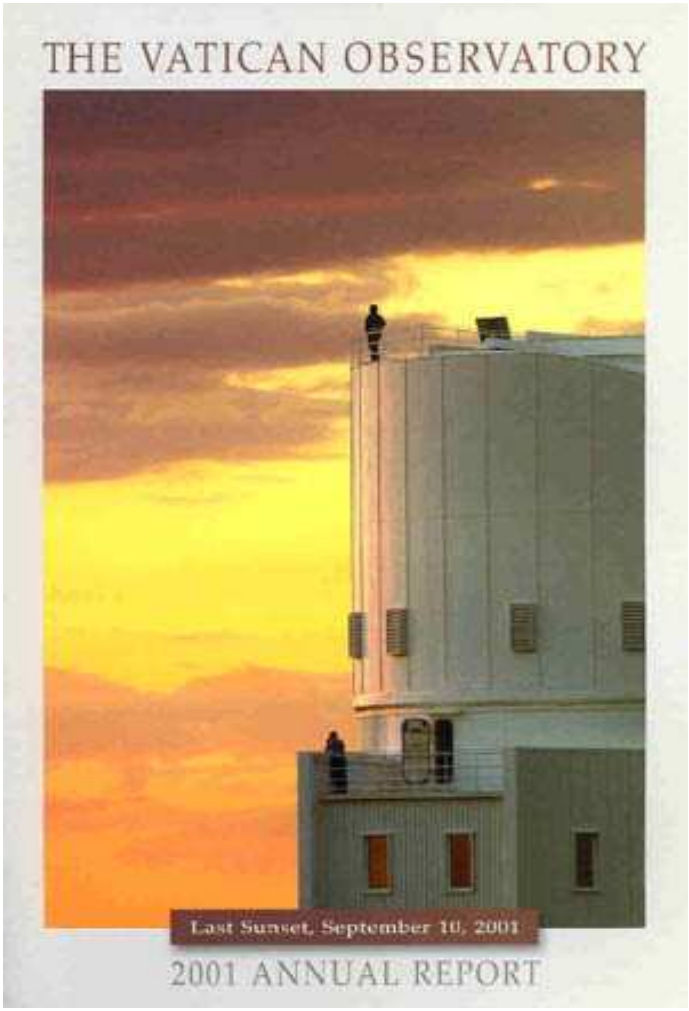
THE VATICAN OBSERVATORY
2001 ANNUAL REPORT

Staff & Directors
From Director

Editor: Elizabeth J. Maggio

Cover: Last Sunset, September 10, 2001



Front Cover:

Vatican Observatory astronomer Christopher Corbally, S.J., (lower level) and visiting scholar Aileen O'Donoghue (upper level) admire the beauty and serenity of the 10 September sunset before beginning their night's observing run at the University of Arizona's Bok Telescope on Kitt Peak outside of Tucson. Horrific events transpiring the next morning on the other side of the continent would change the United States and the world forever. (Photo by David Harvey)

Cover Artist: **Dave Fischer**

2001 ANNUAL REPORT

Vatican Observatory

Annual Report 2001

Vatican Observatory
(Castel Gandolfo)
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From the Director

Cover

From the Director

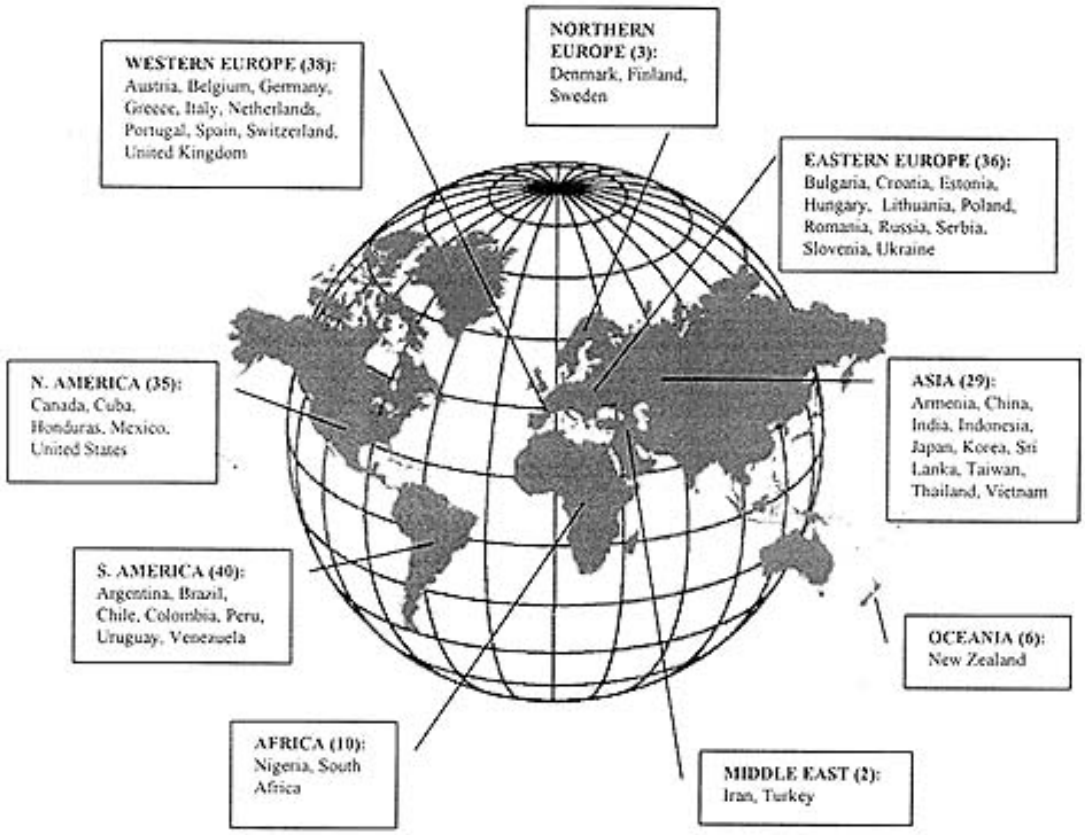
A Year to Remember

Many events occurred over the past year at the Vatican Observatory that we can accept with joy and quiet gratitude. But it would, indeed, be very shortsighted of us if we did not realize that, since the tragic events of 11 September, we all live in a changed world. Our passion to understand the universe as astronomers and friends of astronomers cannot become for us a refuge from the need to confront the problems that face all of us as citizens of the Earth. And so I ask you: Can our scientific research and all of the associated activities that we describe in these Annual Reports make any contribution to nourishing peace and harmony on this insignificantly small piece of the universe on which we live?

The photograph on the cover of this year's Annual Report was selected for the unique moment in the history of the United States, and the world, that it preserves. The photograph was taken the evening of 10 September at the University of Arizona's Bok Telescope on Kitt Peak outside of Tucson. Vatican Observatory astronomer Chris Corbally and visiting scholar Aileen O'Donoghue were preparing to begin a full night of astronomical observations. David Harvey, of the Computer Support Group at the University of Arizona's Steward Observatory, photographed the astronomers as they stood on the telescope's catwalk to watch a magnificent Arizona sunsetthe last, as it turned out, that they would see before the dawn of a new age for the world. The clouds in the evening sky, having displayed their beauty in the setting sun, fortunately disappeared soon afterwards, and our astronomers went inside to work at the telescope to try to understand nature's beauty in the cosmos. When their nighttime labors were over, they slept late into the next morning, unaware of the tragic events unfolding on the other side of the continent. We record that historic sunset on our cover in remembrance of all of the victims of 11 September and with a prayer and a dream that beauty will win out over hatred and that our pursuit of knowledge will contribute to the realization of that dream.

If ignorance nourishes hatred, then knowledge, especially that gained in collaboration with others of different ethnic and religious backgrounds, must surely be a path to peace and harmony. It is our fond hope that the Vatican Observatory's Summer Schools in Observational Astronomy and Astrophysics are serving that purpose, and the memories we have of our schools indicate that our hope is well founded. The eighth Summer School took place this year and is described later in this section. The schools, which began in 1986, have brought together nearly 200 young scholars from 50 different nations around the world. The map shows how far and wide the Summer Schools have reached.

Vatican Observatory Summer Schools in Observational Astronomy and Astrophysics, 1986–2001



Worldwide Student Participation
(number of students in parentheses)

are especially proud that 58 percent of the participants came from developing countries, and that 42 percent were women. Their Summer School experience along with the recommendations provided by the School's faculty have enabled many of the students to go on to study and pursue careers in some of the most prestigious centers in the world for astrophysical research. In particular, six studentsfrom Argentina, Bulgaria, Peru, Russia, South Africa, and the Ukrainehave been awarded graduate scholarships from the Jesuit Community of the Vatican Observatory. We are proud of all of the 200 alumni of the Summer Schools. Each in their own quiet way is a sign to their neighbors that peace is indeed a gift, but one that must be earned by the common pursuit of all those activities that unite us as human beings. The Vatican Observatory Summer Schools bear witness to the fact that a passion to understand the universe through research does just that unites us all.

As the tragic events unfolded in the northeastern United States on the morning of 11 September, it was mid–afternoon in Rome, where Vatican Observatory astronomer Guy Consolmagno and his colleagues were busily into the second half of the second day of the 64th annual meeting of the Meteoritical Society, for which the Vatican Observatory was a major sponsor and Consolmagno served as chair of the local organizing committee.

The meeting was the largest in the history of the Meteoritical Society. Some 600 participants came from more than 20 nations to attend the conference held at the Pontifical Gregorian University. Here, in the historical center of Rome, was a microcosm of a world that had been struck by evil. The morning after 11 September many participants attended the Papal Audience in St. Peter's Square where they were able to share their dismay with John Paul II, who was clearly shaken and who requested

personally that there be none of the song, laughter, and applause that usually exhilarate the audiences. He asked instead for a spirit of recollection and prayer for the victims of the attack and their families, for the many suffering nations, and for a world in which hatred would, in the end, be defeated. During the following days, the international scientific cohort went about their work at the conference, talking about the latest discoveries about meteorites, comets, and asteroids. They did so with heavy hearts but with a sense that their solidarity in research could contribute to bringing about the very thing for which the Pope had prayedthe defeat of hatred in whatever form and wherever it exists.

