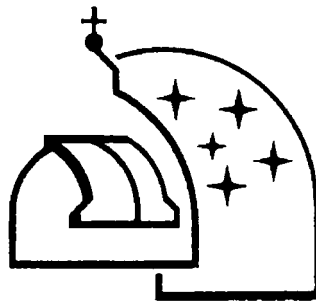


THE VATICAN OBSERVATORY

10
Celebrating the
Tenth Anniversary of the
Vatican Advanced
Technology Telescope

2003 ANNUAL REPORT

Vatican Observatory Annual Report 2003



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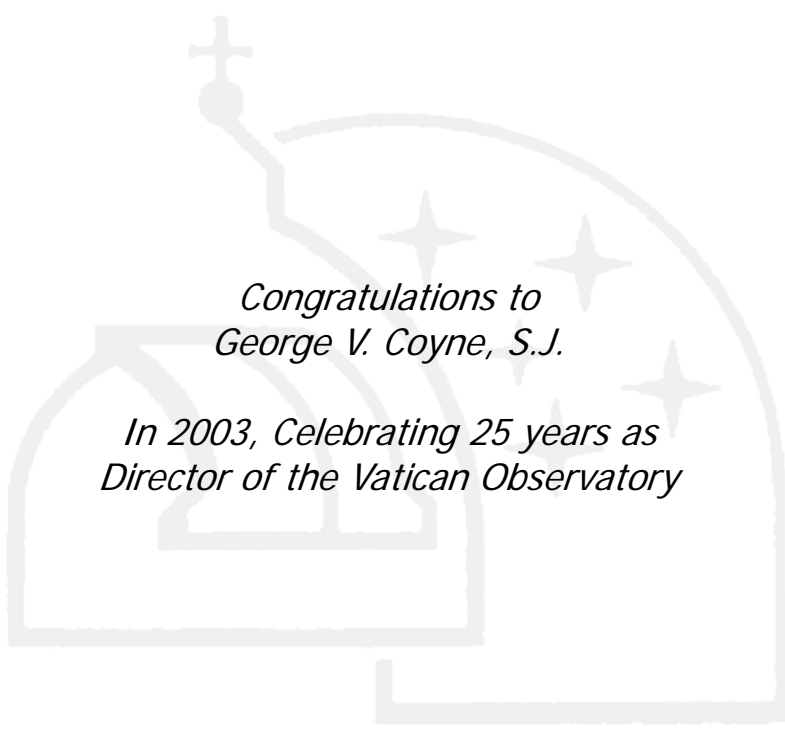
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VATICAN OBSERVATORY



*Congratulations to
George V. Coyne, S.J.*

*In 2003, Celebrating 25 years as
Director of the Vatican Observatory*

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***FRONT COVER** The Vatican Advanced Technology Telescope at the Mt. Graham International Observatory, Arizona. (Photo © David A. Harvey)*

***BACK COVER** Dedicatory plaque on the Vatican Advanced Technology Telescope, with English translation of the Latin text by Martin McCarthy, S.J.*

Editor: Elizabeth J. Maggio
Cover Artist: Dave Fischer

VATICAN OBSERVATORY

From the Director

Why Arizona...and Why the VATT?

In September 2003, the Vatican Observatory celebrated the tenth anniversary of the inauguration of the Vatican Advanced Technology Telescope. Called simply the VATT, this was the first optical/infrared telescope at the Mt. Graham International Observatory in the Pinaleno Mountains, about 135 miles northeast of Tucson near the town of Safford. The map on page 8 shows you where we are located.

As we celebrate a decade of research with the VATT, I would like to record the history that led up to the Observatory's decision to construct the VATT and to do so jointly with the University of Arizona's Steward Observatory. Since I have been Observatory director throughout most of the VATT's pre-history, I am in reality sharing with you my personal memoirs of those years.

The Story Begins with the Schmidt Telescope

To appreciate the events leading up to the VATT, we need to consider the momentous changes that occurred at the Observatory starting around the early 1960s. At that time, under Director Father Daniel O'Connell, S.J., the Observatory installed a Schmidt Telescope in the papal gardens adjacent to the Pope's summer residence in Castel Gandolfo where the Observatory has its headquarters. After a lengthy period of fine tuning and testing, the telescope began its research mission in 1962, primarily to classify stars according to their spectra. Like the VATT, the Schmidt was an advanced technology telescope: essentially an exquisite wide-angle camera to photograph the universe. It was among the largest of its kind in the world.

Father O'Connell's efforts to modernize the Observatory were aided by three young Jesuits—Father Patrick Treanor, S.J. of the United Kingdom, Father Florian Bertiau, S.J. of Belgium, and Father Martin McCarthy, S.J. of the United States—who had just joined the staff. These young astronomers were the first “new blood” for research at the Observatory in a number of decades.



Schmidt Telescope at Castel Gandolfo, inaugurated 16 November 1957.

I think the events described above represent a true renaissance for the Observatory after a rather protracted sleepy period. And it was marvelous! I lived through the later part of that period as a visiting researcher and temporary staff member starting in 1969. During my early tenure with the Specola, it became very clear to me that a most important element in the success of any observatory consists of access both to excellent instruments and to the brains with the know-how to employ those instruments for significant research. But the assistance of an excellent technical support staff is equally important. Providing technical support for the Schmidt Telescope was Brother Karl Treusch, S.J., who before he became a Jesuit had worked for many years as a mechanical engineer with the firm of Carl Zeiss of Jena, Germany, one of the most renowned companies in the world for the design and construction of telescopes and optical systems.

I was privileged to have witnessed the work of this team of Jesuits, all professionally trained and passionate about their trade. With the Schmidt Telescope, this team developed new techniques to use the spectra of stars to study their age, chemical composition, and motions. They made significant contributions to the study of the distribution of young and old stars in the Milky Way compared to nearby galaxies. In brief, they were on the front lines of research in astrophysics. They established a tradition that carries on today at the VATT.

But, as the saying goes, all good things come to an end. In the 1970s the Observatory began to face two serious problems. The first is a recurring one: youth is not eternal and at that time few, if any, young Jesuits were in training for work at the Observatory. Father Treanor, who had succeeded Father O'Connell as director, began recruiting. The second problem is the one whose resolution best explains why we have a research institute today in Arizona. The same artificial sky illumination from Rome's city lights that forced the Observatory to move to Castel Gandolfo in the 1930s, had once again encroached on the Observatory's telescopes by the 1970s. Continued use of the Schmidt Telescope, which as a wide-angle camera required the darkest skies possible, was threatened. Father Treanor and the Observatory staff began immediately to address this second problem and to search for alternative observing sites. It was the wish of Pope Paul VI, however, that they limit their search to Italian national territory.

The Search for a New Observatory Site Starts in Italy

The Vatican Observatory began looking for a new home in collaboration with Italian astronomers who were also seeking a site for a large Italian national telescope. Instrumentation for testing the quality of potential sites was built in the Observatory's shops. Extensive site-testing excursions were made, principally to mountainous areas on the island of Sardinia and in the Basilicata region of southern Italy. It soon became clear, however, that although better sites than Castel Gandolfo existed on Italian territory, none had sufficiently superior qualities to merit moving the Observatory's facilities there, especially the Schmidt Telescope. In fact, the Italian astronomers opted to build their national telescope, named for Galileo, on Spanish territory in the Canary Islands.

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Unfortunately, the Observatory's efforts to find a new home came to an abrupt halt in 1978 when both Pope Paul VI and Father Treanor passed away. Then the papal successor, John Paul I, died only 32 days after his election. During his brief reign, I was appointed Director of the Observatory, although because of obligations to my faculty position at the University of Arizona, I did not assume the position until 1980. In the meantime, however, I became aware of several young Jesuits, either already trained or being trained in astronomy, who were lurking in various parts of the world. Three of them, Richard Boyle, Christopher Corbally, and William Stoeger, are now members of the research staff. It became clear to me from the start that, if decisions regarding the future of the Observatory were to be made, they would have to be made in consort with these young Jesuits.

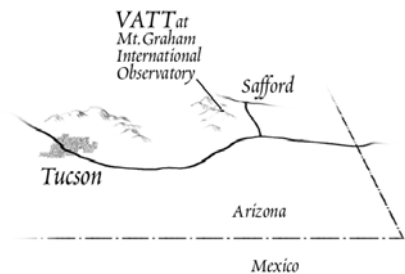
The Search for a New Site Resumes and Leads to Arizona

Over a period of time I visited each of the three prospective staff members, and together we planned for the Observatory's future. We considered several possibilities: move the Schmidt Telescope to the Canary Islands, and like the Italians did, become members of the international observatory in development there, or leave the telescope in Castel Gandolfo and join other European countries at the European Southern Observatory in northern Chile. But we chose a third option that also meant leaving the Schmidt Telescope in Castel Gandolfo: accept an invitation from the Department of Astronomy of the University of Arizona to establish a research institute of the Vatican Observatory in Tucson. The latter option

won out for the following principal reasons: Tucson was rapidly becoming one of the worldwide capitals for observational astronomy; several Observatory staff members had worked at various astronomical institutes in Tucson over a period of years; and for an annual fee, we would be hosted by the University of Arizona with office space and full access to staff support and observing facilities, but we would remain an independent research institute. Aside from Tucson's growing astronomical reputation, the University of Arizona option was the least costly of the three we considered; no capital investment was needed in buildings, telescopes, or other equipment. So with the enthusiastic support of the Vatican and a projected 10% annual increase in the Observatory budget, we founded in 1980 the Vatican Observatory Research Institute (VORG) in Tucson while maintaining our headquarters at Castel Gandolfo.

The VATT Becomes An Unexpected Dream Come True

We hadn't planned to build a telescope in Arizona when we established the VORG. But in 1985 the university offered us the opportunity to join them in constructing an advanced technology telescope that would be the first instrument to use a lightweight pri



Location map for the Vatican Advanced Technology Telescope at the Mt. Graham International Observatory, Arizona.

mary mirror created out of borosilicate glass that is melted, molded, and spun into shape in a specially designed rotating oven. This innovative spin-casting technique had been in development over a number of years at Steward Observatory, and the astronomers were ready to make their first research-grade mirror. We were flattered and tempted by an invitation to join in a partnership on the front lines of modern astronomy. But we would have to find about \$4 million dollars! The prospect of having our own modern telescope on one of the best observing sites in the world, Mt. Graham, was far too attractive. And so like children with joyous dreams of a new tree house in the backyard, and despite our original anticipation of needing no capital investment when we chose the Arizona option for our move, we established the Vatican Observatory Foundation in 1987 to begin raising the necessary funds. And with the generous help of many friends and the full support of the Vatican, we succeeded. The Vatican Advanced Technology Telescope is a dream come true. On pages 14-15 is a timeline for the construction of the telescope.

The VATT alone, however, will not secure the future of the Observatory. Young Jesuit astronomers are required to continue the work of the existing staff. Here too we have fond hopes for the future. As described later in this section under Personnel News, a young Jesuit from the Republic of the Congo has recently joined our staff. And we have regular contact with four other young Jesuits, from the Czech Republic, India, Italy, and the United States, with the prospect that they may one day join us.

Final Thoughts

In closing these reminiscences about how the VATT came to be, I am reminded of the story of the founding of the first major observatory in Southern Arizona, the Kitt Peak National Observatory, on Kitt Peak, a mountain sacred to the Tohono O’odham Native Americans. In the course of the treaty agreements between the U.S. government and the Tohono O’odham peoples it was discovered that they had no word for “astronomer.” The tribe lived under the beautiful skies of Arizona, but it had no word for those who study the skies scientifically. So in order to complete written agreements, they invented in their own language an expression for “astronomers.” Transliterated into English the expression means “The People with Long Eyes,” a perfect image that suits the Vatican Observatory astronomers as well. We must have glass and metal and—yes—money to build new telescopes, but what we build is an extension of our eyes, of our curiosity to understand the universe and ourselves in it. We are deeply grateful to the many friends who have had the “long eyes” to help us, and we firmly trust that young Jesuits with “long eyes” will join us in this marvelous adventure of seeking to understand the universe in which we live by using such magnificent telescopes as the VATT.

