome), Italy. International Symposium on Astrophysics Research and Science Education. RICHARD BOYLE, S.J., GUY CONSOLMAGNO, S.J., CHRISTOPHER CORBALLY, S.J., GEORGE COYNE, S.J., and WILLIAM STOEGER, S.J. participated.

21–27 June. Pasierbiec, Poland. Divine Action Workshop on "Cognition and Neuroscience." CHRISTOPHER CORBALLY, S.J. participated; GEORGE COYNE, S.J. organized; MICHAEL HELLER headed the local organization for the meeting; WILLIAM STOEGER, S.J. gave a paper and served on the scientific organizing committee.

25 July–1 August: Star Island, New Hampshire. Annual Conference of the Institute on Religion in an Age of Science. CHRISTOPHER CORBALLY, S.J. participated and attended the IRAS Council meetings.

26–31 July: Dublin, Ireland. 61st Annual Meeting of the Meteoritical Society. GUY J. CONSOLMAGNO, S.J. presented a paper.

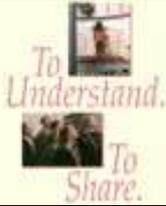
21–25 September: Paris, France. Les Rencontres de l'Observatoire, Meudon 1998, on "Galaxy Evolution". CHRISTOPHER CORBALLY, S.J. gave a paper.

11–15 October: Madison, Wisconsin. Annual Meeting, Division for Planetary Sciences, American Astronomical Society. GUY J. CONSOLMAGNO, S.J. served on the program committee and presented a paper.

15–16 October: Ferrara, Italy. Riccioli and the Scientific Achievements of the Jesuits in the Period of the Baroque. JUAN CASANOVAS, S.J. served on the scientific organizing committee and gave a paper.

26–29 October: Vatican City. Plenary Session of the Pontifical Academy of Sciences: "Changing Concepts of Nature at the Turn of the Millennium." GEORGE V. COYNE, S.J. and MICHAEL HELLER participated.

2–5 November: Garching, Germany. ESO Workshop on Minor Bodies in the Outer Solar System. GUY J. CONSOLMAGNO, S.J. participated.



Publications

Cover

Publications

(The names of Vatican Observatory staff and visiting astronomers are noted in boldface.)

ABT, H. .A., and **CORBALLY**, C. J. "The Maximum Ages of Trapezium Systems," 1997, in *Visual Double Stars: Formation, Dynamics and Evolutionary Tracks*, ed. J. A. Docobo et al., Ap&SS (Conf. Ser.) (Dordrecht: Kluwer), 127–131

ARAUJO, M. E., and **STOEGER**, W. R. "The Exact Spherically Symmetric Solution of the Field Equations in Observational Coordinates with Cosmological Data Function," 1998, *Classical and Quantum Gravity*, submitted

BENNETT, S. M., and **MOSS**, C. "H-alpha Objective Prism Survey of Abell 1060," 1998, *A&AS*, 132, 55

BERTOLA, F., CAPPELLARI, M., FUNES, J. G., CORSINI, E. M., PIZZELLA, A., and VEGA BELTRAN, J. C. "Circumnuclear Keplerian Disks in Galaxies," 1998, *ApJ*, 509, L93

BOYLE, R. P., KAZLAUSKAS, A., VANSEVICIUS, V., STRAIZYS, V., VRBA, F. J., SUDZIUS, J., and SMRIGLIO, F. "CCD Photometry of the M 67 Cluster in the Vilnius Photometric System," 1998, *Baltic Astron.*, 7, 369–391

BRITT, D. T., and **CONSOLMAGNO**, G. J. "Dark Asteroids and Dark Meteorite Densities," 1998, *Lunar Science XXIX*, 1577–1578

CONSOLMAGNO, G. J. "Stargate," 1997, *COMPANY*, 15, 3–6

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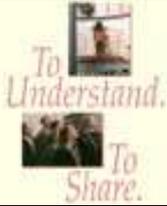
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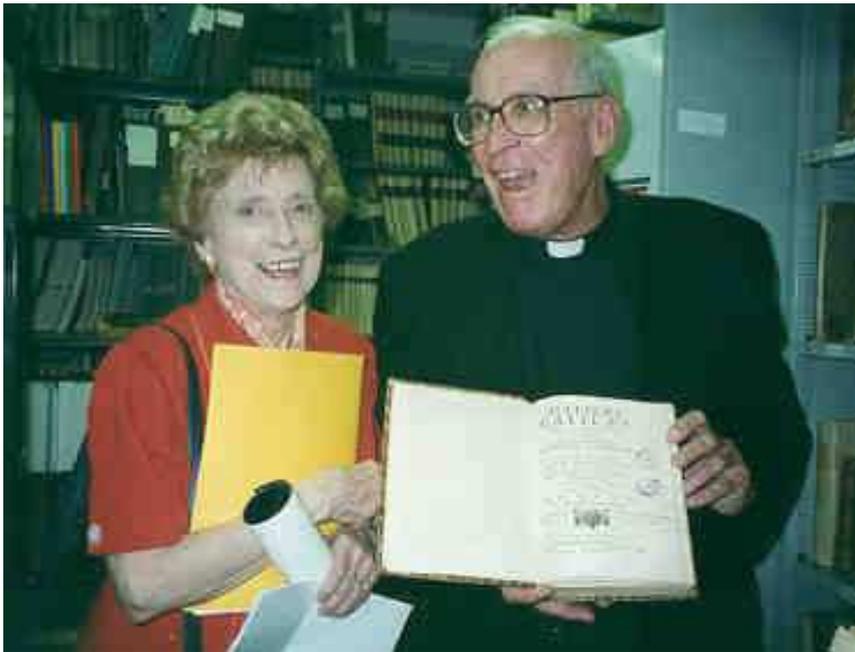