Research Highlights

Chronicling the history of science is an integral part of the research mission of the Vatican Observatory. In that light, we are happy to report the publication this year of Sabino Maffeo's *The Vatican Observatory: In the Service of Nine Popes*, in both Italian and English. This book is a revised and enlarged edition of *In the Service of Nine Popes: 100 Years of the Vatican Observatory*, which was published a decade earlier. Maffeo's meticulous recording of more than 110 years of Observatory history reassures us of the contribution we can make toward a better tomorrow by our scientific research. In that spirit, I wrote the following in the book's Presentation:

As the fruit of the author's labors we have in this book the most complete history of the Vatican Observatory ever written. However, to the attentive reader it will become obvious that we have here not only a faithful presentation of historical facts and figures, but also a fulfillment in our times of the original intentions of Pope Leo XIII in founding the Observatory, namely, " ... that everyone might see clearly that the Church and her Pastors are not opposed to true and solid science, whether human or divine, but that they embrace it, encourage it, and promote it with the fullest possible dedication." This book intends to explain to the general public more than to experts what the Pope's astronomers do and why they do it. Thus it responds in an exemplary way to those original intentions of the Pope.

What gives particular value to this publication is Maffeo's new research on the directorship of Father Angelo Rodríguez, who took over the Specola's administration in 1898. Rodríguez, a meteorologist, had little interest in the observatory's primary astronomical work at the time, which was joining other astronomers around the world in measuring the magnitude and position of stars on hundreds of photographic plates for a project known as the International Sky Map. According to Maffeo, "This enterprise represented the first great example of international collaboration in an astronomical program." Unfortunately, because of the director's lack of interest, work on the star catalog was temporarily suspended. Rodríguez's directorship was an especially difficult period for the Specola as it moved from an institute struggling to establish research programs to a true astronomical observatory. I think that Maffeo's efforts are particularly helpful in that properly recording this part of the Observatory's past reminds us of how human and so how fallible we, and all that we do, are.

The Vatican Observatory's 140−Year−Old Program in Stellar Spectroscopy

Sabino Maffeo's history of the Vatican Observatory describes the accomplishments of Angelo Secchi, S.J., who in 1850 became director of the Observatory of the Roman College, the forerunner of today's *Specola Vaticana* (Vatican Observatory in Italian). In the 1860s, Secchi experimented with a new technique, called spectroscopy, which uses a prism to split light into its component colors. Secchi attached a prism to the front of a telescope and found that this technique could be used to break a star's light into its corresponding spectrum of colors containing features specific to each star. In doing so, he discovered that stars could be classified according to their spectral differences. Secchi, who is considered the father of the spectral classification of stars, used spectroscopy to observe more than 4,000 stars, launching a scientific endeavor that continues today at the Vatican Observatory. Continuing this research for the Specola are Richard Boyle and Christopher Corbally, who have been working for many years along with astronomers from Canada, Lithuania, Poland, Wales, Italy, and the United States, a truly international collaboration.

Each year as we report on the staff's research activities, we are also building up a history of certain continuing areas of the Observatory's interests, such as the spectral classification of stars begun by Secchi. But it is not often that we take the time to purposefully look at that history. Boyle kindly provided us with the historical account presented here of the work that led up to the Vatican

Observatory's current research in this area.

In the early 1900s, the pioneering astronomers Hertzsprung, a Dane, and Russell, an American, made a major advancement to Secchi's initial discovery. They observed that the relative brightness of different colors in a star's spectrum can provide information about the star's intrinsic size and brightness, and ultimately about its age and the history of the region of the galaxy where it formed. By the way, both Hertzsprung and Russel visited the Specola.

Throughout most of the twentieth century, a long−term project of astronomers worldwide was to measure spectra of as many stars in as many regions as possible. Telescopes like the Vatican Observatory's Double Astrograph, and later the Schmidt, at Castel Gandolfo were pressed into service. These instruments were designed to capture light from a wide swath of the sky, guide it through a giant prism, and capture the resulting "rainbows" of starlight on a photographic plate. Astronomers then had to identify and classify each spectrum on the photograph by eye. Thousands of stars were classified this way. But the relatively low sensitivity of photographic plates and the labor−intensive nature of working with them ultimately limited the science that could be done in this fashion.

In the 1960s, the photographic plate began to be replaced by more−sensitive electronic detectors. These photoelectric tubes, however, could only measure one star at a time, but with a precision far greater than the crude spectra on the photographic plates. A further refinement was made by passing the starlight through filters. This allowed astronomers to estimate the star's color rather than look at its entire spectrum. One popular set of filters used at that time was developed by the Danish astronomer Strömgren. Each filter in his set took in a wide range of color. By comparing the brightness of the star from one filter to the next, a stellar classification could be determined for most ordinary stars.

In the 1980s, the light detectors in telescopes were almost completely replaced by electronic CCD chips. These both exceeded the sensitivity of the photoelectric tube and captured at once a whole collection of stars in a given region of the sky. Indeed, the sensitivity of the CCD chips gave rise to a new practical problem: instead of a few bright stars in a given small field of view, astronomers now had to analyze dozens to hundreds of stars in each tiny region of the sky.

Around this time, astronomers recognized an inherent weakness in the Strömgren filters for classifying certain stars whose colors had been altered when their light passed through clouds of interstellar dust. For those stars, data taken with the Strömgren filters gave rise to an ambiguity: Was a given star "red" because of its intrinsic color, or because the dust had scattered away the blue light? A new set of filters, known as the Vilnius filters (named for the Observatory of Vilnius, Lithuania, where this system was developed) was devised that did away with this ambiguity. But an enormous amount of work had already been done using the Strömgren filters, and it seemed a waste to discard that work. Thus in the 1990s, astronomers agreed on a compromise set of filters combining the best of both sets and known today as the Stromvil Photometric System.

Boyle and his collaborators are now making many photoelectric and CCD observations of galactic and globular star clusters using this new Stromvil system with the Vatican Observatory's VATT as well as with other telescopes. Because of its efficiency, the Stromvil filter system has also been proposed for use on the European Space Agency's GAIA mission, scheduled for launch in 2010 to map the billion brightest objects in the sky.

Vatican Observatory Summer School

The Eighth Vatican Observatory Summer School in Observational Astronomy and Astrophysics was held at the Observatory's headquarters in Castel Gandolfo from 16 June to 13 July. The topic of this year's School, "Observations and Theoretical Understanding of Stellar Remnants," attracted 26 students from 19 countries.

VOSS 2001 student Katherine Vieira of Venezuela observes the sun during a class exercise directed by Emmanuel Carreira, S.J. (left). (Photo by VOSS 2001 student Alan Yost, S.J.)

The faculty included Gary Schmidt, University of Arizona; Ramesh Narayan, Harvard Smithsonian Center for Astrophysics; Francesca D'Antona, Rome Observatory at Monte Porzio; and the Vatican Observatory's William Stoeger. On 4 July His Holiness John Paul II received the group in St. Peter's Square at the termination of the General Audience. The Pope gave the students a special written message in which, among other statements, he remarked: "Your personal and professional friendships, which embrace a variety of political, cultural, and religious differences, are one of the most precious fruits of the School, and I pray that these bonds will endure through the years." The young scholars were joined at the audience by the guests of the Vatican Observatory Foundation.

Personnel News

As of 1 September, Giuseppe Koch, S.J., joins the staff of the Observatory as Assistant to the Director. Father Koch entered the Society of Jesus in 1958 and obtained his degree in Mathematics and Physics in 1966 at the University of Rome. Since 1970 he has been doing pastoral work and teaching physics in the Jesuit Secondary Schools of Rome and of Palermo, Sicily.

As of 1 September, Javier Igea Lopez−Fando, priest of the Diocese of Toledo, Spain, joins the staff of the Observatory on a half−time basis. Igea obtained his doctorate in 1998 at New York University with a thesis on proto−planetary disks. He will continue half−time as Professor of Philosophical Cosmology in the seminary of Toledo.

Marcelo B. Ribiero arrived September 4 to begin a year of collaborative research in cosmology with Stoeger at VORG. He is an Associate Professor in the Physics Institute, Federal University of Rio de Janeiro, Brazil, and his research is being funded by Brazil's Ministry of Education, CAPES.

Aileen O'Donoghue, physics and astronomy professor to undergraduates at St. Lawrence University in Canton, New York, since 1988, is spending her sabbatical leave for the 2001−2002 academic year as a visiting scholar with the VORG. Her astronomical research has been almost entirely in the radio band, and she has used the Very Large Array Radio Telescope in Socorro, New Mexico, to image extended radio galaxies and analyze the flow dynamics of the extended structure. Realizing that optical astronomy is more amenable to the involvement of undergraduates in research, she has come to the Vatican Observatory to gain expertise in optical observations and analysis. O'Donoghue is also interested in the science−religion interface and has been involved in the Science and the Spiritual Quest II program of the Center for Theology and the Natural Sciences in Berkeley, California.

Richard J. Murphy, S.J., has been appointed Superior of the Jesuit Community of the Vatican Observatory in Tucson. Sabino Maffeo, S.J., remains as Superior of the Community at Castel Gandolfo.

Carolina Fornino in Longobardi, who resides in Grottaferrata, a neighboring town to Castel Gandolfo, is working as a volunteer in the Vatican Observatory's library.

Vatican Observatory Foundation Annual Meeting

The annual meeting of the members and directors of the Vatican Observatory Foundation was held on 23 February 2001 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, PAUL M. HENKELS, CHRISTOPHER P. HITCHCOCK, CHARLES W. POLZER, S.J., and WILLIAM R. STOEGER, S.J. On the day preceding the annual meeting, a seminar was conducted by members of the Observatory staff to present their research in a popular forum to friends of the Observatory and to members of the Board. On the day after the meeting the same group was accompanied on an excursion to the observatories on Mt. Hopkins.

Through the efforts of NANCY KNOCHE, Development Director, and JAMES McGEE, Chair of the Development Committee, the Foundation continues the two Vatican Observatory Guild giving plans announced in the 2000 Annual Report: the *Circles of Giving* and the *Reaching for the Heavens* Guild membership. At each Board meeting a festive dinner is held to welcome major donors into the various Circles of Giving, which have been named in honor of the following eminent persons in the history of the Church and science: John Paul II, Leo XIII, Gregory XIII, Pius XI, Angelo Secchi, S.J., Eusebio Kino, S.J., Christoph Clavius, S.J., and Georges Lemaître. During the past year, the Development Committee organized a number of events for Observatory supporters, in particular: a luncheon in New York on 4 June hosted by Peter Mullen, with Cardinal Avery Dulles as honorary guest, and a visit to Rome, the Vatican, and the Vatican Observatory at Castel Gandolfo in July organized by Paula D'Angelo, a member of the Foundation Board.

Once again through the efforts of BRENDAN D. THOMSON, an official Vatican Observatory calendar for the year 2001 has been produced with the theme, "Young Astronomers Lead Us to a Better Tomorrow." Among the images featured in the calendar are pictures of Earth and the cosmos taken by alumni of the Vatican Observatory Summer Schools.