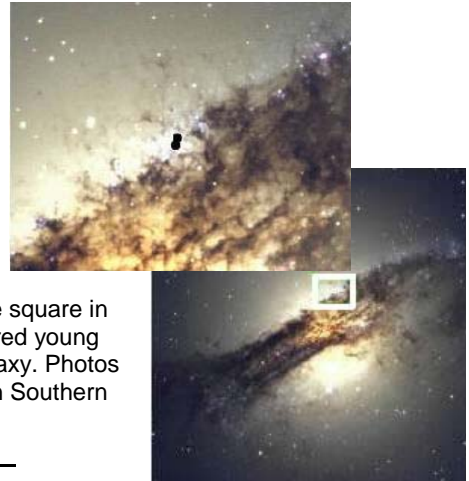
Research Highlights

As we celebrate the tenth anniversary of the inauguration of the VATT, we invite our friends to review the highlights of our past research that have been recorded in previous Annual Reports. Here we add highlights of the most recent studies by Vatican Observa-

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tory astronomers. Each highlight is reported in more detail in section I. Astronomical Research.

- One of the most exciting fields of modern research is the search for planets outside the Solar System. At last count about 120 planets have been discovered. From his spectral studies, Chris Corbally, along with his collaborators, has found that although stars with planets have about the same abundance of heavier elements as our Sun, they have more heavier elements than other Sun-like stars without planets in the local neighborhood of the Galaxy (within about 130 light years of the Sun). Is the higher heavy element abundance favorable for a star to have planets? Is it the result of having planets? Is it at least a signature that there are planets? There are chapters still to be written in this exciting venture.
- To understand the formation, structure, and evolution of galaxies, one must try to understand the formation of star clusters within them. José Funes, along with his collaborators, has discovered two massive young clusters in a nearby giant elliptical galaxy in the constellation of Centaurus. Spectroscopic data reveal that these clusters will merge into one and form a massive globular cluster. This may be one of the few times that we are getting clues to the origins of massive globular clusters, which are a key to understanding galaxy formation. By the way, Funes and his collaborators are all alumni of the Vatican Observatory Summer Schools (VOSS): Dante Minniti (VOSS '86), Marina Rejkuba (VOSS '97), Robert Kennicutt (faculty VOSS '03), and Funes (VOSS '93, faculty VOSS '03).



Black dots in upper photo, an enlargement of the white square in bottom image, show location of the two newly discovered young star clusters in NGC 5128, a southern hemisphere galaxy. Photos taken using the Very Large Telescope at the European Southern Observatory in Chile.

- Sometimes astrophysical research with modern instruments so outpaces classical research that the results of bygone days are forgotten. This is not the case for a group of astronomers, including Alessandro Omizzolo, who are exploring the plate archives of several observatories, the Vatican Observatory included, to extract data that has long been concealed there. Through the use of modern electronic methods for careful scanning and digitalization of images on the plates, these researchers are obtaining some magnificent results, such as the variation of the energy output of quasars over as much as 25 years. Such results will undoubtedly help to understand these enigmatic objects, which are closely related to the formation of structure in the universe.

- The origin of the Moon has always been a much-debated topic. The most acceptable theory is that a collision of a Mars-sized planetesimal (often called “Theia”) with the newly formed Earth splashed out terrestrial material that then congealed to form the Moon. However, recent models suggest the bulk majority of the material that formed the Moon came from the impacting object and not from the Earth. Guy Consolmagno has noted that the impacting object must have already separated out its material into a crust, and below it, a mantle and an iron core. Thus by Consolmagno’s model, the Moon must have formed out of mostly crustal material from the impacting object and, therefore, have a chemical composition that is much different from the average composition of undifferentiated Solar System material. This coincides with recent work by Consolmagno and others who have used lunar meteorites and lunar orbiter data to re-evaluate the chemical composition of the Moon and its early evolution.
- Cosmologists are increasingly interested in the possible existence of a “multiverse” that is much larger than our visible universe and which could contain many other universes or universe domains. Quantum cosmology considerations indicate that this multiverse would be the natural result of the beginning-of-everything in an inflationary expansion after the Big Bang. Along with his colleagues, William Stoeger is using fundamental quantum cosmology to study the difference, conceptually speaking, between the collection of all possible universes and any ensemble of really existing universes. He is also exploring ways in which all of these rather exotic considerations might be tested.
- It is now known that about 90% of the matter in the universe does not radiate. This is the so-called dark matter whose nature is not known. It is expected that there are several types of dark matter in the universe. Over a number of years, Richard Boyle has been working on a research program designed by Arlin Crotts of Columbia University, New York, to use the VATT to detect compact non-radiating but gravitationally lensing objects known as MACHOS (Massive Compact Halo Objects) in the halo of our neighboring galaxy. So far the results indicate that a significant amount of the dark matter there consists of objects with masses similar to stars. What are they? The mystery goes on.

Vatican Observatory Summer School

The Ninth Vatican Observatory Summer School (VOSS) in Observational Astronomy and Astrophysics was held at the Observatory in Castel Gandolfo from 15 June to 11 July. The topic of the 2003 School, “Observations and Theoretical Understanding of Galaxy Evolution: From the Local to the Distant Universe,” attracted 25 students from 20 countries. José G. Funes, S.J. served as Dean of the School. The faculty included: Enrico M. Corsini, Department of Astronomy, University of Padua; Robert C. Kennicutt, Steward Observatory, University of Arizona; Leonidas Matsoukas, Space Telescope Science Institute, Baltimore; Francesca Matteucci, Department of Astronomy,

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University of Trieste; Hans-Walter Rix, Max-Planck-Institut für Astronomie, Heidelberg; Rachel Somerville, Space Telescope Science Institute, Baltimore. On 4 July His Holiness John Paul II received the group in St. Peter's Square at the termination of the General Audience. The young scholars were joined at the audience by the guests of the Vatican Observatory Foundation.

VOSS '03 students on a field trip to the 92/67-cm Schmidt Telescope at the Asiago Observatory. (Photo by Alessandro Omizzolo)



Personnel News

Giuseppe Koch, S.J., was appointed Vice Director for Administration and replaces in this office Sabino Maffeo, S.J., who assumes the office of Assistant to the Director.

Jean-Baptiste Kikwaya, S.J., of the Jesuit Province of Central Africa (Democratic Republic of the Congo) has been assigned as an astronomer to the staff of the Observatory. In 2000, he completed his *Diplome d'Etudes Approfondies*, a requirement to begin doctoral studies in France, in astronomy at the Paris Observatory with a thesis on asteroid satellites. He is currently pursuing a doctorate in astronomy at the University of Western Ontario, London, Ontario, Canada.

José Funes, S.J. was appointed Adjunct Assistant Astronomer in Steward Observatory.

At the International Astronomical Union (IAU) XXV General Assembly in Sydney, Australia, members of the Vatican Observatory took on several positions for the next triennium. Guy Consolmagno, S.J., was elected President of Commission 16, Physical Study of Planets and Satellites, and appointed Secretary of Division III. Similarly, Christopher Corbally, S.J., was elected President of Commission 45, Stellar Classification, and so is also serving on the Organizing Committee of Division IV. He continues as Chairman of the Working Group on Standard Stars. In preparation for the next IAU General Assembly, Corbally has also been appointed Chairman of the Resolutions Committee. José Funes, S.J., became National Liaison for the Vatican City State to Commission 46, Astronomy Education and Development, taking over this post from Corbally.

We were saddened by the death of Charles W. Polzer, S.J., on 4 November at Los Gatos, California. He served for many years on the Board of Directors of the Vatican

Observatory Foundation. In the early years of VORG in Tucson, he kindly accommodated the Jesuit astronomers at the Jesuit Residence, Kino House, which he founded.

We rejoice with George J. Goudreau, Sr., a generous benefactor with his deceased wife Lenore of the Vatican Observatory Foundation, on the celebration of his 100th birthday on 11 April. On a trip to Cleveland about one month before the magic date, George V. Coyne, S.J., the Foundation President, joined him and his family for a celebration.

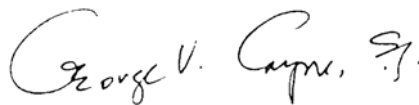
Vatican Observatory Foundation Annual Meeting

The annual meeting of the members and directors of the Vatican Observatory Foundation was held on 28 February 2003 in Tucson, Arizona. The following were elected to serve as members and directors for a three-year period: RICHARD P. BOYLE, S.J.; MICHAEL A. CRONIN; CHARLES L. CURRIE, S.J.; KAREN DALBY; SHEILA GRINELL; ROCCO L. MARTINO; and BRENDAN D. THOMSON. PAUL M. HENKELS was elected Chairman of the Board, and MANUEL J. ESPINOZA was named Chair of the Investment Committee. GEORGE V. COYNE, S.J., remains as President of the Foundation.

On the day preceding the Foundation's annual meeting, members of the Observatory staff conducted a seminar 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 for an excursion to the Mt. Graham International Observatory, where the Vatican Advanced Technology Telescope is located. Through the efforts of NANCY KNOCHE, Development Director, and JAMES MCGEE, Chair of the Development Committee, the Foundation continues the two giving plans announced in previous Annual Reports: the *Circles of Giving* and "*Reaching for the Heavens*" *Guild Memberships*. A Capital Campaign has been inaugurated, with ROCCO L. MARTINO as Chairperson. The Campaign's first major initiative, scheduled for May 2004, is a pilgrimage to the Vatican for major donors with a personal visit to the Pope.

Once again through the efforts of BRENDAN D. THOMSON, Board Member, an official Vatican Observatory calendar for 2004 has been produced with the theme "A Universe for All Persons."

A visit to Rome, the Vatican, and the Vatican Observatory at Castel Gandolfo was organized for friends of the Foundation from 29 June to 6 July by CARLA KEEGAN, President of KKK, the Foundation's accounting firm, with the assistance of NANCY KNOCHE, the Foundation's Development Director.



George V. Coyne, S.J., Director

VATICAN OBSERVATORY

Construction Timeline Vatican Advanced Technology Telescope

1983 *Site testing begins on Mount Graham (photo 1).*

1985 *March: Spin-casting of 1.8-meter primary mirror in Steward Observatory Mirror Lab (photo 2).; Vatican Observatory and Steward Observatory agree to use mirror in a joint telescope.*

1986 *September: Incorporation of Vatican Observatory Foundation as a nonprofit. November: Design of telescope begins.*

1987 *March: First fundraising campaign begins.*

1988 *July: Contract for telescope mount with L&F Industries. November: Arizona-Idaho Conservation Act authorizes construction on Mt. Graham.*

1989 *January: Second fundraising campaign begins. Grand total raised: \$6.5 million. February: Design of astrophysics facility begins. May: Contract for secondary mirror with Space Optics Research Labs.*

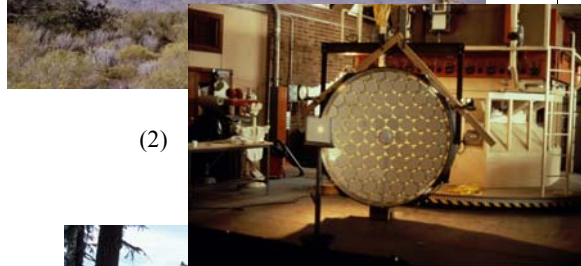
1990 *February: Telescope mount delivered to test facility near Tucson. October: Contract with T.L. Roof signed and site clearing for astrophysics facility on Mount Graham begins (photo 3).*

1991 *November: Steward Observatory completes polishing of primary mirror.*

1992 *April: Construction resumes on Mount Graham after weather delays (photo 4). May: Polishing of secondary mirror completed. October: Telescope mount and dome installed on Mount Graham.*



(1)



(2)



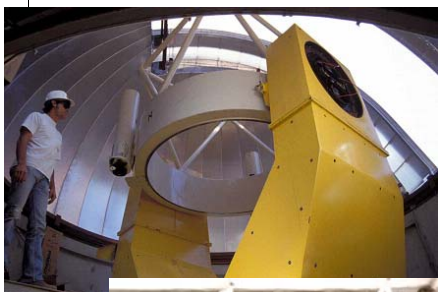
(3)



(4)

A Milestone Year

1993



(5)

March: VATT ready for installation of scientific equipment and primary mirror (photo 5).