Observatory Visitors

Cover

Observatory Visitors

The Vatican Observatory in Castel Gandolfo, Italy, and the Vatican Observatory Research Group in Tucson, Arizona, hosted a number of visitors during 1998.



George Coyne, S.J., shows Ambassador Corinne Boggs an early edition of Galileo's "Dialogue," one of the volumes in the rare book collection of the Vatican Observatory at Castel Gandolfo. (Photo by Yvonne Thayer)

In May MAFFEO hosted a visit by the faculty and staff of the Pontifical Lateran University of Rome. He also hosted a visit in April by the Board of Directors of the Dan Murphy Foundation of Los Angeles. In August COYNE received the Ambassador to the Holy See from the United States, Mrs. Corinne C. Boggs, who was accompanied by Ms. Yvonne F. Thayer, Chargé d'Affaires; Senator Barbara A. Mikuski, United States Senator from Maryland; and Mr. A. Reynolds, Scientific Attaché, Embassy of the United States to the Italian Republic. On 11 December COYNE received the Ambassador to the Holy See from Iran, Mr. Mohammad Hadi Abd Khoda'i, who was accompanied by the Scientific Attaché, Mr. Hamid Monajemi, and several astrophysicists from Shiraz University. On 18 May COYNE received a group from the Papal Foundation for a visit organized by Paul HENKELS, who serves on the Vatican Observatory Foundation Board.

Some 2,000 people, especially with school groups, visited the Observatory at Castel Gandolfo under the guidance of MAFFEO.

The following individuals paid extended working visits to the Observatory:

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

PIOTR FLIN, Pontifical Theological Academy, Krakow, Poland

JOSÉ FUNES, S.J., Astronomical Observatory of Padua, Italy

JEAN-BAPTISTE KIKWAYA ELUO, S.J., Congo

A. M. MAGALHAES, Institute of Astronomy and Geophysics, University of São Paulo, Brazil

PIERO RAFANELLI, Astronomical Observatory of Padua, Italy

GOTTARD RICHTER, Astrophysical Institute, Potsdam, Germany

The following made occasional working visits to the Observatory:

AJOY K. DASGUPTA, Institute of Astronomy, University of Rome "La Sapienza," Rome, Italy; and South Glamorgan Education Department, Cardiff, UK

FILIPPO SMRIGLIO, Institute of Astronomy, University of Rome "La Sapienza," Rome, Italy

ROBERT UGLESICH, Department of Astronomy, Columbia University, New York, USA

Among other professional guests of the Observatory during the year were: *Gianandrea Bianchini*, University of Padua, Padua, Italy; *Claudio Casacci*, Alenia, Turin, Italy; *Bruno Coppi*, Massachusetts Institute of Technology; *Charles L. Currie, S.J.*, President of the Association of Jesuit Colleges and Universities, USA; *Rick Hill*, University of Arizona; *V. Keilis-Borok*, Russian Academy of Sciences; *Jonathan Lunine*, University of Arizona; *Terry Rettig*, *Sun Hong Rhie*, *Lindsay King*, University of Notre Dame; *William Romanishin*, University of Oklahoma; *Eileen Ryan*, Planetary Science Institute, Tucson, Arizona; *William Ryan*, Eastern Arizona College, Safford, Arizona; *Martha Schaefer*, Yale University; *Roberto Somma*, Alenia, Rome, Italy; *Piero Todesco*, University of Bologna, Italy; *Stephen Tegler*, Northern Arizona University.

The following participated in the Working Group on the Church and Science (see sec. III, Observatory Conferences): *Ugo Baldini*, University of Padua, Italy; *Richard J. Blackwell*, Department of Philosophy, St. Louis University, USA; *Annibale Fantoli*, University of Victoria, Victoria, British Columbia, Canada; *Paolo Maffei*, University of Perugia, Italy; *Ernan McMullin*, Program in the History and Philosophy of Science, University of Notre Dame, Indiana; *Michael Segre*, Institut für Geschichte der Naturwissenschaften, Ludwig Maximilian Universität, Germany.

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