George V. Coyne, S.J., Director

Theoretical Studies, Astrophysics, and Cosmology

STOEGER and ARAÚJO (Universidade Federal do Rio de Janeiro) and collaborators and students have completed and published their treatment of constructing solutions to the Einstein field equations with cosmological data functions for dust (pressure–free matter) in observational (past–light–cone–based) coordinates in the case of open and closed (non–flat) Friedmann–Lemaître–Robertson–Walker (FLRW) universes and in perturbed FLRW cases. They published their results for all exact spherically symmetric cases in 1999. Now they are working to complete the solution scheme for the general perturbation case (including non–spherically symmetric perturbations to FLRW) and for cases involving a mixture of dust and a vacuum energy (non–zero cosmological constant). They have made significant progress on both fronts.

STOEGER and RIBEIRO (Physics Institute, Universidade Federal do Rio de Janeiro) have begun some preliminary work on bridging the chasm between theoretical relativistic cosmology and the observational cosmology treatment of data as it applies to FLRW models of the universe. In particular, they are trying to describe mathematically the relationship which obtains between the galaxy luminosity function and relativistic energy–density of the universe at various redshifts. They are also studying how such data, including that pertaining to clusters of galaxies, might eventually be able to be used to constrain both cosmological models and luminosity and number evolution, without assuming that the universe on a particular scale is FLRW. One particular motivation for this work is to determine what is the smallest length scale on which our Universe is approximately FLRW.

ELLIS, MCEWAN, and DUNSBY (Department of Mathematics, University of Cape Town) together with STOEGER have completed and submitted preliminary work on both the dynamics and the horizon growth (causality) of inflationary universes with positive spatial curvature. In such universes the curvature will always dominate at early enough times. This puts limits on the number of inflationary e–foldings that can have occurred, without regard for what may have happened in the Planck era. This also means that causality will almost never connect the entire spatial extent of the universe. Any solution to the horizon problem, it turns out, really must be solved in the Planck era. Inflation merely serves to blow up to a very large scale whatever causally self–connected patch emerges from the Planck era. It does not determine the causal self–connectivity of the original patch, nor how large that patch is. Those characteristics must be determined by quantum–gravity processes in the Planck era itself. STOEGER and the Cape Town group are continuing their investigation of these issues, in particular, by deriving more precise constraints on inflationary effects in these models (e–foldings and horizon sizes). They are doing this by treating carefully the mixed–radiation and vacuum–energy dominated pre–inflationary phase of the universe's evolution, and by determining the effect of Planck era processes on the size and homogeneity of the pre–inflationary patch, according to what quantum cosmologists are discovering.

LISZKA (Swedish Institute of Space Science, Sförs), PACHOLCZYK (Steward Observatory, University of Arizona), and STOEGER are continuing their work on ROSAT and Chandra X–ray data sets of Seyfert galaxies to separate out deterministic signals, which may be due to processes in the sources themselves, from both extrinsic and intrinsic stochastic processes. This work is directed toward a more precise understanding of the central engine of active galactic nuclei, in particular, whether or not there is just a single central black hole or rather multiple black holes (e.g., a cluster of black holes). STOEGER and PACHOLCZYK are also beginning to study how black holes may be involved in gamma–ray bursts, and how initial gamma–ray bursts from ballistic black–hole events can be degraded in some cases to X–ray energies through their interaction with surrounding matter and high energy radiation fields (photon–photon pair–production processes).

JUST (Department of Physics, University of Arizona) continues to work in quantum field theory together with STOEGER, particularly on developing and refining the quantum induction program.

WHITMAN continues to work on the holonomy problem. This seeks to identify the possible geometric structures, one of which being the structure of our universe, that are described by Einsteinian geometry. Within this problem is an older one, first solved around a hundred years ago: the problem of classifying the real, irreducible representations of real forms of the simple complex Lie algebras. Over the century more understanding and sharper results were reported with respect to this problem. However, this literature is diffused throughout many journals and books, and it is difficult to understand the larger picture. Thus WHITMAN is now working to give an exposition of this development from its beginnings in the theory of Lie algebras. He has also presented another exposition of a part of the holonomy problem. Complex representations of simple complex Lie algebras is the basis for the beginning of the solution of this problem. Among these representations appear the rather surprising spin representations. In order to show how these spin representations might have been discovered, WHITMAN prepared a detailed analysis of the isomorphisms of the low dimensional Lie algebras in which these spin representations naturally appear. With this foundation it became much easier to show the structure of these spin representations as coming from certain Clifford algebras. In particular, the surprising difference between the even−dimensional and odd−dimensional spin representation became very clear. This material was assembled into a set of notes by WHITMAN, "Low Dimensional Isomorphisms of Simple Complex Lie Algebras and Spin Representations."

Extragalactic Research

These images of NGC 628, a spiral galaxy at a distance of 9.7 Mpc (32 million light years), were taken by Vatican Observatory astronomer Jos, Funes, S.J. and Sanae Akiyama with the University of Arizona. The images, obtained at the VATT in November 2001, illustrate the H−alpha survey of star formation in the local universe. The R−band image is at left; the H−alpha image at right. The H−alpha image reveals those regions where stars are forming.

Understanding star formation rates (SFR) is crucial for the comprehension of galaxy formation and evolution. A key question is: How does the distribution of SFR evolve with redshift? To answer this question, other researchers (Madau and collaborators) attempted in 1996 to measure the redshift evolution of the co−moving SFR density. The result is the so−called "Madau plot." However, this plot is influenced by systematic uncertainties in the underlying SFR scales (extinction and incompleteness biases). To address the incompleteness and environmental effects, FUNES along with KENNICUTT (Steward Observatory, University of Arizona), SAKAI (University of California, Los Angeles), and AKIYAMA (University of Arizona) are obtaining H−alpha images to complete a volume−limited survey of integrated SFRs for a complete sample of nearby galaxies within the local 11 megaparsec volume. In order to probe the population of field galaxies, they are compiling and measuring the integrated H−alpha luminosities and SFRs for a complete sample. The data will be used to: (1) construct the local SFR distribution function as a reference for cosmological look−back studies; (2) develop new diagnostic measures of the rate and distribution of star formation in galaxy populations; (3) quantify the role of starbursts in the evolution of low−mass galaxies; (4) quantify the incompleteness biases in star

formation surveys; (5) study the environmental dependence of the SFR distribution function; and (6) provide a reference catalog and image database for use by workers in the field. The observations for this program are being obtained with the Vatican Advanced Technology Telescope (VATT) at Mt. Graham, the Steward Observatory 90−inch Bok Telescope at Kitt Peak, and the Cerro Tololo Interamerican Observatory 0.9−m telescope at Cerro Tololo, Chile.

FUNES continues to seek an accurate determination of the black−hole mass in early−type disk galaxies by studying the gaseous kinematics in the inner regions of these galaxies. This work is being done in collaboration with BERTOLA, CORSINI, PIZZELLA (University of Padua, Italy), SARZI (University of Durham. U.K.), and VEGA BELTRAN (Instituto de Astrofisica de Canarias, Canary Islands). It is now commonly accepted that almost every galaxy hosts in its center a supermassive black hole (BH). Supermassive BHs may have played a major role in galaxy evolution, as recently indicated by the correlation between the black−hole mass and the bulge stellar velocity dispersion. However, it should be kept in mind that the current demography of supermassive BHs suffers from important biases related to the limited sampling over the different basic properties of their host galaxies. In particular, it is evident that the number of BH mass estimates in spiral galaxies is strongly under−represented. New spectroscopic observations with the Space Telescope Imaging Spectrograph have been scheduled to map the ionized gas velocity field of three early−type disk galaxies, for which we will be able to derive high precision BH mass measurements. Indeed, the sample galaxies have been selected from among 37 observed objects by means of ground−based, high−resolution spectroscopy, whereby we recognized in the central regions of the selected galaxies the clear presence of a circum−nuclear Keplerian disk of ionized gas suitable for dynamical modeling.

OMIZZOLO and CRISTIANI (European Southern Observatory, Munich) are determining the luminosity function for a sample of about 800 X−ray emitting, bright quasar candidates. Low−resolution red region spectra were obtained in collaboration with CORBALLY at the Steward Observatory Bok Telescope on Kitt Peak, and reduction of the data was completed at the Department of Astronomy of the University of Padua. OMIZZOLO and CRISTIANI are also studying the spectral data for NGC 526, an active galaxy, to determine the kinematics of this interesting object. The spectra were taken at the ESO observatories in Chile and at the Galileo Italian National Telescope in the Canary Islands.

The Galaxy and Galactic Objects

CORBALLY and GRAY (Appalachian State University, Boone, North Carolina) completed their spectroscopic search for lambda Boötis stars among late B, A, and early F−type stars in 12 young and intermediate−age open clusters. Numerous classical Ap (three notably extreme) and Am stars were found among the 130 stars observed. In addition, three emission−line stars and two candidate lambda Boötis stars were found. Neither of these lambda Boötis candidates turned out to be members of their respective clusters. When combined with 184 stars previously classified in 10 other intermediate−age open clusters, also devoid of lambda Boötis stars, and correcting for cluster membership probabilities, a statistically significant null result was obtained. Since the frequency of lambda Boötis stars in the field amounts to 2%, a small but significant percentage, the null result from clusters suggests some factor(s) external to the star and related to membership in open clusters that prevents the operation of the lambda Boötis mechanism.

The investigation of heavily reddened stars in clusters and of peculiar stars continues. These were selected by STRAIZYS (Institute of Theoretical Physics and Astronomy, Vilnius, Lithuania) from photometric classifications in the Vilnius seven−color system. Heavily reddened stars in the area around Nova V1500 Cygni, in the Camelopardalis dark clouds, and in the dark cloud between the North American and Pelican Nebulae have been classified by CORBALLY from spectra he obtained with the Steward Observatory's Bok Telescope.

RUEGER (Diocese of Brooklyn), with the help of RECCA (Manhasset, NY), has finished processing the *UBVRI* observations obtained with the VATT of two fields in the North Galactic Pole (NGP). With CORBALLY, they are using these fields to calibrate new, direct images of the NGP that were taken with the MDM 1.3−m McGraw−Hill Telescope in the spring. These images, each 45 arcmin square, were acquired through a collaboration with CROTTS (Columbia University), whose MDM 8K CCD

array camera was used to considerably enlarge the search area for G–dwarf stars in the Galactic Halo.