15 September: First light with primary mirror in place and beginning of commissioning phase.

18 September: VATT dedication on Mt. Graham, attended by family members of principal benefactors, Thomas J. Bannan and Fred A. Lennon. Photo 6: holding dedication plaque are, left, Karen Dalby, granddaughter of Bannan; right, John Lennon and Catherine (Lennon) Lozick, son and daughter of Lennon.

(6)



12 July: second light with secondary mirror in place.

1994

January: Scientific observations begin (photo 7 © David A. Harvey 2004).

1995



(7)

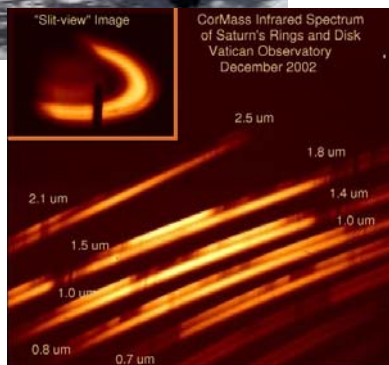
March: Kresge Science Initiative Grant starts; brings VATT close to planned optical and mechanical performance and reliability.

1999

December: In collaboration with University of Virginia, installation of CorMASS (Cornell Massachusetts Slit Spectrograph) on the VATT. Usable in bright of moon, this instrument nearly doubles available observing time. Initial CorMASS/VATT observations produce an infrared spectrum of Saturn's rings and disk (photo 8, courtesy of J. Wilson and M. Skrutskie, U. of Virginia; J.D. Smith, U. of Arizona; C. Henderson, Cornell University; and M. Nelson, Vatican Observatory).

2002

(8)



18 September: Tenth Anniversary of the VATT. 2003

(Thanks to Lori Stiles, Office of Public Information, University of Arizona, and Christopher Corbally, S.J., for preparing this chronology.)

I. Astronomical Research

Theoretical Studies, Astrophysics, and Cosmology

In collaboration with the group of mathematicians of Warsaw Technical University, HELLER continued the program on applications of noncommutative geometry to physics. They have made substantial progress in constructing a model unifying general relativity and quantum mechanics. Since the model is based on a finite group, it was possible to compute it in all its details, resulting in clarification of several problems encountered in previous work.

HELLER continues to research the status of time in relativistic cosmology and, in particular, in fundamental theories based on noncommutative geometry. In the latter theories, time is not given *a priori* but emerges out of the primordial atemporal (and a-spacial) physics. He is also working on the problems, both technical and conceptual, connected with the Majid program to construct the fundamental physical theory based on the theory of quantum groups.

STOEGER and ARAÚJO (Universidade Federal do Rio de Janeiro) are nearing completion of their project of specifying and implementing a detailed procedure for solving the Einstein field equations in observational coordinates with cosmological data functions for general perturbations to Friedmann-Lemaître-Robertson-Walker (FLRW) cosmological models. This includes both the case in which there is just dust (pressure-free matter) and the more difficult case in which there is both dust and vacuum energy (a cosmological constant).

STOEGER AND RIBEIRO (Physics Institute, Universidade Federal do Rio de Janeiro) are beginning to extend their completed work, relating galaxy luminosity functions to relativistic energy density and to number counts in the case of Einstein de Sitter cosmologies (flat universe models), to other FLRW cases, including those with a non-zero cosmological constant (vacuum energy). Once that is finished, they will be applying their approach to Lemaître-Bondi-Tolman cosmological models (which are isotropic, but not spatially homogeneous) and to perturbed-FLRW models. They also are beginning to investigate how to include improved models of galaxy number and luminosity evolution in their procedure.

Following up on earlier work he did with ELLIS, DUNSBY, and McEWAN (Department of Mathematics, University of Cape Town), STOEGER is continuing his investigations of mixed radiation-vacuum energy epochs in the very early universe, just after the Planck era and just before inflation. This study hopefully will shed further light on the constraints that adequate inflation places on the relative amounts of radiation and vacuum energy at these early times and, therefore, on some of the conditions necessary for inflation itself. Connected with this work, STOEGER is also pursuing research on

the very difficult question of how possible Planck-era processes could set the size and the requisite smoothness for the pre-inflationary patch from which our universe evolved. This requires careful consideration of time and causality during the Planck (quantum cosmology) era itself—issues that are far from resolved in quantum cosmology.

Closely connected with these efforts, STOEGER has been participating with ELLIS, MURUGAN, and TSAGAS (Department of Mathematics, University of Cape Town) in working out the details of how an inflationary universe, with a single minimally coupled scalar field having a physically acceptable potential, can begin from an initial asymptotic Einstein static state (without a singularity) and emerge after inflation into a standard hot Big Bang evolutionary phase. It appears that none of the characteristics of the model is at odds with current observational constraints.

ELLIS and KIRCHNER (Department of Mathematics, University of Cape Town), with STOEGER, have completed preliminary work on the cosmology of multiverses, which are ensembles of many universes or universe domains. These have received a great deal of attention recently, both as the natural outcome of the originating process that generated our own universe, and as an explanation for why our universe appears to be fine-tuned for life and consciousness. In their work so far, they have carefully considered how multiverses should be defined, stressing the distinction between the collection of all possible universes and ensembles of really existing universes. It is only ensembles of really existing universes that provide a possible resolution to the fine-tuning problem. Furthermore, it is very clear that such realized multiverses are by no means unique. To define them adequately, a proper measure on the space of all really existing universes or universe domains is required, so that probabilities can be calculated. And for each such multiverse a distribution function is also needed to specify which, and how many of each, possible universes are realized. Physically, this means there must be a cosmogonic process, such as Andrei Linde's "chaotic inflation," which is capable of generating the really existing multiverse with its given distribution function describing the variety of universes it contains. This indicates that any really existing multiverse we consider must have some common generating mechanism or process. It appears, furthermore, that really existing universes cannot have an infinite number of members, since there are strong philosophical arguments against any realized infinity. Infinity is not a specifiable number that can be concretely instantiated.

Finally, ELLIS, KIRCHNER, and STOEGER address the issue of the stability of multiverses. Obviously, they are not directly testable—we will never be able to observe, or receive information from, other universes. However, though it may seem unlikely, we may be able to confirm their existence indirectly. This is possible if there are cosmological theories relying on the existence of multiverses that enjoy long-term success and fruitfulness, that is, they provide greater and greater well-confirmed intelligibility for our universe and the characteristics it possesses. This would mean, for instance, that we were able to determine that our universe originated by some process, driven by a specific type of potential, that explains the detailed history and physics of our uni-

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verse—including its propensity for complexity and life—and which at the same time would more than likely produce many other universes of different types. Ideas for such potentials have been suggested, but so far none of them are particularly compelling or well constrained. ELLIS, KIRCHNER, and STOEGER are currently preparing another paper focusing in detail on the philosophical issues raised by multiverses.

With LISZKA (Swedish Institute of Space Science, Sförs) and PACHOLCZYK (Steward Observatory, University of Arizona), STOEGER is extending and solidifying earlier work on reliable detection and modeling of low-level quasi-periodic and deterministic X-ray variability from quasars and active galactic nuclei (AGN), particularly from Seyfert I galaxies. These phenomena are connected with the presence of supermassive black holes, or clusters of black holes, in the core of these massive systems. Liszka now has several clear X-ray signals from NGC 5548 that could be interpreted as the signature of a bright flare, or flare patch, spiraling into a medium-sized black hole.

WHITMAN continued work on his project of exposing the real irreducible representations of real forms of the simple complex Lie algebras. He presented six lectures on this topic to the Clavius Group of Mathematicians (see Conferences, section III. Observatory and Staff Activities). This material is essential for understanding Lie groups, and it is not easily found nor well organized in the literature on this subject. This is the reason that WHITMAN decided to make this material more accessible.

Extragalactic Research

In their project studying star formation in the local universe, FUNES along with KENNICUTT, AKIYAMA, LEE (Steward Observatory, University of Arizona), and SAKAI (University of California, Los Angeles) have finished the H-alpha imaging of a complete sample of nearby galaxies within the local eleven megaparsec volume (300 galaxies in the northern hemisphere and about 70 galaxies in the southern one). The observations were carried out with the VATT, the Steward Observatory 90-inch Bok Telescope at Kitt Peak, and the Cerro Tololo Inter-American Observatory 0.9-m telescope, Chile. The data have been fully reduced and now analyzed. The survey has the following goals: (1) to construct the local star formation rate (SFR) distribution function as a reference for cosmological look-back studies; (2) to develop new diagnostic measures of the rate and distribution of star formation in galaxy populations; (3) to quantify the role of starbursts in the evolution of low-mass galaxies; (4) to quantify the incompleteness biases in star-formation surveys; (5) to study the environmental dependence of the SFR distribution function; and (6) to provide a reference catalogue and image database for use by workers in the field. Star-forming galaxies in the local universe provide important clues for understanding the evolutionary properties of galaxies and the physical processes that drive that evolution.

MINNITI (Pontifical Catholic University of Chile), REJKUBA (European Southern Ob-

servatory), and FUNES continue the study of the nearest giant elliptical galaxy NGC 5128 (Centaurus A) in their search for SFR in globular clusters.

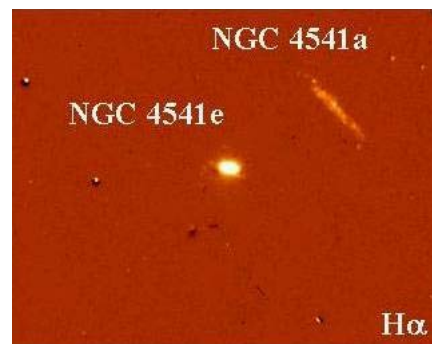
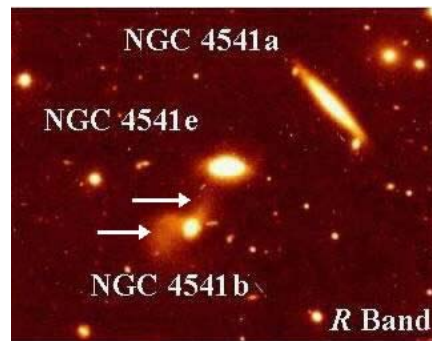
MINNITI, REJKUBA, FUNES, and KENNICUTT have used images from the Very Large Telescope (VLT) at the European Southern Observatory in Chile to identify the ionizing source centered on the largest HII region of NGC 5128. This source turns out to be a close pair of bright and blue star cluster candidates. Spectroscopy obtained with the Magellan II telescope (Las Campanas, Chile) confirms that these are massive young clusters, and the radial velocities confirm the physical association with the giant HII region. Dynamical models predict that binary clusters with these properties would merge in a short timescale of a few orbital periods. The discovery of this binary cluster suggests that mergers of young massive clusters could lead to the formation of the most massive globular clusters such as Omega Centauri in our Galaxy and G1 in M31.