CORBALLY, GRAY and McFADDEN (Appalachian State University, Boone, North Carolina), and GARRISON (David Dunlap Observatory, University of Toronto) have been joined by O'DONOGHUE (Vatican Observatory Research Group visiting scholar) this year in their 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. This is part of the Nearby Stars (NStars)/Space Interferometry Mission Preparatory Science program, and its goals were described in the Annual Report of 2000. Progress has been steady since the project began in July 2000. Some 60% of the spectra have been observed, some 20% have been classified, and the analysis technique was refined for late–type spectra and is being applied down to K5. To help with the analysis, O'DONOGHUE traveled to Appalachian State University in July to work with GRAY. While there, she acquired data that had already been obtained by the project as well as the computer programs GRAY had written for analysis of the spectra. When she arrived at the Vatican Observatory Research Group in September, she brought with her familiarity and experience with the programs, as well as the programs themselves.

In the age of "big glass," the future of smaller telescopes (up to 4–m aperture) might be questioned. At the prompting of OSWALT (Florida Institute of Technology), the general editor of a book on this topic, CORBALLY, GARRISON, and GRAY collaborated in thinking through which spectroscopic observations from smaller telescopes would best provide the high priority projects for stellar physics in the present decade. Various kinds of surveying and monitoring of stars were proposed, along with the refinement of digital and automated techniques in the classification and analysis of stars. In all of the proposed projects, the complementarity between data obtained with small and large telescopes was stressed, since astronomy of the future will require that both kinds of telescopes be used efficiently to understand the most interesting stars.

Stellar population survey work, long a mainstay of astronomy at the Specola, continues today with an innovated combination of electronic data collection and computerized data reduction. A historical perspective of the evolution of this work is found in the "From the Director" section of this Annual Report. At present, the work facing the astronomers is threefold: (1) to understand and learn to correct for all the fluctuations inherent in the electronic gathering of faint light with CCD chips; (2) to collect overlapping data sets that can serve to tie together the existing Strömgren and Vilnius data with the next generation of Stromvil data sets; and (3) to address the need that arises from all these data for a repeatable, automated system where computer analysis of the electronic images can help speed up the enormous work of classifying hundreds of stars in hundreds of CCD images. Work on all three of these issues was carried forward by BOYLE, in collaboration with PHILIP (Union College, Schenectady, New York), JANUSZ (Cracow, Poland), DASGUPTA (Cardiff, Wales), SMRIGLIO (University of Rome), and KAZLAUSKAS, LAUGALYS, and STRAI_YS (Vilnius, Lithuania).

During the course of the year, BOYLE spent 23 days in separate runs at the VATT with PHILIP to obtain images of globular clusters and open clusters with the Stromvil filter system. KAZLAUSKAS and LAUGALYS spent 39 nights observing standard stars at the Mt. Lemmon 60–inch telescope in Tucson and 7 nights at the United States Naval Observatory 1–m telescope in Flagstaff, Arizona. The goal of this work was to calibrate the Stromvil system by taking photoelectric standards in selected fields including open and globular clusters, and also for field stars.

JANUSZ has developed an automated system for data reduction of these CCD images that allows the computer to recall the complex sequence of steps needed to remove known artifacts and errors (flat fielding) from each image, and that can even automatically identify stars of interest within the field. This speeds up the reduction process by a large factor. BOYLE and JANUSZ tested and refined this system, and DASGUPTA then applied it to real–world cases, comparing the reductions done with the automated system with those performed by hand using traditional methods. The final version of this system promises to greatly reduce the time and effort needed to classify stars in a set of CCD images.

The goal of all the work described above remains the classification and characterization of stars in various regions of the galaxy. This stellar census will contribute to our understanding of how the Milky Way galaxy, and other spiral galaxies, develop over time.

IGEA, in collaboration with HUGGINS (Physics Department, New York University) is studying dust scattering in multiple–shell circumstellar envelopes. When a star ejects matter periodically or

episodically, it forms a series of nested, concentric shells. Such a phenomenon has been recently observed around a number of asymptotic giant branch (AGB) stars and around some post−AGB stars. It may prove to be an important phenomenon in the later stages of stellar evolution. Radiative transfer of scattered light in spherical geometry is fairly well understood, but little is known about transfer is such multiple−shell envelopes. IGEA and HUGGINS are carrying out Monte−Carlo calculations for dust scattering in such shells, which are illuminated by both external and internal radiation. The principal variables in the calculations to reproduce the observations are the dust grain properties and the shell geometries.

Planetary Sciences

Meteorites

In recent years, CONSOLMAGNO along with STRAIT (Alma College, Michigan) and BLAND (Open University, Milton Keynes, England) have studied microcrack porosity in meteorites, correlating the measured porosity in a hand sample with the amount of volume taken up by cracks in a thin section of the same meteorite. A problem with meteorite thin sections has been that previously only a tiny fraction of an entire section typically was imaged; at times, as few as two images were used to characterize the entire section. This past year, however, the researchers worked with a thin section of Knyahinya (L/LL 5), which fell in Ukraine in 1866, that has been imaged over much of its surface using a JSM 840A SEM at Central Michigan University. Several hundred digital backscatter electron microscope images were generated that covered approximately 50% of the surface. Porosity in the thin section images was measured using NIH Image software. The data, averaged over the areas, indicate an average porosity of 6.0%, with about 0.5% of the cracks filled. This was in agreement with the porosity previously measured by CONSOLMAGNO and BRITT (University of Tennessee) in the whole rock.

In evaluating the porosity distribution in the thin section of the Knyahinya meteorite, the researchers observed that the porosity tended to be higher at the edges of the section, where larger cracks were evident; several areas had significantly higher porosity (10−15%). These areas tend to have major cracks through the fabric of the section, large holes, or gaps at the edges of large inclusions. There was a gradual transition into and out of these high−porosity areas, so it was not an artifact of the measurements. This may be consistent with the idea that these cracks are the result of a shock having passed through the meteorite, with a greater effect near its edges. When did this shock afflict the rock? It could have occurred at any timewhen the rock was residing on its asteroidal parent body; during the event that ejected the rock into Earth−crossing orbit; or even during the shock it experienced when hitting the Earth. Telling the difference will require measuring the microcrack porosity of different types of meteorites, including meteorites that came from rocks known to have been fractured while on the surface of an asteroid and those that appear to have remained relatively intact before arriving at Earth. The one event that all meteorites have in common is their arrival at Earth; if all meteorites show identical microcracks, regardless of type or previous history, that would suggest the cracks were all made at this time, while differences among types would be consistent with cracks occurring in the asteroidal parent body.

In other meteorite−related activities, ROCHETTE (Istituto Nazionale di Geofisica, Rome and University of Aix−Marseille, France) visited the Vatican meteorite collection, housed at the Vatican Observatory's headquarters in Castel Gandolfo, in January to make measurements of the magnetic susceptibility of more than three hundred stony meteorites in the collection. Measurements of the magnetic property of meteorites, which is controlled by their iron content, may provide a rapid nondestructive technique to characterize meteorite samples and probe their homogeneity in the 1 to 100 cc volume ranges. Moreover, the knowledge of average magnetic properties for a given meteorite class is needed to interpret spacecraft magnetic data, such as provided in possible future follow−ons to the NEAR mission to asteroid Eros. Magnetic susceptibility is the most suitable parameter to measure, as it can be measured on various volumes and shapes, and it is also nondestructive of the paleomagnetic natural remnant magnetization. This work was part of a larger effort, involving ROCHETTE, SAGNOTTI (Istituto Nazionale di Geofisica, Rome), FOLCO and MELLINI (Antarctic Museum of Siena, Italy), MARAS and PANZARINO (University of Rome), PESONEN and TERHO (University of Helsinki),

and SERRA (Museum of San Giovanni in Persiceto, Italy), to characterize the magnetic properties of meteorites held in collections throughout the Italian peninsula. The researchers merged this database with previous data from Finnish and Czech collections, allowing them to analyze about 750 different ordinary chondrites, including both those seen to fall and collected while still fresh, and those found in places like hot deserts or Antarctica. For a large number of meteorites, especially falls (those recovered after having been observed falling to Earth), numerous samples from various collections were measured, allowing the team to see if the susceptibility values were the same from sample to sample. Falls turn out to be quite homogeneous; finds (meteorites not observed falling to Earth) are less so, as are some brecciated or veined falls where one would expect to see locally variable metal concentrations. After separating falls from finds, a very narrow range of susceptibility values can characterize H, L, and LL ordinary chondrite classes, with practically no overlap (except for some brecciated or veined samples). On the other hand, finds show a variable decrease of susceptibility correlated to the degree to which Earth's water and air have caused the iron in the meteorites to weather and rust. Previous studies had neglected to separate falls from finds, and so had missed this separation of magnetic properties in different ordinary chondrite classes.

From this analysis of a large number of samples, it is clear that finds, even from Antarctica, have to be excluded from efforts to define mean magnetic properties of asteroids related to ordinary chondrites. When finds are excluded, the magnetic properties of meteorites remain in a very narrow range for a given class. The standard deviation for all falls of a given class is only about two times the standard deviation for multiple pieces of the same fall. This supports the hypothesis that all falls from a given ordinary chondrite class (H, L, LL) may come from the same, rather small–sized object. Although magnetic susceptibility cannot be used to classify finds (a weathered H, for example, gives the same value as a fresh L), the magnetic susceptibility of finds can be used to probe weathering stage and to determine if two meteorites found at different locations are part of the same fall ("pairing"). This is a quick way to classify a large number of specimens, for instance, to confirm the identification of meteorites within a large collection.

As a result of these measurements, the classification of about half a dozen samples in the Vatican collection is now being reevaluated. Intriguingly, the work described above suggests that by measuring the magnetic properties of rock remotely, spacecraft may be able to determine with great precision the iron content of asteroids or even materials on the surface of terrestrial planets.

Asteroids

The number of asteroid bulk–density measurements has been rapidly increasing, thanks to spacecraft missions, observations of asteroid satellites, and observations of asteroid mutual gravitational events. In most cases, asteroid bulk densities tend to be substantially below likely meteorite analogs, indicating significant porosity (as described in previous Annual Reports). The bulk porosity of these asteroids can be estimated by using the grain density data of the analog meteorites to constrain the amount of pore space that would be required for an object of that composition and measured bulk density. For example, 433 Eros has a measured bulk density of 2.67 ± 0.03 g/cm^3 and probably has an L–chondrite composition, which implies a grain density of 3.75 g/cm^3. To make the L–chondrite grain density consistent with the asteroidal bulk density would require a bulk porosity of 28.8%. To better assess asteroidal structure, BRITT (University of Tennessee), CONSOLMAGNO, YEOMANS (Jet Propulsion Laboratory, Pasadena, California) and HOUSEN (Boeing, Seattle, Washington) took the analysis a step further this past year by recognizing that most meteorites have some level of micron–scale *microporosity* that does not seriously affect the meteorite's cohesive strength. This implies that microporosity would also not affect the parent asteroid's coherent strength. By subtracting the average meteorite analog microporosity from the bulk porosity of an asteroid, we can estimate the asteroid's large–scale *macroporosity*. An asteroid's macroporosity are the fractures, cracks, and voids that are large enough to affect its coherent strength and define its internal structure. Note that this estimate requires two assumptions: first, that we know the asteroid's meteorite analog and, second, that the meteorites delivered to Earth are a representative sample of that material. Both assumptions are open to debate.

Estimated macroporosities for the asteroids measured so far appear to divide into three rough groups. The first group includes the large asteroids 1 Ceres, 2 Pallas, and 4 Vesta. Their bulk densities are very close to the bulk densities of their analog meteorites, indicating essentially zero macroporosity.

These asteroids are probably strong, coherent objects that have not been disrupted throughout solar system history. It is interesting that all three asteroids with diameters >500 km all fall in the zero macroporosity group. The second group includes the S asteroids 433 Eros and 243 Ida, as well as 762 Pulcova and 121 Hermione. These asteroids have between 15 and 25% macroporosity, indicating that they have been extensively fractured. However, this fracturing was probably not extensive enough to disrupt the object, and asteroids with less than approximately 25% macroporosity probably have some measure of coherent strength. In terrestrial geology, well–sorted sedimentary rocks can have up to 30% porosity and still be coherent. However, greater than 30% porosity usually indicates loose rubble or soils. The third group are those asteroids with greater than 30% macroporosity. These objects are probably pervasively fractured and may have been disrupted and reassembled by mutual gravity.

Asteroid 16 Psyche is likely the most porous object obser ved so far. Its reflectance spectra and radar albedo strongly indicate a metallic surface composition. Assuming an iron meteorite grain density of 7.4 g/cm^3, the asteroid's inferred low bulk density would require a bulk porosity of 75%, which suggests a pervasively disrupted object that has been loosely reassembled and held together by mutual gravitation. Simulations of impacts into porous materials indicate that porosity can dramatically affect the evolution of asteroid regoliths, impact ejecta, and structure. Impacts into high–porosity asteroids create craters, primarily by compaction and with most ejecta being retained within the crater. As porosity increases, ejecta velocities tend to drop, the sizes of ejecta blankets are reduced, and the efficiency of asteroid impact gardening (the churning up of soil by repeated impacts) is significantly reduced. Because the compaction process dissipates impact shock more effectively, highly porous asteroids may be significantly more resistant to impact disruption and, as a result, have increased dynamical lifetimes.

This new understanding of asteroid structure changes the way we think about how planets were formed from the accretion of small bodies. More importantly, it also changes the way we must think about how to move, or destroy, any "killer" asteroids on a path aimed at Earth. Such rubble piles cannot be simply disrupted by a single well–placed bomb (a la Hollywood), since the rubble will simply dissipate the energy of the explosion. Nor can "pushing" on one end of the asteroid necessarily result in the entire body moving into a new path. On the other hand, one could expect to find a large amount of loose material on such a rubble–pile asteroid. This material could easily be launched from the surface, either to act as "reaction mass" to nudge the body in the opposite direction, or to exploit the material for its mineral wealth.

The Moon

Since the early 1970s our understanding of lunar formation has been dominated by the magma ocean model, that is, that the early Moon started with a layer 400 km thick of completely molten rock, whose stratified freezing gave rise to the different rock types seen in the samples returned by the Apollo mission. However, recent work, spurred in part by the results of the Clementine and Lunar Prospector space missions of the 1990s, has challenged this model on a number of grounds. DYAR (Mount Holyoke College, Mt. Holyoke, Massachusetts) and CONSOLMAGNO have begun a collaboration to explore three specific questions raised by this model.

(1) *Is the magma ocean model consistent with the giant–impact origin for the Moon?* In the 1980s, ten years after the magma ocean model was proposed, a new theory for the Moon's origin was put forth. This suggested that the Moon formed from material splashed into space by the impact of a large planetesimal onto Earth early in our planet's history. But such an impact–formed Moon, depleted in those elements normally found in an iron core, must have been well mixed and probably *completely* meltednot to just a depth of 400 kmduring the initial impact and core formation. DYAR and CONSOLMAGNO, along with other workers, have noted that the geophysical constraints on the composition and evolution of such a Moon are difficult to reconcile with the standard magma ocean model.

(2) *Did a chilled anorthosite crust exist?* The magma ocean model predicts that the upper 60 km of the Moon would be made primarily of the calcium– and aluminum–rich mineral anorthite, the main constituent of anorthosite rocks. But data from the recent lunar orbiters indicate that the average crustal composition of the Moon is significantly different from the composition of the limited Apollo samples on which the magma ocean hypothesis was based. Lunar anorthosites may have formed over

too long a period to be consistent with a rapidly chilled crust. And the thorough melting of asteroid Vesta, believed to be the source of basaltic meteorites, apparently did not form anorthosite meteorites; none have ever been found. CONSOLMAGNO and DYAR have begun to look at models of the Moon analogous to the successful chemical models of Vesta, which include more pervasive equilibrium and significant mixing during melting, rather than the stratified layers implied by the lunar magma ocean model.

(3) *Is the depletion of volatiles in both the Moon and Vesta (the basaltic meteorite parent body) primordial*? We know that both the Moon and the basaltic meteorites are depleted in water, oxygen, and elements like sodium and potassium. The standard magma ocean model assumes that these volatiles were never present once the Moon was formed. Some authors suggest that they were lost during the giant impact formation of the Moon. But this would not explain why they are lost in the same way on Vesta, which presumably was not the result of a giant impact. Other authors have suggested that the loss of volatiles could have occurred during fire−fountain volcanism. DYAR and CONSOLMAGNO note that the abundant vesicles ("frozen bubbles") seen in pristine lunar basalts and basaltic meteorites (including samples in the Vatican collection at Castel Gandolfo) suggest both the Moon and Vesta were much richer in oxygen and other gases than the magma ocean model supposes. New Mossbauer and micro−XANES measurements by DYAR have found ferric (oxidized) iron in lunar anorthosites, which also suggests that the early Moon was originally more oxygen rich than seen today. DYAR's work suggests that large−scale shock reduction and dehydrogenation are also possible for these rocks. Further measurements of both additional lunar samples and basaltic meteorite samples from the Vatican collection should help us understand this problem further.

The significance of this work extends far beyond the Moon. The concept of a "magma ocean" has been borrowed to explain terrestrial bodies from Mercury to Vesta. Until these basic challenges to the lunar magma ocean model are resolved, we will not be able to make progress in understanding the other terrestrial planets. If the magma ocean hypothesis survives these challenges, it will be a theory we can use with greater confidence; if it fails, everything we know about the origin of the terrestrial planets will need to be rethought.

Small Outer Solar System Objects

Observations of Kuiper Belt Objects (KBOs) continued at the VATT through 2001. ROMANISHIN (University of Oklahoma), TEGLER and BOTTHOF (Northern Arizona University, Flagstaff), RETTIG (University of Notre Dame), and CONSOLMAGNO obtained optical (B, V, and R filter) photometry of KBO (26308), 1998 SM165, over eight nights in the fall observing seasons of 1999, 2000, and 2001. These data were analyzed to show a light curve with a large amplitude and a rotational period of 7.98 hours (assuming the brightness variations are due to shape). If this is an ellipsoidal body with a uniform albedo of 0.04, typical of KBOs, it must have dimensions of 600 × 360 × 360 km. That would make (26308) one of the largest, significantly non−spherical bodies in the solar system. Data from 1999 and 2000 show no evidence of color variations with rotational phase. Color versus phase data, obtained during a second run at the VATT in the fall of 2001 by TEGLER and ROMANISHIN, may shed further light on the nature of this object's surface materials.

History and Philosophy of Science; Interdisciplinary Studies

IGEA has finished a paper on the religious implications of the origin of the universe in preparation for a conference on science and religion that will be held in Puebla, Mexico. He explores the possibility of having a self−explanatory theory of the universe and its knowledgeability by human reason.

Recent work by STOEGER on the philosophy of cosmology has yielded an article in *Philosophy in Science* describing, from a philosophical point of view, "the universe which cosmology studies." With PACHOLCZYK (University of Arizona), he has also written a paper treating problems connected with correspondence, the succession of acceptable theories (e.g., Newton's theory of gravity and Einstein's general relativity), and the notions of truth associated with them.

STOEGER has been continuing his work in formulating a theology of creation in light of contemporary scientific knowledge. As part of this effort, he is in the preliminary stages of developing a philosophy of relations and causes, which would more adequately delineate and connect these concepts at the scientific, ontological, and theological levels, relying on the insight that relations are more basic than causes.

CARUANA has published a textbook entitled *Fondamenti Filosofici delle Scienze Naturali* (Philosophical Foundations of the Natural Sciences), directed primarily at philosophy undergraduates. It includes a presentation of the basic philosophical arguments on scientific methodology and on the general nature of things. This Italian edition is meant primarily for students attending the Pontifical Gregorian University.

RIBEIRO, a Vatican Observatory Research Group visiting scholar, with VIDEIRA (both from Department of Philosophy, Federal University of Rio de Janeiro) is working on a Brazilian Portuguese edition of the book by STOEGER, *The Laws of Nature, the Range of Human Knowledge and Divine Action*, which was originally published in Poland by Biblos in 1996. It will be published by the Paulinas Publishing House in São Paulo.

CARREIRA has prepared a study on the interpretation of the anthropic principle as an indication of a design at the origins of the universe. The study is being readied for publication in *La Civiltà Cattolica*.

As described in the "From the Director" section of this Annual Report, MAFFEO has written *The Vatican Observatory: In the Service of Nine Popes,* a revised and enlarged edition of his earlier history of the Vatican Observatory. The new book has been published in both English and Italian.

Instrumentation and Technical Services

Cover

Observatory Operations and Activities

Steward Observatory's Randall Swift (left) and Gary Rosenbaum (center reflection and right) prepare to wash the VATT's primary mirror prior to the start of the new observing season in September. (Photo by Christopher Corbally, S.J.)

The Vatican Advanced Technology Telescope (VATT), part of the Mount Graham International Observatory (MGIO) in Arizona, has benefited substantially from the involvement over the last two years of Ned FRANZ at Steward Observatory. Many projects have come near to completion due to his efforts, including a new dome encoding system, primary mirror metrology, fixes to the secondary mounting, and new encoder mounts for the telescope. Also, Randy SWIFT of Steward Observatory/MGIO has continued to expand his involvement with the VATT and has taken over the majority of the site maintenance and operations, in addition to continued involvement with various observatory improvements, most notably the telescope hydraulics and dry air supply.