FUNES, REJKUBA, MINNITI, AKIYAM, KENNICUTT, and THILKER (Johns Hopkins University, Baltimore) are studying star formation in the disk of NGC 5128. Little quantitative progress has been realized in recent years on the issue of NGC 5128's continuing star formation. Using VLT images of the innermost regions, they identify young stars and blue clusters plus old globular clusters embedded in the dusty regions of the NGC 5128 disk. In addition, H-alpha images are used to derive the HII region luminosity function effectively constraining ensemble characteristics of those clusters formed most recently.

The study of satellite galaxies can provide information on the merging and aggregation processes that, according to the hierarchical clustering models, form the larger spiral galaxies. With the aim of testing hierarchical models of galaxy formation, FUNES, GUTIERREZ (Instituto de Astrofísica de Canarias, Spain), PRADA (Instituto de Astrofísica de Andalucía, Spain), and AZZARO (Isaac Newton Group of Telescopes, Spain) have conducted an observational program comprising H-alpha imaging for both the parent and the satellite galaxies, taken from the compilation by Zaritsky et al. (1997) that contains 115 galaxies orbiting 69 primary isolated spiral galaxies. They have observed a sub-sample of 37 spiral and irregular galaxies taken from this

TOP: Arrows indicate where two tidal tails emerge from the satellite galaxy NGC 4541b in this R-band image taken at the VATT. One tail points to the other satellite galaxy NGC 4541e; the other points in the opposite direction. These tidal tails are a sign of interaction between the two satellite galaxies.

BOTTOM: H-alpha image of same view. Images taken by Funes and Gutierrez (Instituto de Astrofísica de Canarias, Spain).



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compilation. The aim of this study is to determine star formation properties of the sample galaxies. The observations were carried out with the VATT. Preliminary results indicate that interacting satellite galaxies exhibit a higher level of star formation than satellites with no signs of interaction. This work extends to satellite galaxies the idea, established previously for luminous galaxies, that interactions trigger star formation.

In their project on the kinematics and dynamics of disk galaxies, BERTOLA, CORSINI, PIZZELLA (University of Padua), and FUNES continue to obtain spectroscopic data that will allow an accurate investigation of the dark matter distribution within the optical regions of low surface brightness galaxies.

OMIZZOLO, in collaboration with CRISTIANI (Astronomical Observatory of Trieste) and GRAZIAN (Rome Astronomical Observatory at Monte Porzio), has completed the low red shift quasar survey needed to determine the quasar luminosity function. The results of this extensive survey were presented in a poster at the General Assembly of the International Astronomical Union in July in Sydney, Australia (see International Meetings, section III. Observatory and Staff Activities), and they have been submitted for publication in the *Astronomical Journal*. Plans are being made to enlarge the survey with observations at telescopes in the 4-6 meter range to study quasar clustering.

In collaboration with BARBIERI (Department of Astronomy, University of Padua), OMIZZOLO is researching the light curves of quasars from data obtained by scans of the photographic plates in the Vatican Observatory's archives at Castel Gandolfo (see section II. Instrumentation and Technical Services). The first results were presented at the Sydney meeting of the International Astronomical Union in July and at astronomy meetings in Italy. From scans made at the Asiago Observatory, an historical light curve of the quasar 3C 345 has been obtained, and a report was presented at the meeting on active galactic nuclei at Cozumel, Mexico in December.

The Galaxy and Galactic Objects

The Nearby Stars (NStars) project, to obtain spectra, spectral types, and basic parameters of the 3600 stars within 40 parsec of the Sun and earlier than M0 spectral type, continued to make good progress this year. The observational program is now 98% complete, and the principal collaborators with CORBALLY are GRAY, MCFADDEN (Appalachian State University, Boone, North Carolina), GARRISON (David Dunlap Observatory, University of Toronto), and O'DONOGHUE (St. Lawrence University, Canton, New York). They have now turned their full attention to the analysis of these data. They are using the spectra to provide new, precise spectral types and basic physical parameters (T_{eff} , $\log g$, $[M/H]$). In addition they are providing measures of the chromospheric activity of these stars. Recent results of this program include the basic physical parameters of stars with exoplanets. They conclude that stars with planets have a mean metallicity that is similar to that of the Sun. However, this mean *is* significantly

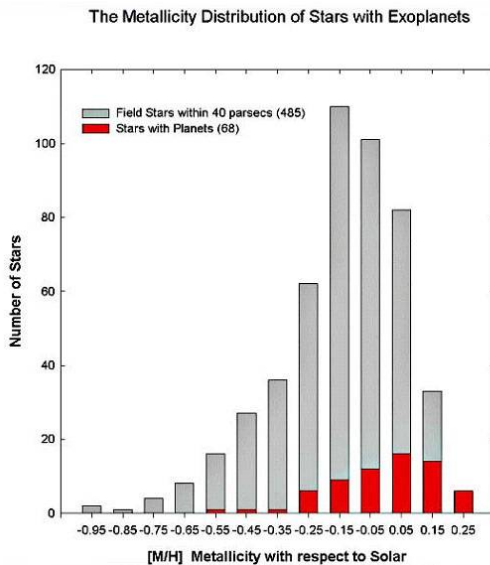
higher than the metallicity for the general run of solar neighborhood, solar-type stars (*see graph*). They have also discovered stars with high levels of chromospheric activity; are making a refinement of the stellar census within 40 parsec of the Sun; and are finding the possible presence of “Maunder Minimum” dwarfs in the solar neighborhood. Observed and derived data from this project are being released on the project's website <http://stellar.phys.appstate.edu>.

In the continuing investigation with STRAIZYS and collaborators (Vilnius, Lithuania) of heavily reddened stars in clusters and of peculiar stars, CORBALLY and O'DONOGHUE have included the Aquila Rift dark clouds in a spectroscopic observing program that complements initial Vilnius 7-color photometry and classification. They also finished observing with the Steward Observatory 2.3-m telescope some 20 stars in the Aries dark cloud. The spectroscopy is being used to determine precise spectral classes, luminosities, and any peculiarities, so that a distance and extinction study can be completed. It is thus hoped to understand better the star forming regions within the Gould Belt.

RUEGER (Diocese of Brooklyn), with the help of CORBALLY, continues to process *UBVRI* observations obtained with the VATT of two fields in the North Galactic Pole.

BOYLE, with STRAIZYS, KAZLAUSKAS, SPERAUSKAS, LAUGALYS, CERNIS (Vilnius University, Lithuania) and PHILIP (Union College, Schenectady, New York), has been pursuing an observational program to calibrate the Strömvil Photometric System by observations of 1000 stars at the Steward Observatory 1.5-meter telescope on Mt. Lemmon. The Chretien Grant awarded to STRAIZYS provides travel support to the Lithuanian astronomers. The portable photometer built at Vilnius achieves very precise magnitude measurements in the seven filter system. To date they have made three observing runs over the years 2000 to 2003, each run of about a three month duration. The calibration involves observing stars having already known astrophysical quantities, e.g., temperature, luminosity, and atmospheric metallicities. The calibration consists in the correspondence of these quantities with the color indices derived from the new photometry. The work is almost completed for the stars of solar metallicity, but further observations are planned for other stars.

BOYLE and PHILIP have been observing galactic and globular star clusters in this same Strömvil System with the CCD camera at the VATT. Photometric calibration of



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these observations will follow from using standard stars observed photoelectrically in the previously mentioned program. They are paying close attention to the precise calibration required from flat fielding the CCD observations. JANUSZ (University School *Ignatianum*, Kraków, Poland) has developed a “CommandLog” software product to automate with precision the processing of the CCD data. They are now obtaining quality one percent photometry needed for classifying the stars observed.

SPERAUSKAS with BOYLE and UPGREN (Yale and Wesleyan Universities) is carrying out other observational work also related to stellar statistics in our Galaxy. With his Coravel type spectrometer, he is measuring the radial velocities of several hundred stars. This requires many nights at the following University of Arizona telescopes: 1.5-meter on Mt. Lemmon, 1.54-meter on Mt. Bigelow, and 2.3-meter Bok Telescope on Kitt Peak. The team seeks to obtain radial velocities for a full dynamical picture of more than one thousand nearby stars of which some two-thirds have been observed.

After many nights of observing at the VATT from 1995 to 1999 by CROTTS, TOMANEY, UGLESICH (Columbia University, New York) and BOYLE, the program devised by CROTTS in search of MACHOS (Massive Compact Halo Objects) in the neighboring galaxy M31 is now producing results. The search for these mysterious massive objects is now strongly suggesting that a significant fraction of the dark matter halo of M31 is composed of roughly stellar-mass objects.

Planetary Sciences

Lunar Science

- *Magma Ocean Modeling:* The most commonly accepted proposal for the origin of the Moon posits a Mars-sized planetesimal (often called “Theia”) impacting the Earth. According to the most recent simulations, the bulk majority of the material that went into forming the Moon from this impact would have been derived from the surface of the impactor, Theia, and not from the Earth. For this material to be depleted in iron and siderophiles, Theia itself must have already been differentiated into a core and mantle.

In a paper at the 2003 Lunar and Planetary Science Conference, CONSOLMAGNO argued this model implies that the Moon’s starting material must have been already chemically processed at least once before being remelted during lunar accretion. And if the Moon’s material represents only the upper portions of the impactor, then it is presumably enriched in elements likely found in the crust, and depleted in mantle material, compared to cosmic abundances. If so, its lithophile incompatibles could be enriched by as much as a factor of 10 compared to chondrites. Such a lunar composition may also be more compatible with the seismic velocities than more traditional models are.

The composition of a primordial magma varies with the size of the source planet, the amount of iron or sodium present, and other factors. Eucrites (presumably derived from

the small asteroid Vesta) are roughly 40% plagioclase, while the proportion of plagioclase in the lunar Fra Mauro basalts can range up to 65%, implying that they have seen a wider range of source region initial pressures or compositions. If this trend holds for the Mars-sized impactor Theia, its initial crustal material (and hence the initial lunar composition) should have been even richer in plagioclase.

Lunar primordial magmas, formed by remelting this crustal material from Theia under different lunar conditions, should produce basalts whose composition would exhaust pyroxene before plagioclase. Thus further melting would result in the production of anorthosites (instead of the orthopyroxenites seen in the Martian and Vesta meteorites). This mechanism provides a more geophysically reasonable way to make anorthosites than the problematic “floating anorthosite crust” first proposed for the Moon thirty years ago.

Further developments of this model hold promise to explain anomalies in both the Apollo-era lunar seismic data, and the compositions of outcrops in the South Pole-Aiken basin measured by the Lunar Prospector and Clementine missions.

- *Lunar Meteorite Trace Elements:* As mentioned above, one of the spurs to re-evaluating origin models for the Moon is recognition that certain meteorites in our collections are lunar samples delivered to Earth by impacts on the surface of the Moon. Unlike Apollo samples, we do not know exactly where on the lunar surface these lunar meteorites came from, but almost certainly they sample more areas than the narrow region of flat, equatorial, near-side plains that Apollo and Luna landers visited.

Several such lunar meteorites, first discovered in the Sahara desert, have been donated to the Vatican Observatory collection in recent years. These include samples of Dar al Gani 400, Northwest Africa 482, and Dhofar 081. All three are chemically similar to highland anorthosites (rocks dominated by calcium-rich plagioclase, called anorthite). From the Apollo samples, we know that such rocks are among the oldest on the Moon. But since being formed, these meteorites have all been severely reworked by extensive shocks, presumably due to impacts including (but not limited to) the cratering event that launched the samples off the Moon’s surface. Because of these shocks, at present the rocks consist of a very dark fine-grained matrix surrounding small white glassy or microcrystalline veins and clasts.

In the past year RUSSELL and JEFFRIES (Natural History Museum, London) have done extensive measurements of major and trace element abundances of fragments from these samples. In collaboration with them, CONSOLMAGNO has used these data to calculate the bulk mineralogy that the clasts and matrix had before the mineral structure was destroyed by shock. From knowing how the trace elements, especially the Rare Earth Elements (REE), partition themselves between any given mineral and the magma from which the mineral is crystallizing, it is then possible to calculate the likely composition of the melt from which these rocks first formed.

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One significant finding is that small relict grains of pure anorthite in the clasts have REE patterns that would be in equilibrium with a primordial melt whose REE abundances are unfractionated but uniformly enriched to 10 times chondritic values. Such a composition is a good candidate for a primordial lunar melt. The REE patterns of the other clasts lie between the anorthite grains and this model liquid, and may represent a mixture of the anorthite and the melt.

Meteorite Physical Properties

As described in last year's Annual Report, CONSOLMAGNO along with WEIDEN-SCHILLING (Planetary Science Institute, Tucson) and BRITT (University of Central Florida, Orlando) are examining the way in which dust in the solar nebula became lithified into dense, essentially unporous meteorite rocks. A key ingredient in the mix of necessary physical processes appears to be the shock produced by impacts in the early nebula, strong enough to lithify the dust but not so strong as to totally disrupt the sample. One difficulty is that the rapid compression of highly underdense material by even low degrees of shock will lead to temperatures elevated high above those experienced by the meteorites themselves. Thus a multi-stage scenario of initially slow compression by weaker impacts may be necessary. This theoretical modeling continues.

In attempting to learn how meteorites are initially lithified, how their fabric evolves with time, and how their transport from the asteroid belt to the Earth's surface biases our understanding of meteorite structure, STRAIT (Alma College, Alma, Michigan) and CONSOLMAGNO have used meteorite porosity to constrain the internal structure of asteroid parent bodies. To do this, they use a computerized point-counting system to measure void spaces visible in Scattering Electron Microscope images of ordinary chondrite meteorite thin sections and then compare these data with reported hand-sample porosity measurements.

Although questions about microcrack porosity in meteorite samples have been resolved (as described in previous Annual Reports), other questions have arisen as a consequence of these porosity measurements. Are shock-induced microcracks emplaced during the event that ejects the meteorite from the parent body, or during the impact of the meteorite with the Earth (either with its atmosphere, or on hitting the ground)? How does the porosity in meteorites on Earth compare with that of the material while it is still in its parent body?

One way to address these questions is to measure the microcrack porosity of terrestrial basalt. This is material similar in nature to meteoritic material, but it has not experienced ejection from a parent body, transportation through space, atmospheric entry, and impact on the surface of the Earth. When measurements of the microcrack porosity of terrestrial basalts are compared to those of meteoritic basalts, the data show similar porosities. This supports the idea that porosity measured for meteorites on Earth is a good indication of their porosity while still on their asteroidal parent bodies.

Another way to address these questions would be to study samples collected *in situ* from a body where we also have samples that have experienced ejection, transport, entry, and impact onto Earth. Samples that would fit this category unequivocally are Apollo moon rocks and lunar meteorites. Preliminary work is encouraging, but this question will need to be more extensively studied with a broader range of samples.

Outer Solar System Objects

- *Asteroid Satellites and the Pluto-Charon System:* The astrometric method to detect asteroid satellites is based on the search for the reflex effect on the primary object due to the orbital motion of a possible satellite. As reported previously by KIKWAYA, working with THUILLOT and BERTHIER (Paris Observatory), the astrometric signature of a satellite of 146 Lucina may reach several milliarcseconds, indicating it may have a satellite. Spectral analysis of the observed positions of this asteroid compared against its computed orbit might then detect the signal with a good signal/noise ratio, given high quality astrometric measurements and extensive coverage by different observation sites.

However, the astrometric method cannot be applied to all binary systems of asteroids. Its applicability depends strongly on the mass ratio of the two bodies and on the distance between them. The Pluto-Charon system provides a good test of this method. Previous work based on direct imaging of Charon show that its period is 6.357 days and the mass ratio is 0.122, putting this system in the range that can be observed by the astrometric method.

Using archived photographic observations (1914-1995) and CCD observations from U. S. Naval Observatory, Flagstaff Station (1995-1998), Bordeaux Observatory (1996-1997), and McDonald Observatory (1997), the position of Pluto is being analyzed to see if its wobble effect due to Charon (which should provide an amplitude of around 95 milliarcseconds) can be detected and if the orbital period of Charon can be recovered through spectral analysis of Pluto's observed position compared to its computed orbit. If successful, this detection would confirm the ability of the astrometric method to find asteroid satellites.

In addition, KIKWAYA is collaborating with MERLINE (Southwest Research Institute, Boulder) to predict possible mutual events (such as eclipses and occultations) of known binary asteroids. These predictions can then be used to suggest possible observations of the light curves of these asteroids, to provide a more precise set of orbital elements for the satellites, and ultimately to obtain a better measure of their masses and densities.

- *Kuiper Belt Objects:* TEGLER (Northern Arizona University, Flagstaff), ROMANISHIN (University of Oklahoma, Norman), and CONSOLMAGNO continued their BVR photometric survey of Kuiper Belt Objects (KBOs) at the VATT, along with observations at the Keck I 10-m telescope on Mauna Kea, Hawaii, and the University of Arizona 2.3-m Bok Telescope on Kitt Peak. These objects, irregular lumps of ice and

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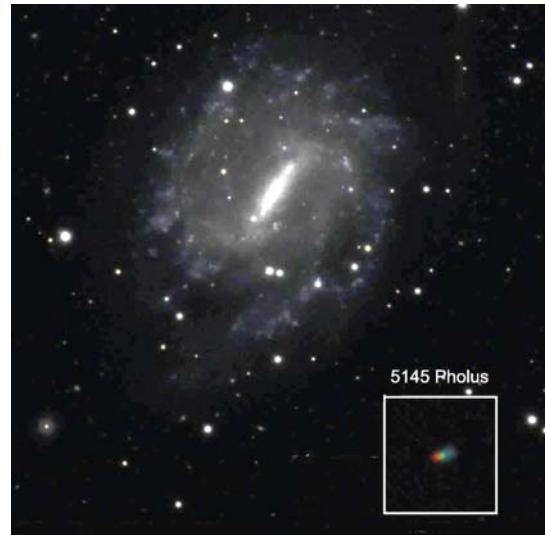
rock orbiting at or beyond the orbits of Neptune and Pluto, appear to represent some of the most primordial material in our Solar System and may be the source of at least one class of comets.

In examining the data to date, certain dynamical classes of KBOs are now seen to exhibit very distinctive surface colors. Seventeen of 20 objects on large-inclination and large-eccentricity orbits with aphelion distances larger than 70 AU (a dynamically hot population) exhibit gray, $B-R < 1.5$, surface colors. In contrast, 21 of 21 classical KBOs on small-inclination and small-eccentricity orbits with perihelion distances larger than 40 AU (a dynamically cold population) exhibit red surface colors, $B-R > 1.5$. In addition, 22 Centaurs observed to date divide into two very different color populations, gray and red. In all cases, the odds that these trends are merely random fluctuations of a uniform color distribution (as seen by applying the Dip Test and Student's T Test) are less than one part in several thousand.

These observations are consistent with a primordial origin of KBO surface colors based on their original heliocentric distance. During their formation, objects that formed closer to the Sun, at warmer temperatures, may have incorporated methane in the form of methane clathrate, a mixture of roughly seven parts water to one part methane. Loss of methane from such a surface by sublimation or UV photolysis would result in a gray water ice "lag" deposit. By contrast, in the colder outer reaches of the solar nebula, methane could condense directly as an ice on the KBO surfaces, where it could be turned into more complex hydrocarbons (typically red) by the action of ultraviolet and cosmic irradiation.

The gray objects that formed closer to the Sun would be orbiting in regions subject to orbital perturbations by an outward migrating Neptune; this would result in dynamically "hot" orbits. Red objects formed farther from the Sun would be only partly perturbed by Neptune (contributing to the Centaur population). The farthest objects (red surfaces, cooler orbits) would remain unperturbed.

The reddest of these objects have a color previously only seen on few inner solar system objects, most notably the asteroid (or perhaps extinct comet nucleus) 5145 Pholus. However, recent observations have suggested that



The reddest KBOs have a color similar to that of the asteroid 5145 Pholus. By coincidence, during observations at the VATT, the asteroid passed near the galaxy NGC 5964, and Consolmagno and Tegler took its picture (boxed area). Pholus moved between exposures and appears as a streak of light.

the extreme red color seen on Pholus 10 years ago may be changing; if so, this might represent outgassing of material from its interior. VATT observations of Pholus by TEGLER and CONSOLMAGNO are being analyzed to see if this change can be confirmed.

History and Philosophy of Science; Interdisciplinary Studies

CARUANA continues to engage in research in three main areas. The more long-term project involves the study of how the scientific mentality may affect the ethical dimension of human beings; the results will eventually be published as a book entitled *Science and Virtue*. The second project involves research on the impact of Albert Einstein's special theory of relativity on some central issues in philosophy of religion. The resulting paper will be published in the 2005 special issue of the journal *Revista Portuguesa de Filosofia* to commemorate the centenary of Einstein's 1905 paper on special relativity. The third project involves the preparation of 10 hours of advanced lectures on philosophy and cognitive science scheduled for 2004 within the Science and Philosophy specialization currently being offered at the Pontifical Gregorian University.

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

In preparation for an International Forum on Science, Religion, and Consciousness, CORBALLY reflected on the effect that an encounter with extraterrestrials of superior intellect might have on organized religions. He considered how an understanding of the physical cosmos, presumably shared by terrestrials and by extraterrestrials, leads to insights into the nature of the Creator. Hence he concluded that humanity's fundamental ideas of God would not change in such an encounter. Hopefully, though, there might result some continued purification of religion from "error and superstition," a task for science suggested in a Message of Pope John Paul II (*Physics, Philosophy, and Theology: A Common Quest for Understanding*, ed. R.J. Russell, W.R. Stoeger, S.J., and G.V. Coyne, S.J. Vatican: Vatican Observatory Publications 1997, 3rd Edition, pg. M13).

COYNE served as a consultant to the John Templeton Foundation on the evaluation of the proposal for the "Science, Theology, and the Ontological Quest" program of three Pontifical Universities in Rome: Gregoriana, Lateranense and Regina Apostolorum. He continues to serve on the Advisory Council for that program.

OMIZZOLO in collaboration with BERTOLA (Department of Astronomy, University of Padua) has organized a second series of seminars on interdisciplinary themes in science, philosophy, and theology. He has also been actively involved in these themes at the University of Brescia and in Venice.

STOEGER has extended his research on divine action, theology of creation, the science and philosophy of causality, and on reducibility and emergence.

II. Instrumentation and Technical Services

Thanks to the services offered by the Rome Observatory at their facilities at Campo Imperatore, KOCH and MAFFEO organized the re-aluminizing of the mirror of the Castel Gandolfo astrograph.

Under the guidance and monitoring of CORBALLY, CROMWELL and NELSON (Steward Observatory and VORG), with HARMER (National Optical Astronomy Observatories), manufacture of the mechanical components for the VATT's medium-resolution optical spectrograph, VattSpec, has begun. Astronomical Consultants & Equipment of Tucson has completed solid models of the various modules and the box. Fabrication will begin in 2004, to be followed by testing.

HARMER completed an optical design for a wide-field corrector to match the field of the coming 4K x 4K CCD camera for the VATT. BOYLE, CORBALLY, CROMWELL, and NELSON provided input. Modeling of the corrector's ghost images is underway to make sure it will be an improvement over an earlier corrector.