Improvements at the VATT continue, now under the leadership of scientist Matt NELSON, since Richard CROMWELL is now part–time on the project. The VATT/MGIO weather system now monitors site weather full time. Improvements to standard weather information, which help observer planning and observations, include the availability of a boundary–layer seeing estimation and a cloud sensor. After nearly a year of experience with the repaired secondary mount, it is becoming clear that image quality has improved by 0.2–0.4 arc seconds at the VATT, resulting in regular reports of sub–arcsecond seeing from observers. Finally, progress is being made on improving the pointing of the telescope though improvements both in the pointing model used and in the encoder mounts. This results in more consistent feedback to the mount motion control system.

The project to provide VATT with a medium–resolution optical spectrograph, last worked on in 1995, has been revived by CORBALLY, CROMWELL, HARMER (National Optical Astronomy Observatories), and NELSON. The optical barrels for the camera and collimator have been manufactured, and the optical testing of these lens assemblies is nearly completed. The spectrograph's mechanical specifications are under review.

CORBALLY continued to maintain the World Wide Web site of the Vatican Observatory and its Foundation. He added dedicated target windows for off−site links, and he implemented index frames for the Annual Reports, including that of 2000, to ease navigation through them. CORBALLY and KNOCHE (Vatican Observatory Foundation Development Director) worked with MacIVER (Sandline Productions) to allow accepting credit card contributions for calendars or making donations directly from the Foundation's web pages. The home page is at http://clavius.as.arizona.edu/vo/

At Castel Gandolfo, a new Alpha Station 64−bit workstation running Unix has been installed, provided by the International Center for Relativistic Astrophysics. During the summer, BOYLE installed the astronomical image processing software package IRAF and the DS−9 Image Display System as well as other software needed for image processing. With ever−heightening levels of security at both the Vatican and the University of Arizona internet offices, the Secure Shell environment for the Specola's network of computers has also been installed.

Under the care of MAFFEO, the dome of the Zeiss visual telescope at Castel Gandolfo has been completely restored. This was accomplished through generous donations from the Fondazione Cassa di Risparmio della Banca di Roma, the Compagnia di S. Paolo di Torino, and SARAS, Raffinerie Sarde.

A new H filter for use with the telescopes at Castel Gandolfo has been generously donated to the Observatory by David Lunt and Geraldine Hogan of the Coronado Technology Group, Tucson, Arizona.

OMIZZOLO and BARBIERI (University of Padua) carried out a preliminary study of the feasibility of the digitization of the Vatican Observatory's archival astronomical plates. With the collaboration of CASANOVAS, they are at the same time creating a digital catalogue of the plate collection at Castel Gandolfo.

CASANOVAS, with the assistance of library volunteer FORNINO, is creating an electronic file of the Vatican Observatory's library holdings at Castel Gandolfo.

Conferences

During the week of 10–14 September, nearly 600 meteoriticists from around the world gathered for the 64th annual meeting of the Meteoritical Society, hosted by the Observatory and held at the Pontifical Gregorian University in Rome. CONSOLMAGNO served as chair of the local organizing committee; COYNE also served on the organizing committee, while MAFFEO, LORI, ROSSI, and IGEA provided significant support before and during the meeting.

The conference was the largest in the history of the Meteoritical Society with attendees from more than 20 nations. The scientific discussions took place during 30 oral sessions, with a total of 221 papers presented. During the coffee breaks, another 201 poster papers were presented. Sessions were held concurrently in the Aula Magna and another ground–floor classroom, while the Main Atrium was filled with posters and displays. Other classrooms were used for special meetings, and one room was dedicated to an Internet Point, arranged and staffed through the efforts of Alenia, a major conference sponsor. The Internet Point, filled with more than a dozen computers provided by Compaq Italia, helped the international assembly keep in touch with home, which was especially appreciated during the days following 11 September.

Special sessions at the meeting centered on understanding Mars from the meteorite perspective; spacecraft observations of near–earth objects; and laboratory simulations of circumstellar dust. Welcoming remarks were given by Father Franco IMODA,

Guy Consolmagno (right) holds a 70 g piece of the Fermo meteorite, which fell on 25 September 1996 near Fermo in central Italy. Through the efforts of Giordano Cevolani (left), with Italy's National Research Council, the sample was donated to the Vatican meteorite collection by the city of Fermo. An ordinary chondrite type H5 with H3 clasts, the specimen was presented to the Vatican Observatory during the Meteoritical Society meeting in Rome. (Photo by Judith Britt)

President of the Pontifical Gregorian University, and by Archbishop Giuseppe PITTAU, Secretary of the Vatican Congregation for Catholic Education. Invited talks were given by COYNE on the history of the Vatican Observatory, and by OLSON (New York Academy of Arts) and PASACHOFF (Williams College, Massachusetts), who described the artist's interpretation of meteorite impacts in a talk entitled "Meteoritics as Visual Metaphors." And after the meeting, MONTANARI (Osservatorio Geologico di Coldigioco) guided a field trip to meteorite impact sites in Italy, including the famous Gubbio K/T boundary, where he had been part of the team to first discover the iridium layers hinting at a giant impact cause for mass extinctions 65 million years ago.

For all of its scientific accomplishments, however, the meeting will be remembered most by the attendees for an event that happened thousands of miles away from Rome: the tragic terrorist attacks in the United States on 11 September, the Tuesday of the meeting week. The sad news was announced to conference participants at 17:00 hours, Rome time. The next day, Wednesday, had already been set aside for a morning Papal Audience. More than 400 conference attendees, family members, and guests joined a silent crowd of 50,000 gathered in St. Peter's Square as prayers for peace were offered by the Pontiff. Listening to the Pope, surrounded by monuments to the tragedies and triumphs of Rome's two–thousand–year–old history, helped put the terrible news in perspective.

At the meeting banquet held Thursday in Rome's Trastevere section, Dava SOBEL lectured on her highly acclaimed book, *Galileo's Daughter,* and reminded the attendees of the significance of science in a world of good and evil. The era of Galileo was one of terrible plagues and bitter conflictthe Thirty Years' War was the backdrop of his famous trialand yet the achievements from those days that remain fixed in our memory are those of the great artists and scientists: Shakespeare and Milton; Caravaggio and Bernini; Galileo and Kepler. She reminded the assembled scientists and their guests that to understand the natural universe and our place in it represents a part of the highest achievement of the human spirit; one that remains when wars and hatred are long forgotten.

The Large Binocular Telescope Board met at the Vatican Observatory at Castel Gandolfo from 29 June to 1 July.

The Clavius Group of Mathematicians, a community of Jesuits, other religious, and lay persons co–founded by WHITMAN in 1963, held its 39th meeting from 1 to 28 July at the Institute for Advanced Study in Princeton, New Jersey. WHITMAN gave a series of 10 lectures on "Low Dimensional Isomorphisms of Simple Complex Lie Algebras and Spin Representations."

In October the Vatican Observatory at Castel Gandolfo hosted the meeting of the International Planetarium Society with the participation of 21 regional associations. The meeting was coordinated by CONSOLMAGNO.

Presentations and Academic Activities

BOYLE Worked in January with PHILIP at Union College in Schenectady, New York, and he presented a colloquium there on "From the Colors of the Stars." Presented several lectures on data reduction and CCD image processing techniques and coordinated the expanded computer network for the students at the Vatican Observatory Summer School. Taught at a summer school on "CCD Observing and Image Processing" in Antalya, Turkey from 25–29 June at a national school for 49 graduate students in astronomy who came from five regions of Turkey. He was part of a faculty that included three Americans, a Russian, and a Lithuanian. During the school he also visited the Turkish national telescope in the mountains outside of Antalya.

CARUANA Gave a paper entitled "Possible Responses of Jesuits in Science to Critical Post–Modern Culture" at the First International Conference for Jesuits in Science, Chennai, India in January. Participated in the Seventh European Meeting of Jesuits in Science held at Malaga, Spain. Presented the annual course "Philosophy of Science and Nature" at the Philosophy Faculty, Pontifical Gregorian University, Rome. Directed a seminar on the nature of science according to Pierre Duhem and Alfred North Whitehead for graduate students at the same university.

CASANOVAS Lectured in Livorno, Italy, at the Museum of Natural History on the Star of Bethlehem. Participated in the dedication of a new solar telescope in the Observatorio del Ebro, Spain. Conducted a survey of the Greek island of Tynos for the installation of a solar telescope for the measurement of solar oscillations. Lectured on Fr. Angelo Secchi on the occasion of the publication of the correspondence between Secchi and astronomer Tacchini. Participated in the Workshop on the Solar Orbiter Satellite held in Puerto de la Cruz, Tenerife, Spain. Gave a paper on the problem of precession in the Alfonsine Tables at the meeting on "Cosmology Through Time," held in the observatory of Monte Porzio, Italy. Gave a course in Solar Physics for PhD candidates in the Observatorio del Ebro of the University Ramon Llull, Barcelona. Participated in the conference on Tycho Brahe, Prague, Czech Republic.

CONSOLMAGNO Continued to serve as secretary of Commission 16 of the International Astronomical

Union. As part of his duties he created and maintained the Commission 16 web site. Continued to serve as a member of the Division of Planetary Sciences (DPS) Committee of the American Astronomical Society (AAS) Committee. In addition to his regular duties on this committee, he also visited Cambridge, England, from 31 January to 2 February to inspect the proposed site of the 2005 DPS meeting, and from 14–15 August attended a special meeting of this committee at the AAS headquarters in Washington, DC, including a meeting at NASA headquarters with Code S administrators. Spoke on "Asteroid Densities and Porosities" at the following venues: Inter–University Center for Astronomy and Astrophysics, Pune, India; Northern Illinois University, Department of Physics; American Museum of Natural Science, New York; California Institute of Technology, Division of Geological and Planetary Sciences, Pasadena, California; Physics Department, Purdue University, Lafayette, Indiana. Spoke on "Rethinking the Lunar Magma Ocean" at the following venues: Physics Department, Drexel University; Department of Terrestrial Magnetism, Carnegie Institute of Washington. Worked at the Field Museum in Chicago with BRITT (University of Tennessee), WADHWA (Field Museum), and WILKISON (Northwestern University) to set up the helium pycnometer described in previous annual reports, in order to begin measurements of the grain densities and porosities in the Field Museum Collection. Paid a working visit to the University of Texas (Austin) to work with COCHRIN, SCHAEFER, and SCHAEFER. Worked on the measurement of meteorite bulk densities with MCCOY and MACPHERSON at the Smithsonian Institution, Natural History Museum, Washington, DC. Visited the Natural History Museum, London, to prepare meteorite sample thin sections and consult with RUSSELL.

CORBALLY Was reappointed President of the Institute on Religion in an Age of Science for the year 2001–2002. He chaired council meetings in January at Manchester Village, Vermont, and in July at Durham, New Hampshire, and he chaired the annual meeting on Star Island, New Hampshire. Presented a lecture on "The Stars of Yesterday and Today: Young and Old" at the Vatican Observatory Foundation seminar in February. Visited the Raytheon Optical Discussion Group, Tucson, to talk on "The Vatican's Little–Big Telescope." Collaborated with Steward Observatory and Mt. Graham International Observatory personnel to improve outdoor lighting code in the Gila Valley. Continued on the Board of the St. Albert the Great Forum at the Catholic Newman Center, University of Arizona.

COYNE Served on the Organizing Committee and participated in the Third Meeting on the Inspiration of Astronomical Phenomena in Palermo, Sicily. On the occasion of the meeting he gave a public lecture entitled, "Modern Cosmology and the Image of God, Creator of the Universe." Participated in the Council meetings and in the Plenary Session of the Pontifical Academy of Sciences where he presented a paper entitled, "Modern Cosmology, A Source for Elementary School Education." As a member of the Board met with the International Center for Relativistic Astrophysics at Stanford University. Was confirmed for another three–year appointment on the Advisory Council of the Centre for Studies in Religion and Society, University of Victoria, Canada and participated by teleconference in the Council meeting. Met at Georgetown University with the founding members of the Institute for Advanced Catholic Studies. As a member of the Advisory Board of the Peter Gruber Foundation Cosmology Prize participated at Bern, Switzerland, in the Prize Award to Martin Rees. Gave a seminar on "Big Telescopes of the Future" at the Astronomy Department of the University of Minnesota. Gave a paper on "Galileo: The Myth and Attempts by the Church to Dispel Them" at the meeting at the Observatory of Rome at Monte Porzio Catone, Italy, on "Cosmology Through Time." Gave a paper on "Science and the Search for Ultimate Meaning in the Thought of John Paul II" at the Templeton Foundation Workshop on Science and Religion at Pune, India. Continues to serve on the "Science and Human Values Program" of the European Science Foundation. Taught the course, Natural Sciences 102, during Spring Semester at the University of Arizona.

FUNES Observed at the 0.9m telescope at Cerro Tololo Inter–American Observatory, Chile, in May and September. Eleven nights in total were awarded to the project on "Star Formation in the Local Universe." Gave a talk on that project at the 18th Steward Observatory Internal Symposium, held in Tucson on 1–2 November. At the Universidad Catolica de Cordoba, Argentina, he lectured on "Astronomy and Faith" to the faculty and gave lectures to students of the School of Engineering, School of Philosophy, and the School of Agriculture and Animal Sciences.

HELLER Participated at the following meetings in Cracow, Poland: Seventh Cracow Methodological Conference "Chance and Necessity" with a paper on "Origin of Probability"; International Conference "Quantum Theory and Symmetries" with a paper on "Generalized Symmetries and Time"; Historians of

Science Conference with a paper on "Remarks on the History and Philosophy of Science." At Warsaw at the International School he spoke on "Noncommutative Geometry and Quantum Groups" and gave the Staszic Memorial Lecture on "Structure of the Initial Singularity." For the symposium at Lublin, Poland, on "Limits of Naturalism" gave a paper on "Is Christian Naturalism Possible?" For the symposium at Toruñ, Poland, on "Logos and Chaos" gave a paper on "The Universe as a Whole."

MAFFEO Gave a talk on "Father Angelo Secchi and Meteorology" to the Central Institute of Agrarian Ecology at the Institute's offices in the one–time Roman College where Secchi carried out his research. Completed further research in the Observatory archives that resulted in a much enlarged edition of his original history of the Observatory (see Sec. IV. Publications, under MAFFEO).

O'DONOGHUE Participated in January at a workshop of the Science and the Spiritual Quest II program in Paris, France. She gave a short talk and engaged in three days of intense discussions with the physics and cosmology group. In October, attended a public conference held at Harvard Memorial Church, Boston, entitled "The Quest for Truth, Knowledge, and Values in Science and Religion."

OMIZZOLO Is working as representative of the bishop of Padua, Italy, to create a group to investigate the relationship between faith and science. The group will include the Diocese of Padua and various departments of the University of Padua. The group's coordinator is RAFANELLI, director of the university's Department of Astronomy.

STOEGER Continues to team–teach the "Science and Theology" course in the Molecular and Cellular Biology Department, University of Arizona, with professors LINDELL and HEWLETT. Convened and chaired the Theology and the Natural Sciences continuing group session at the Catholic Theological Society of America meeting in Milwaukee, Wisconsin, June 7–10. Attended in January the workshop of the Science and Religion Course Program of the Center for Theology and Natural Sciences at Luther College in Adelaide, Australia, where he gave two invited presentations: "Cosmology and a Theology of Creation" and "Science, the Laws of Nature and Divine Action." Participated in a panel at Flinders University, Adelaide. On February 26 participated as an examiner in a dissertation defense on theology and science at St. Paul's University in Ottawa, Ontario, Canada. Gave lectures on "General Relativity and Black Holes" during the first ten days of the Vatican Observatory Summer School in Castel Gandolfo, Italy. Attended the 16th International Conference on General Relativity and Gravitation at the International Conference Centre in Durban, South Africa, July 15–21, presenting a paper there with ARAÚJO on "Perturbed Spherically Symmetric Dust Solution of the Einstein Field Equations in Observational Coordinates with Cosmological Data Functions." Afterwards he participated in the "Early Universe Cosmology" workshop in Cape Town, South Africa, July 22–26. In late August was an invited participant at the "Anthropic Arguments in Cosmology" workshop at the home of Sir Martin REES in Cambridge, U. K., where he presented a paper, "Are Anthropic Arguments Legitimate?"

Public and Educational Outreach

CARREIRA Gave a series of six lectures, sponsored by the Physics Department of John Carroll University in Cleveland, Ohio, on milestones in the development of the physical world from the "Beginning of Time" to "The Space Age."

CARUANA Gave a talk entitled "Natura e Divinità: loro mutua implicanza" at the Sala Convegni della Cassa di Risparmio, Florence, as part of an ongoing cultural seminar on Nature and Culture, organized by the group Eumeswil.

CONSOLMAGNO Gave popular astronomy presentations at the following venues: Capricon Science Fiction Convention, Chicago, Illinois; Library of Science and Technology, New York City; Astronomical Society of Long Island, New York; Vatican Observatory Foundation Seminar, Tucson, Arizona; Rose Center/Hayden Planetarium, New York City; Adler Planetarium, Chicago; Web Broadcast from University of Wisconsin and a presentation at the Madison, Wisconsin, "Space Place" Museum; Amateur Astronomy Association of New York City; Windycon Science Fiction Convention, Chicago; Sun City Astronomy Club, Tucson, Arizona. Gave presentations on the interrelations between science and religion at the following venues: De Nobili College, Pune, India; Harvard University Society of Physics Students, Cambridge, Massachusetts; MIT Catholic Community, Cambridge, Massachusetts; Templeton Lecture, Loyola University of New Orleans, Louisiana; Stonyhurst College, England; Drexel University, Philadelphia, Pennsylvania; Templeton Lecture, Purdue University, Lafayette, Indiana.

CORBALLY Spoke in Tucson on three occasions sponsored by the Knights of Columbus: to St. Thomas the Apostle parish on "Stars and the Vatican"; to St. Joseph and to St. Francis de Sales parishes on "The Pope's Scope in Arizona." Gave talks to the sixth and seventh grade students of Immaculate Heart Middle School, Tucson, also on "The Pope's Scope in Arizona." Spoke to three classes at Marana High School, Arizona, for the careers awareness program. Gave lunchtime talks to the Optimists Club, Tucson, on "The Vatican Observatory" and to the Serra Club, Tucson, on "The Heavens Declare the Glory of God." Gave a public lecture on "The Coolest, the Oldest, and the Prettiest Stars in Our Galaxy" for the Lyceum series sponsored by the New Mexico Military Institute, Roswell, New Mexico. Continued as an advisor to the Earth & Sky radio series. Was interviewed for two astronomy projects at University of Arizona. Hosted various visits to the VATT on Mt. Graham: with O'DONOGHUE, a nighttime visit by the docents of Discovery Park, Safford; two Dark Sky Parties for civic leaders from Graham County and local cities; and a daytime visit with COYNE for clergy and staff from the Diocese of Tucson Chancery. Hosted various visits to the Steward Observatory Mirror Laboratory, including one for the Vice−Rector for Science from the Silesian University of Technology, Gliwice, Poland, and another for sixty fifth−grade students from Lafe Nelson Elementary School, Safford.

COYNE Gave two lectures at the Istituto L. Murialdo, Albano, Italy, on "Modern Cosmology and the Image of God the Creator." Spoke at the Capitoline Museum, Rome, on the search for extra−solar planets. Spoke on the "Origins of Life in the Universe" at the annual meeting of Las Servidoras, Santa Maria de la Armonía, Cobo and Buenos Aires, Argentina. Gave talks in Scutari and Tirana, Albania, on the most recent developments in astrophysics. Talked to the "Spirit of the Senses Salons" in Phoenix, Arizona, on "Will the Universe Expand Forever?" Discussed "God and the Big Bang" with the physics seminar of that same title at Brophy Preparatory School, Phoenix. Spoke about the Galileo case to the Italian Cultural Society, Sun City, Tucson, Arizona. Gave a talk on "Wayfarers in the Universe" to the Centro Culturale Guglielmo da Volpiano, San Benigno (Turin), Italy. Presented the talk, "When the Sacred Cows of Religion and Science Meet," at the following venues: the Pierson Lecture at Mt. Olive College, North Carolina; Fraternità Sacerdotale dei Missionari di San Carlo Borromeo, Rome; keynote address at the meeting of the Association of Science−Technology Centers in Phoenix, Arizona; Christ Presbyterian Church, Tucson, Arizona; Santa Clara University, California; Tucson Children's Museum Mars Quest, Tucson, Arizona; Cosmos Club of Washington; Community School of Naples, Florida; Mt. St. Mary's College, Emmitsburg, Maryland; University of L'Aquila, Italy; the Phoenix Country Club, Arizona; Science and Culture Class, University of Arizona; Movimento Ecclesiale Impegno Culturale, Vercelli, Italy; Association of Amateur Astronomers, Rome, Italy; St. Thomas University, St. Paul, Minnesota.

FUNES Gave a public lecture on "The Origin of the Universe" at the Universidad Nacional del Nordeste, Corrientes, Argentina. Gave lectures to the general public with the title "Astronomía y fe: Dos aventuras del Espíritu" at the Iglesia Jesús Nazareno, Corrientes, Argentina and to Saint Cyril's Parish, Tucson.