The local area computer network (LAN) at Castel Gandolfo was upgraded by the Vatican Telephone Services according to the proposal by BOYLE and ROSSI. CAT-5 cabling and switches were installed to operate at 100 Mbps ethernet speed.

BOYLE and ROSSI installed IRAF, TABLES, STSDAS, DS9, TeX, etc. software on the new AlphaStation provided by RUFFINI (International Center for Relativistic Astrophysics [ICRA], University of Rome *La Sapienza*) from ICRA funds.

PELETIER (Nottingham, UK), with collaboration from CORBALLY, has given the website of the Vatican Observatory and its Foundation a new look and made it more informative. CORBALLY continues to update the website, which can now be accessed at <http://www.vaticanobservatory.org>.

OMIZZOLO continues the digitalization of the photographic plates in the Observatory's archives at Castel Gandolfo using scanners both at Castel Gandolfo and at the Asiago Observatory of the University of Padua. The Observatory has acquired a scanner identical to the ones being used in the Italian national program of constructing a digital archive of data from photographic plates, thus providing homogeneity in the scanning procedures. Eight hundred archival plates taken with the Vatican Schmidt Telescope have been scanned thus far. In a collaboration with NESCI, ROSSI and DI PAOLA (University of Rome *La Sapienza*), OMIZZOLO is in the process of reducing data from scans made of spectra on objective prism plates taken with Schmidt telescope.

Work continues under the direction of CASANOVAS on the construction of an electronic file for the library of the Specola.

III. Observatory and Staff Activities

Celebration

On 28 February, 60 friends, Vatican Observatory Foundation board members, and colleagues of George V. Coyne, S.J., celebrated his 25th anniversary as Director of the Vatican Observatory with a dinner at the Café Terra Cotta, Tucson. He was recognized as an inspiring teacher by former students, a dedicated researcher by fellow astronomers, a committed leader of the Vatican Observatory Foundation by board members, a skillful tennis player by opponents, and a cherished friend to all. The anniversary celebration started the year before, during the SuperVOSS II meeting 7-13 July, 2002, when Coyne was honored with a trip to a country inn for an outdoor buffet of homemade regional specialties and informal speeches. In conjunction with the anniversary, VOSS '93 alumna Ayvur Peletier developed a special link on the Vatican Observatory's website where students, colleagues, and friends could leave a congratulatory message for Coyne.



Guest of honor George V. Coyne, S.J., acknowledges his colleagues, friends, and Vatican Observatory Foundation board members during a dinner in Tucson 28 February, 2003, honoring his 25th anniversary as Director of the Vatican Observatory. (Photo by Christopher Corbally, S.J.)

Conferences

The Governing Board of Euroscience, a European Association for the Promotion of Science and Technology, was hosted by Sabino Maffeo, S.J., for a meeting at Castel Gandolfo 8-9 February.

From 6 to 8 June the Observatory hosted "Weekend Conversations on the Specola Vaticana" at which the following young Jesuits interested in research in astronomy participated: Richard D'Souza, S.J. (Province of Goa), who is studying for a Master's Degree in astrophysics at the University of Heidelberg; Paul Gabor, S.J. (Province of Bohemia), who has studied quantum mechanics and elementary particle physics and is completing his theology studies; Gabriele Gionti, S.J. (Province of Italy), who completed his doctorate in 1998 with a thesis in quantum gravity at the International School of Trieste, Italy and who is now pursuing his philosophy studies; and Jean-Baptiste Kikwaya, S.J. (Province of Central Africa), who has already been assigned to the Observatory staff (see Personnel News in the section From the Director).

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The Clavius Group of Mathematicians, a community of Jesuits as well as other religious and lay persons co-founded by Andrew Whitman, S.J., in 1963, met 15 July-14 August for its 41st meeting at the *Institut des Hautes Études Scientifiques* in Bures-sur-Yvette, outside Paris.

Andrew Whitman, S.J., lectures on Engel's Theorem to members of the Clavius Group of Mathematicians meeting outside Paris. (Photo by Pedro Suarez, S.J., Barry University, Miami Shores, Florida)



From 7 to 13 September at Castel Gandolfo the Observatory hosted the Capstone Conference of the series “Scientific Perspectives on Divine Action.” The series and the Capstone Conference have been jointly sponsored by the Observatory and the Center for Theology and the Natural Sciences at Berkeley, California. The series of seven conferences, held over a period of fifteen years, has resulted in seven books covering a wide range of topics from quantum cosmology to evolutionary and molecular biology and the neurosciences. The purpose of the 2003 Capstone Conference was to evaluate the series and to plan for the future.

The Observatory helped to host the meeting of the European Jesuits in Science held in Rome 11-14 September. Giuseppe Koch, S.J., organized the local arrangements. Cardinal Carlo Maria Martini, S.J., spoke to the group and entertained a discussion on the intellectual apostolate of the Jesuits. The participants visited the Observatory at Castel Gandolfo on the evening of 13 September.

Presentations and Academic Activities

CARUANA • Presented the annual undergraduate course “Philosophy of Science and Nature” at the Gregorian University, and also the more advanced course “Science, Nature and God” for second cycle students. • In June, concluded the direction of a doctoral thesis on philosophical issues in the realm of psychosomatic medicine with special reference to anorexia nervosa. • Gave a paper on “Science and Priestly Formation” at the VIII Conference of European Jesuits in Science, held in Rome 10-14 September.

CASANOVAS • On 13 January gave a lecture on “Early and Modern Meridians in Italy.” • On 29 March served on the examining board of a doctoral thesis on solar physics. • On 30 April lectured in the *Museo de las Ciencias* in Tenerife, Spain. • 5-7 June participated in a meeting on the history of astronomy at the University of Bari, Italy.

CONSOLMAGNO • Presented “New Models for the Origin of the Lunar Crust” on 14 April at the University of Tennessee Department of Geosciences; on 20 May at the Drexel University Department of Physics, and on 13 November at the Georgia Southern University Department of Geology and Geography. • On 9 October discussed “What Lithified the Meteorites?” at the State University of New York (Stony Brook) Department of Geology and Geophysics. • Paid working visits to BLAND at Imperial College, London, on 15 January; to RUSSELL and GRADY at the Natural History Museum, London, on 10 February, May 26, July 4, October 6, and December 5; to SCHAEFER at the University of Texas Austin on 13 March; and to GARGET at Cambridge University Press on 3 July.

CORBALLY • As Immediate Past President of the Institute on Religion in an Age of Science, participated in council meetings in February at Louisiana State University, Baton Rouge, and in July on Star Island, New Hampshire. • Participated in the Star & Planet Formation Discussion Group at Steward Observatory. • Gave a colloquium on 31 January to the St. Mary's University, Halifax, NS, Astronomy and Physics Department on “The Enigmatic Lambda Boötis Stars,” and on 7 March spoke on the same topic at the regular FLASH colloquium at NOAO, Tucson. • Assisted with Wheeling Jesuit University's second observing run at VATT and with the inauguration of CORMASS. • Gave an evening lecture in June to the VOSS at Castel Gandolfo on “The Personalities of Stars and Galaxies Through Their Spectra.” • During the XXV General Assembly of the International Astronomical Union in Sydney, Australia, in July, gave a talk at meeting of the Working Group on Ap and Related Stars entitled “Does ‘Location, Location, Location’ Matter for Lambda Boötis Stars?”; chaired the meeting of the Working Group on Standard Stars; attended meetings as the National Representative for Vatican City State; and worked as a member of the Resolutions Committee. • Led a workshop at the IRAS Annual Conference on Star Island, NH, in July on “When Astronomers and Environmentalists Clash Over a Sky Island.” • In late October presented an invited paper at the International Forum on Science, Religion, and Consciousness, at the University Fernando Pessoa, Porto, Portugal, entitled “Will Organized Religion Survive an Encounter with Extraterrestrials?” • Collaborated with Steward Observatory and MGIO personnel to implement the outdoor lighting code around Mt. Graham, and represented the Vatican Observatory at International Dark-Sky Association “Excellence in Lighting” awards in the Pima County area. • Continued on the Board of the St. Albert the Great Forum at the Catholic Newman Center, University of Arizona.

COYNE • In September, gave the Cyril Ponnampereuma Invited Lecture on “An Overview of Cosmic Evolution” at the Trieste Conference on Life in the Universe • Serves on the Advisory Board for the new journal “Omega: Indian Journal of Science and Religion” published in Kerala, India. • Hosted in September the visit to Rome of the planning group of the “Galileo Circle” of the College of Science of the University of Arizona, Tucson. The group was headed by Joaquin Ruiz, Dean of the College. • To the Society for the History of Astronomy of Southern California, spoke in April in Pasadena

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on “Galileo’s Universe Revisited.” • In the series *Fondamenta, Senza Più* in Venice, Italy, in October spoke on “Science and Faith: The Limits and the Hopes.” • Served on the organizing committee and delivered a lecture at the seminar on “Emergence in Science, Philosophy and Theology” at *La Armonia*, Mar del Plata, Province of Buenos Aires, Argentina. • Spent a week in October as Visiting Scholar at the University of Washington, Seattle. While there, in addition to the John and Jessie Danz Public Lecture, gave the following lectures: “Origins and Creation” to the Astrobiology Seminar; “History and Significance of the Vatican Observatory Summer Schools” to the Astronomy faculty and students; a talk on Galileo to the History of Science class; “The Modern Church and the Perennial Galileo” to the Astronomy Colloquium; a talk on the approach of a scientist today to the science-religion dialogue to the Benefactors Club; “The Roots of an Anti-science Bias in Renaissance Italy” to the Italian Studies Program; “Galileo and Bellarmine: Eyeball to Eyeball” to the joint departments of History, Philosophy, Italian Studies, and Comparative Religion. • While a Visiting Scholar at the University of Washington also spoke about the Church and modern science to the Astrobiology class at Seattle University and gave an evening seminar on the same topic to a group of undergraduate students from Seattle University and the University of Washington. Also gave an Astronomy Colloquium on “The Emergence of Life in the Universe” at the Herzberg Institute for Astrophysics, Victoria, BC, Canada, and conducted a round table discussion on the Galileo affair. Gave a public lecture on the interaction of science and religion at the Centre for Religion in Society, University of Victoria.

FUNES • As invited professor, taught a course in March on “Extragalactic Astronomy” to graduate students at the *Universidad Nacional Autónoma de Honduras* in Tegucigalpa. Also gave a seminar on his extragalactic research and a lecture on “Astronomy and Faith” to the faculty of the graduate study program.

HELLER • Participated 2 May in Paris at the panel discussion of “Quantum Physics and Mathematics.” • In August gave a paper on “Are We Special in the Universe?” at the Castel Gandolfo Papal Seminar: Science-Religion-History, and another on “Ultimate Explanation in Cosmology” at the International Wittgenstein Symposium in Austria.

MAFFEO • At the meeting of the *Accademia Nazionale dei Lincei* (Italian National Academy of Sciences) on 27 January to celebrate “One Hundred Years of Astronomy in Italy” presented a paper on the “*Carte du Ciel* Program and the Founding of the *Specola Vaticana*.” • Gave lectures to the Master’s Program at the Pontifical University *Regina Apostolorum* on the relationship of science and faith.

STOEGER • Helped prepare the academic program for the Vatican Observatory-Center for Theology and the Natural Sciences (CTNS) Capstone Conference on Scientific Perspective on Divine Action held in Castel Gandolfo, 7-13 September, and for the University of San Francisco-CTNS-Vatican Observatory conference on Reductionism and Emergence at USF, 7-12 October. • Gave a Templeton Foundation Lecture on

“Cosmology and a Theology of Creation” at Emmanuel College, Victoria University, Ontario, Canada, on 21 January, and on 23 January gave another Templeton Lecture on “Cosmology, the Laws of Nature, and Divine Action” at Queen's University, Kingston, Ontario. • On 22 March gave an invited response to Paul Davies' CTNS Forum Lecture, “Multiverse or Design? Reflections on a Third Way,” at the Graduate Theological Union Library in Berkeley, California, and participated in the ensuing day-long discussion. • From 6 April to 6 May was at the Department of Mathematics, University of Cape Town, Cape Town, South Africa, working with George Ellis and his colleagues on various theoretical cosmology projects. Gave a seminar there 29 April on “The Relativistic Mass-Energy Density, Number Counts and the Luminosity Function” to the Theoretical Cosmology Group. • Attended the Catholic Theological Society of America Annual Convention at the Westin Hotel in Cincinnati 5-8 June, and both convened and chaired the Theology and the Natural Sciences Program Group Sessions. • Lectured on “The Mass-Energy Density, Number Counts and Luminosity Functions” at the Vatican Observatory Summer School on Galaxy Evolution. • Was an invited participant in October at the conference “The Past and Future of the Science-Religion Dialogue: Celebrating the Work of Ian G. Barbour,” and also contributed an article to the *Barbour Festschrift*. • Continues to team with Professor Tom Lindell (Department of Molecular and Cellular Biology, University of Arizona) in teaching the upper-division undergraduate departmental elective course “Science and Theology.” • Continues as managing editor of the journal *Philosophy in Science* (Pachart Publishing House, Tucson, Arizona) and as chairperson of the St. Albert the Great Forum Board at the Catholic Newman Center, University of Arizona. • Gave a Forum presentation on “Myth, the Creation Literature of the Old Testament, and Science” on 19 November.

Public and Educational Outreach

CONSOLMAGNO • Discussed the history of the Vatican Observatory in a talk “Why Does the Pope Have an Astronomer?” on 24 January at the Southwest Research Institute of Boulder, Colorado; on 10 May at the Custer Observatory (Long Island) Family Astronomy Day; and on 24 September at the University of Dallas, Rome campus. • Spoke of the adventures of a Brother Astronomer on 14 May at the Discovery Circle Dinner of the H. R. MacMillan Space Centre, Vancouver, BC, Canada, and on 15 May presented there the annual Michael Ovendon Memorial Lecture, “Astronomy, God, and the Search for Elegance.” • Also spoke on that topic 11 April at the Agnes Scott College Planetarium, Decatur, Georgia; on 23 August at the Midland Center for the Arts, Midland, Michigan; and on 6 December at Ampleforth College, England. • 23 March presented a talk “Can Science and Religion be Reconciled?” at the Webster Presbyterian Church, Webster, Texas • 24 October at Marygrove College, Detroit, Michigan, presented “Reflections on Free Will and the Anthropic Principle.” • Gave a class 19 February at the Adler Planetarium, Chicago, on “Confronting the End of Everything.” • Was featured in a planetarium program in March at Burke Baker Planetarium, Houston, on

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“Galileo’s Legacy.” • Spoke of “God Under the Dome” to the Great Lakes Planetarium Association’s annual meeting in Cleveland, Ohio, on 22 October. • Spoke on 7 February at Stonyhurst College, England, on “When the Sky Falls to Earth” and on 27 February on “Research in Planetology with the VATT” to the Vatican Observatory Foundation seminar in Tucson. • On 5 April spoke to the Merton Center, affiliated with Stanford University, Palo Alto, California, on the topic “Heaven or Heat Death?” • Spoke to classroom groups on 24 March at Strake Jesuit High School, Houston; on 4 April at the St. Elizabeth Seton Grade School, Palo Alto; on 14 May at Notre Dame High School, Vancouver, BC, Canada; on 15 May at Vancouver College High School, Vancouver, BC, Canada; on 11 April at Agnes Scott College, Decatur, Georgia; on 20 May at Drexel University; and on 24 October at Marygrove College, Detroit, Michigan. • Was a featured speaker and panelist at science fiction conventions in Boston and Chicago and at the World Science Fiction Convention in Toronto, Canada.

CORBALLY • On 30 January gave a public lecture sponsored by the Newman Society at St. Mary’s University, Halifax, Canada, on “Encountering ET, Encountering a New God?” • Gave a talk on “Building the First ‘LBT’” at a seminar 27 February for friends and benefactors of the Vatican Observatory Foundation. • Was the speaker on 20 May for the Rotary Club, Marana, Arizona, with the topic “The Pope Scope in Arizona.” • On 9 July gave the 2003 Annual Rochester Lecture, sponsored by the Diocese of Christchurch, at the University of Canterbury, New Zealand, with the title “From a Calendar to the Cosmos.” • Lectured on the same topic at the Eastern Arizona College, Thatcher, on 4 November. • On 6 November spoke to the Marian Club, St. Thomas the Apostle, Tucson, on “Enhancing Faith through an Astronomer’s Filter.” • Continued as an advisor to the *Earth & Sky* radio series. • Was interviewed for astronomy projects by students at the University of Arizona and answered enquiries by e-mail and phone from the general public. • Prepared for the first live video link with St. Agatha Church, Portland, under its “Evangelization through Visual Astronomy” program. • Hosted visits to the VATT on Mt. Graham, including one for the Bishop of Tucson, Gerald F. Kicanas.

COYNE • In February presented a talk at the St. Albert the Great Forum at the Catholic Newman Center, University of Arizona, on “The Myth of Galileo” and at the University Presbyterian Church in Tempe, Arizona, on “Origins and Creation.” On the latter occasion also preached on the theme of creation at the Sunday liturgy. • 20 February at John Carroll University, Cleveland, Ohio, lectured on “Seeing is Believing: A Priest Looks at the Cosmos” to the Tuohy Program on Science and Religion. On that occasion, celebrated along with family members the 100th birthday of George Goudreau, Sr., a generous benefactor of the Vatican Observatory Foundation. • In March in Padua, Italy, spoke to the local Rotary Club on “Light: Physical Reality and Religious Symbol.” At the Department of Astronomy of the University of Padua lectured on the origins of life in the universe. Also spoke at the University College of the Abruzzi in L’Aquila, Italy, on cosmological themes in the science-religion dialogue. • Spoke at the Steward Observatory Public Evening in March on “Galileo Still Haunts the Church.” • At the Fels

Planetarium of the Franklin Institute in Philadelphia, on the occasion in April of a gathering of friends of the Vatican Observatory Foundation organized by Paul and Barbara Henkels, spoke on the history of the Vatican Observatory and its place today in research in astrophysics. • At the Houston Museum of Natural Science in April participated in a public dialogue with Steven Weinberg (University of Texas at Austin) on “The Universe and the Presence of God.” • Gave a lecture on “A Brief History of the Vatican Observatory Summer Schools (VOSS)” to the VOSS 2003. • To the Jesuit Partnership Council of Minneapolis/St. Paul, Minnesota, spoke in October on “When the Sacred Cows of Religion and Science Meet.” • Lectured in October to the class of Marilyn Halonen, Professor of Pharmacology, University of Arizona, on the origins and the meaning of life. • Also lectured in October at the H.R. McMillan Space Science Centre in Vancouver, BC, Canada, on “When the Sacred Cows of Religion and Science Meet,” and at a two-day seminar at the Christ the King Benedictine Abbey, Mission, BC, Canada, on the “Universe of Scientists, The World of Humans.” • In November at Cento, Italy, gave a talk to the *Gruppo Scientifico Centese* on “Cosmology and the Origin of Life,” and participated in a debate on the same theme at the Turin Polytechnic at Mondovì, Italy, together with Giorgio Palumbo, University of Turin, and Piero Bianucci of the *La Stampa* newspaper. • On 19 December presented a seminar at the Albanian Academy of Sciences in Tirana on the emergence of life in the universe. • Continues to serve on the Council of the Pontifical Academy of Sciences.

FUNES • Gave a lecture to the general public at the Sun City Astronomy Club, Tucson.

MAFFEO • Gave talks on the role of the Vatican Observatory in the science-faith dialogue to amateur astronomy groups in Montelupo Fiorentino, Salerno, and Vallinfreda (Italy), as well as to a Rotary Club of Rome.

STOEGER • Lectured on “Cosmology: The History and Evolution of the Universe” to the Sun City Astronomy Club, Arizona, on 16 January. • Gave a popular talk and led a discussion on “Evolution and Creation” at Kolbe House (the Catholic Chaplaincy at University of Cape Town) on 28 April. • Participated in the conference “Theology and Science in the African Context” held 16 April at the Breakwater Hotel, Waterfront, Cape Town, South Africa. • Gave a talk on “The Wonders and Mysteries of the Universe” to the Science Club at Point Fermin Elementary School, San Pedro, California, in late May. • On 9 August gave a lecture, “Cosmology, the Cosmic Background Radiation and the History of the Universe,” to the Mesa Astronomical Society, Arizona. • Participated in a retreat/workshop on science, ecology, and the theology of religious vows at Linwood Retreat Center, Rhinebeck, NY, and gave a presentation on “Cosmology: The History and Structure of the Universe.”

TERES • Gave a series of four lectures to students and professors of the Theological Academy, Szeged, Hungary, on the “Biblical Account of Creation and Modern Cosmology” and on the “History of the Vatican Observatory.”

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News Media Coverage

Galileo's Sons, a documentary on the life of Vatican Observatory astronomers by Alison Rose of Inigo Films, Toronto, Canada, premiered 17 November on Canadian National Television. In production for the past several years, this film required the collaboration of many staff members and of students at the Vatican Observatory Summer Schools.

CASANOVAS • Hosted a visit to the Observatory at Castel Gandolfo of Richard Cohen, journalist (*Commonweal* and *The Tablet*) and author, who is researching the scientific and cultural history of the sun. • Was interviewed by *Catalan Television* for a story about the Observatory.

CONSOLMAGNO • Was the featured presenter of a five-part radio program, *A Brief History of the End of Everything*, which ran the week of 17 January-1 February on BBC Radio 4. • Was interviewed on the national CBC (Canadian) radio program *Richardson's Roundup* on 15 May. • Was featured in a multi-page spread of *The Vancouver Sun* on 10 May. • Was also interviewed for NOW Television (British Columbia) on 16 May. • The *Midland Daily News* (Michigan) carried an interview (17 August) and summary (25 August) of talk on "Astronomy, God, and the Search for Elegance" presented two days earlier at the Midland Center for the Arts. • Assisted the Rome office of the Associated Press to distribute a feature about observing Mars from the Vatican telescopes in Castel Gandolfo that ran in more than a hundred American newspapers on 24 August.

CONSOLMAGNO and CORBALLY were featured on an installment of the national CBS radio program *The Osgood File* on 4 July.

CORBALLY • Was featured in a story on the Mt. Graham International Observatory in the *Tucson Weekly*, 5-11 December 2002. • Provided interviews to the following media and journalists: Mark Weismuller, *Florida Catholic*, on the Star of Bethlehem; Olivier Dessibourg of Fribourg, Switzerland, for *La Liberté*, on the Star of Bethlehem and the Vatican Observatory; Dermot Purgavie, for the Sunday Magazine of the *Sydney Telegraph & Herald*; Paula Gagnon, *Halifax Seaside-FM Radio*; David Portree, *Earth & Sky*, on the cosmic death of stars; Barbara TeMiha, *Plains Radio*, Christchurch, New Zealand; Kathleen Casey, *New Zealand Catholic*; Cindy Wooden, *Catholic News Services*, on Mars viewing at Castel Gandolfo; Julieta Gonzalez, University of Arizona *News Services*, on the 10th anniversary of VATT; Suzanne Branco, *Expresso* magazine, Portugal; Elizabeth Kelly for an article, "When Science is God's Work," which appeared in the December issue of *Your Magazine*. • Answered questions from Jeff Israely, *Time Europe*, Rome office, and from Victoria Dorage, Huntington, New York, on Rome tours.