HELLER Lectured on various occasions to the general public in Poland on recent developments in cosmology and on the philosophical and religious aspects of science.

O'DONOGHUE For the past two years, has written a semi−monthly column for the magazine of the Adirondack Mountain Club, *Adirondac*. Aimed at those with enthusiasm and interest, but little or no formal education in astronomy, the primary purpose of the column is to familiarize readers with the sky and keep them informed of the positions and motions of the planets and events such as conjunctions, eclipses, and other sky phenomena such as the Aurora. As the faculty advisor for the Saint Lawrence University Habitat for Humanity chapter, spent a week building houses in Anniston, Alabama, with a crew of 12 university students and 60 other students and advisors from other high schools and colleges, who chose to spend their spring break working to provide interest−free housing for economically challenged families.

STOEGER Spent 10 days in Kota Kinabalu, Sabah, Malaysia, during which he gave a 5−day retreat−seminar on theology and science to the priests, religious, and seminarians of the two dioceses of Saba; a day−long seminar on the same subject to the Catholic students at the University of Malaysia, Sabah; and a two−day series of lectures on theology and science to the Catholic laity of Kota Kinabalu. At Gonzaga University, Spokane, Washington, gave a Templeton Lecture, "Cosmology, Theology and Creation," and participated in both faculty and student colloquia. Gave a public lecture

on "Black Holes" at the Arizona Science Center in Phoenix.

TERES Gave lectures at many Hungarian universities and colleges on: "Modern Cosmology and Scripture," "Solar–Terrestrial Relations," and "History of the Vatican Observatory."

WHITMAN Continues to advise the Jesuit Social Center Presidente Kennedy in the city of Campinas in the State of São Paulo, Brazil. This work is part of the outreach of the Jesuit's mission to serve the Faith and Justice Apostolate of the Third World. The Center is doing a thorough revision of its mission, and in particular, is tooling up for a move into the twenty–first century in order to initiate a program in distance learning. This new program should be in place by early 2002.

News Media Contacts

BOYLE Was host to MOYNIHAN (*Inside the Vatican* magazine) during a visit to Castel Gandolfo.

CONSOLMAGNO Appeared in January on Italian television discussing Space in the Year 2001. Was filmed in February in Oxford, England, for a BBC/PBS Nova special based on the book *Galileo's Daughter* by Dava Sobel. Appeared with the author TIMOTHY FERRIS on the PBS television show *Uncommon Knowledge,* which was taped in February at the Hoover Institute of Stanford University, and aired in May. Was filmed at the VATT for the National Geographic Channel in April. Was interviewed in September by RAI (Italian National Television) discussing meteorites. Appeared on the syndicated radio programs "Religion with Brother Bernard Seif" on February 14, and "Dr. Sky" on May 31. Was interviewed in August for the series *The DNA Files,* which aired on Public Radio in November and December. Was interviewed by the *Times of India* in January; by *Catholic New World* (Chicago Diocese Catholic Newspaper) in March; and in *Corriere della Sera* (Milan daily) in September.

CORBALLY Provided interviews to the following journalists: Renée Houghton, *Texas Catholic*; Alexandra Foldarait, *Noticias,* Argentina, on the Christmas Star; Tim Dill, *KINF*, Roswell, New Mexico Answered questions from: Cara Conway, Georgetown University; Tom Stauffer, *Arizona Star*; Alison Rose for PTV Productions, Toronto, Canada; Alison Cherry, BBC Radio Scotland; Neal Buckley, *London Weekend Television*; Craig Smith, *National Geographic Cable Television.*

COYNE Provided interviews to the following media and journalists: RAI UNO "A Sua Immagine"; Roberta Rose of Cicada Film, Discovery Channel; Renée Horton for the *Texas Catholic*; Alison Rose for PTV Productions, Toronto, Canada; Vincent Gielly for TV 2 France, Paris; Fred Guterl, *Newsweek International*; Claudia Windisch–Graetz, Global Satellite Broadcasting Network; Axel Schnuch, *Der Spiegel*, Germany; Charles Seife, *Science*, Magazine of the American Association for the Advancement of Science; Marie–Pierre Olphand, *Ciel & Espace*, Paris; Allan Chapman, *Kugelblitz*, London; Patricia Briel, Basel Switzerland; Ralph Breier, Berlin, Germany; Klaus Bachman, *GEO Magazine*, Hamburg, Germany. Participated in the presentation by Gruppo Ugo Mursia Editore of the book by Giovanni Bignami, *La Storia nello Spazio*.

FUNES Provided interviews to the *San Diego Union Tribune*, to the weekly magazine *Noticias* of Buenos Aires, Argentina, and to Canal 13, Corrientes, Argentina.

HELLER Gave several interviews to various Polish newspapers, journals, radio, and television on the interaction among science, philosophy, and theology.

MAFFEO Provided assistance to Alison Rose for PTV Productions, Toronto, Canada during her filming at Castel Gandolfo in June and July.

O'DONOGHUE Has come to be familiar to listeners of North Country Public Radio (NCPR) of Canton, New York, which regularly invites her for short chats about astronomical and sky phenomena. Participated as a guest host for the NCPR "Readers and Writers on the Air" series of call–in discussions with authors of current books. She discussed *Galileo's Daughter* with the author Dava Sobel and the NCPR station manager and series director, Ellen Rocco. Annibale Fantoli, author of the Vatican Observatory Publication "Galileo: For Copernicanism and for the Church" also contributed to the discussion by phone from Victoria, Canada.

STOEGER Gave a radio interview in Adelaide, Australia, on the interaction between science and theology.

TERES Provided interviews to: Dunat TV and Zenit TV, Budapest; Local TV, Kecskemet; Remeny Radio, Pecs; Miskolc Radio; Vatican Radio, Rome.

International Meetings

31 December–6 January: Palermo, Sicily, Italy. Third Meeting on the Inspiration of Astronomical Phenomena. GEORGE V. COYNE, S.J. served on the Organizing Committee and gave a paper.

4–6 January: Chennai, India. International Jesuits in Science Conference. GUY CONSOLMAGNO, S.J. presented a paper.

7–11 January: San Diego, California. 197th Meeting of the American Astronomical Society. RICHARD BOYLE, S.J., and CHRISTOPHER CORBALLY, S.J. gave papers.

9–11 March: Tucson, Arizona. Annual Meeting 2001 of the International Dark–Sky Association. RICHARD BOYLE, S.J., and CHRISTOPHER CORBALLY, S.J. participated.

12–16 March: Houston, Texas. Thirty–second Lunar and Planetary Science Conference. GUY CONSOLMAGNO, S.J. was co–author of two presented papers.

11–15 June: Palermo, Sicily, Italy. Asteroids III. GUY CONSOLMAGNO, S.J. presented a paper.

17–20 June: Monte Porzio Catone, Italy. International Conference on "Cosmology Through Time." JUAN CASANOVAS, S.J. and GEORGE V. COYNE, S.J. gave papers.

28 July–4 August: Star Island, New Hampshire. Annual Conference of the Institute on Religion in an Age of Science. CHRISTOPHER CORBALLY, S.J. participated and chaired the IRAS Council and Annual Meeting.

5–9 September: Malaga, Spain. European Jesuits in Science. LOUIS CARUANA, S.J. and GEORGE V. COYNE, S.J. participated.

10–14 September: Rome, Italy. 64th Annual Meeting, Meteoritical Society. GUY CONSOLMAGNO, S.J. chaired and GEORGE V. COYNE, S.J. served on the Local Organizing Committee. CONSOLMAGNO was co–author on two papers.

5–8 November: Boston, Massachusetts. Geological Society of America, Annual Meeting. GUY CONSOLMAGNO, S.J. was co–author of a paper.

17–20 November: Denver, Colorado. Annual Meeting of the American Academy of Religion. CHRISTOPHER CORBALLY, S.J. presented awards at the Institute on Religion in an Age of Science's reception during the meeting.

19–21 November: Vatican City. Plenary Session of the Pontifical Academy of Sciences on the Challenges for Science Education for the Twenty–First Century. GEORGE V. COYNE, S.J. gave a paper.

27 November–1 December: New Orleans, Louisiana. Annual Meeting, Division for Planetary Sciences, American Astronomical Society. GUY CONSOLMAGNO, S.J. was co–author of two papers.

29 December–2 January: Pune, India. Workshop on Modern Science and Contemporary Religions. GEORGE V. COYNE, S.J. participated and gave a paper.

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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 at Castel Gandolfo.

Among the groups who visited the Observatory at Castel Gandolfo were: friends of Cardinal Avery Dulles, S.J., who visited with the Cardinal on the occasion of his becoming a Prince of the Church; a pilgrimage group from the Diocese of Down and Connor, Ireland, led by Bishop Patrick Walsh, an alumnus of the 1991 Summer School in Astrophysics for Bishops; and the alumni group of the University of Dallas, led by Richard Olenick, professor of physics.

We were privileged to have a visit from the newly appointed Ambassador to the Holy See from the United States, R. James Nicholson.

In connection with the annual meeting of the Meteoritical Society held in Rome 10–14 September, 65 members of the Meteoritical Society visited the Observatory in Castel Gandolfo.

The following individuals paid extended working visits to the Observatory:

AJOY K. DASGUPTA, South Glamorgan Education Department, Cardiff, UK

ROBERT JANUSZ, S.J., Cracow, Poland

ALGIS KAZLAUSKAS, Institute of Theoretical Physics and Astronomy, Vilnius, Lithuania

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

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

STEPHEN J. SHAWL, Department of Physics and Astronomy, University of Kansas, Lawrence, Kansas, USA

Among other professional guests at either Castel Gandolfo or Tucson during the year were:

DAN BRITT, University of Tennessee; GIOVANNI DEMARIA, University of Rome; DANIEL HEYNDERICKX, Belgian Institute for Space Aeronomy, Brussels, Belgium; C. RENEE JAMES, Sam Houston State University, Huntsville, Texas; OMAR KURTANIDZE, Republic of Georgia; JONATHAN LUNINE, University of Arizona; G. MACPHERSON, Smithsonian Institution, Natural History Museum; ADRIANA MARAS, University of Rome; DMITRI PAPANASTASSIOU, California Institute of Technology; ANNA GANNON RECCA, Manhasset, New York; PIERRE ROCHETTE. University of Aix–Marseille; WILLIAM RUEGER, Diocese of Brooklyn; FILIPPO SMRIGLIO, Department of Physics, University of Rome; RAMON D. WOLSTENCROFT, Royal Observatory, Edinburgh, UK; FRANK YOUNGER, Dominion Astrophysical Observatory, Victoria, Canada.

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