COYNE • Appeared on the talk show of Steven Scher, KUOW, in Seattle. • Was interviewed on the program, *EXPLORA Primo Piano*, of RAI TV (Italian National Televi-

sion). • Hosted at Castel Gandolfo the crew of *La 7 TV* for a documentary on the Observatory in the Italian series, *Stargate, Linea di Confine*. • Was featured in articles in *WIRED Magazine* in December 2002; in the *Phoenix Tribune* on 15 February; in *Polytyka*, Warsaw, Poland, on 22 February; in *Il Piccolo* of Trieste, Italy, on 16 September; in *Avvenire* in September; and in the *British Columbia Catholic* on 20 October. • Gave an interview to Jeff Israely, Rome correspondent for *Time Europe*, for a report on the Galileo Commission that appeared in the 8 September issue. • Assisted the crew of *Le Figaro* for a series of films on the Observatory. • Was interviewed by Radio 101 of Croatia (Zagreb) for a report on the Observatory as part of the series *Back to Europe*. • Was interviewed for the program *Leonardo* on RAI Torino (Italian National Television, Turin) on 21 November. • In collaboration with Annual Report editor Elizabeth Maggio, wrote an essay, “Science and Religion: Can We Talk?,” for the December 2003 issue of *Sky & Telescope*.

FUNES • Wrote a column for the weekly news magazine *Noticias* (Argentina).

KOCH and CONSOLMAGNO • Hosted a film crew from the Houston Museum of Natural Science in preparation for two shows organized at the Museum: “Saint Peter and the Vatican, Legacy of the Popes” and “Galileo’s Legacy.”

MAFFEO • Received for interviews at Castel Gandolfo journalists from *Famiglia Cristiana* and from *Le Figaro*. • On the occasion of the close approach of Mars, arranged staff interviews with Cindy Wooden of the Catholic News Service, Rome office, and with the Associated Press Television News.

International Meetings

New membership:

The Observatory has become a member of the International Network of Centres for Relativistic Astrophysics (ICRANET) with headquarters at Pescara, Italy. Cardinal Angelo Sodano, Secretary of State of the Holy See, designated George V. Coyne, S.J. as signatory to the agreement and as representative of the Holy See on the Steering Committee of the ICRANET. This new entity is an extension of the International Centre for Relativistic Astrophysics, of which the Observatory is already a part.

5-9 January: Seattle, Washington. 201st Meeting of the American Astronomical Society. RICHARD BOYLE, S.J., CHRISTOPHER CORBALLY, S.J., and JOSÉ FUNES, S.J., gave papers.

17-21 March: Houston, Texas. 34th Annual Lunar and Planetary Sciences Meeting. GUY J. CONSOLMAGNO, S.J., and JEAN-BAPTISTE KIKWAYA, S.J., each presented papers.

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21-23 March: Tucson, Arizona. Annual General Meeting of the International Dark-Sky Association. CHRISTOPHER CORBALLY, S.J., chaired a session.

2 May: Paris, France. Quantum Physics and Mathematics. MICHAEL HELLER participated.

26-30 May: La Palma, Canary Islands, Spain. Satellites and Tidal Streams. JOSÉ FUNES, S.J., gave a poster paper.

8-11 June: Cannes, France. Sixth Workshop on Catastrophic Disruptions. GUY J. CONSOLMAGNO, S.J., presented an invited review.

14-25 July: Sydney, Australia. XXV General Assembly of the International Astronomical Union. RICHARD BOYLE, S.J., GUY J. CONSOLMAGNO, S.J., CHRISTOPHER CORBALLY, S.J., JOSÉ FUNES, S.J., and ALESSANDRO OMIZZOLO gave papers.

21-25 July: Sydney, Australia. IAU Symposia 220 on Dark Matter and 221 on Star Formation at High Angular Resolution. JOSÉ FUNES, S.J., gave poster papers.

26 July-2 August: Star Island, New Hampshire. Annual Conference of the Institute on Religion in an Age of Science. CHRISTOPHER CORBALLY, S.J., led a workshop.

27 July-1 August: Münster, Germany. Annual Meeting of the Meteoritical Society. GUY J. CONSOLMAGNO, S.J., presented two papers.

5-6 August: Castel Gandolfo, Italy. Seminar with the Holy Father: Science-Religion-History. MICHAEL HELLER gave a paper.

7-9 August: Kirchberg am Wechsel, Austria. International Wittgenstein Symposium. MICHAEL HELLER gave a paper.

1-5 September: Monterey, California. Annual Meeting of the American Astronomical Society, Division for Planetary Sciences. GUY J. CONSOLMAGNO, S.J., and JEAN-BAPTISTE KIKWAYA, S.J., each presented papers.

10-14 September: Rome, Italy. European Jesuits in Science. GIUSEPPE KOCH, S.J., hosted this meeting; GUY J. CONSOLMAGNO, S.J., presented a paper; GEORGE V. COYNE, S.J., and JUAN CASANOVAS, S.J., participated.

15-19 September: Trieste, Italy. Seventh Conference on Chemical Evolution and the Origin of Life. GEORGE V. COYNE, S.J., served on the Advisory Committee and presented an invited paper.

17-20 September: Vilnius, Lithuania. Stellar Photometry: Past, Present and Future, an

international meeting dedicated to the 250th anniversary of the Astronomical Observatory of Vilnius University. RICHARD P. BOYLE, S.J., gave a paper and was co-author on five others.

6-7 October: Tucson, Arizona. Steward Observatory Internal Symposium. CHRISTOPHER CORBALLY, S.J., and JOSÉ FUNES, S.J., participated.

23-25 October: Porto, Portugal. International Forum: Science, Religion and Consciousness. CHRISTOPHER CORBALLY, S.J., gave an invited paper.

2-6 November: Seattle, Washington. Annual Meeting of the Geological Society of America. GUY J. CONSOLMAGNO, S.J., gave invited and contributed papers.

4 December: London, UK. History of Geology Group of the Geological Society of London Special Meeting: "Fireballs and Stones from the Sky." GUY J. CONSOLMAGNO, S.J., gave an invited paper.

8-12 December: Cozumel, Mexico. Multiwavelength AGN Surveys: Guillermo Haro Astrophysics Conference. ALESSANDRO OMIZZOLO gave a paper.

IV. Publications

BARTASIUTE, S., ASLAN, Z., **BOYLE**, R.P., KHARCHENKO, N. V., OSSIPKOV, L. P., and SPERAUSKAS, J. "Stellar Populations of the Galactic Disk: Metallicity Distribution and Kinematics," 2003, *Baltic Astronomy*, 12, 539

BOYLE, R.P., JANUSZ, R., LAUGALYS, V., and PHILIP, A.G. DAVIS. "CCD Flatfield Correction by Differential Stellar Photometry: Automated Methods," (abstract) 2003, *BAAS*, 35, 1207

BOYLE, R.P., JANUSZ, R., PHILIP, A.G. DAVIS, KAZLAUSKAS, A., and LAUGALYS, V. "Flatfielding Errors in Strömvil CCD Photometry," 2003, *Baltic Astronomy*, 12, 476

BOYLE, R.P., LAUGALYS, V., and PHILIP, A.G.D. "Flatfield Correction by Differential CCD Photometry in M 67," (abstract) 2002, *BAAS*, 34, 1257

BUDZIK, S. and **HELLER**, M., eds. *Fides Quaerens Intellectum, Quaestiones ad disputandum-2*, 2002 (Tarnów: Biblos)

BRITT, D. T. and **CONSOLMAGNO**, G. J. "Stony Meteorite Porosities and Densities: A Review of the Data through 2001," 2003, *Meteorit. Planet. Sci.*, 38, 1161-1180

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CARUANA, L. "Science Interacting with Philosophy: The Case of Ludwig Wittgenstein," 2003, *Gregorianum*, 84/3, 584-616

CASANOVAS, J. Entries in the *Diccionario Histórico de la Compañía de Jesús*, eds. C. E. O'Neill and J. M. Rodríguez (Rome: Institutum Historicum; Madrid: Universidad Pontificia Comillas, 2001): "Astronomia," 259-263; "Calendario Gregoriano," 602-603; "Copernicanismo," 940-943; "Hagen, J. G.," 1864-1865; "Kepler, J.," 2189; "Rodés Campdera, L.," 3386

COCCATO, L., CORSINI, E. M., PIZZELLA, A., FUNES, J. G., BERTOLA, F. "Minor-Axis Velocity Gradients in Disk Galaxies," 2003, accepted for publication in *A&A*

CONSOLMAGNO, G. J. Book Review of *The Life and Death of Planet Earth* by Peter D. Ward and Donald Brownlee, 2003, *Meteorit. Planet. Sci.*, 38, 1131-1132

_____. "God Under the Dome," 2003, in *Proceedings of the 39th Great Lakes Planetarium Association Annual Conference*, ed. D. W. Smith, in press

_____. "Meteoritical Evidence and Constraints on Impacts and Disruption," 2003, *Abstracts, 6th Workshop on Catastrophic Disruption in the Solar System*, 8

_____. "Religion, Science Fiction, and the Real Universe," 2003, *Argentus*, 3, 3-8

_____. "Remote Sensing the Whole Meteorite," 2003, *Program and Abstracts, Geological Society of America Annual Meeting*, 264

_____. "The Composition and Evolution of a Geophysically Reasonable Moon Produced by a Giant Impact," 2003, *Lunar Planet. Sci.* XXXIV, 1165

_____. "Grappling with a Universe," 2004, *Company*, 21, 27-29

CONSOLMAGNO, G. J., RUSSELL, S. S., and JEFFRIES, T. E. "REE Studies of Three Lunar Highland Meteorites: Clues to the Ancient Lunar Crust," 2003, *Program and Abstracts, Geological Society of America Annual Meeting*, 266

CONSOLMAGNO, G. J., WEIDENSCHILLING, S. J., and BRITT, D. T. "Forming Well-Compacted Meteorites by Shock Events in the Solar Nebula," 2003, *Meteorit. Planet. Sci.*, 38, A128

CORBALLY, C. J. "The Anchor Points in Bob Garrison's Astronomical Life," 2003, in *The Garrison Festschrift*, eds. Gray, R. O., Corbally, C. J., Philip, A. G. D. (Schenectady: L. Davis Press), 77-85

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V. Observatory Visitors

The Vatican Observatory at Castel Gandolfo and the Vatican Observatory Research Group in Tucson, Arizona, hosted a number of visitors during the year. Noteworthy were the number of school groups and cultural groups received by **MAFFEO**, assisted by **KOCH**, at Castel Gandolfo. We were especially happy to receive members of the Pontifical Academy of Sciences and officials of the Vatican Congregation for Religious. The close approach of Mars to Earth in late August and early September brought many visitors to the Observatory, among them Mrs. Kathryn Colvin, Ambassador from the United Kingdom to the Holy See.

The following individuals paid working visits to the Observatory:

MARCELO ARAÚJO, Universidade Federal do Rio de Janeiro, Brazil

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

GABRIELE GIONTI, S.J., Institute for the Study of Philosophy, Antonianum, Padua, Italy

JOHN HEARNshaw, University of Canterbury, Christchurch, New Zealand

ROBERT JANUSZ, S.J., University School *Ignatianum*, Kraków, Poland

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

WITOLD MACIEJEWSKI, Astronomical Observatory, Jagiellonian University, Kraków, Poland and the Arcetri Observatory, Florence, Italy

AILEEN O'DONOGHUE, St. Lawrence University, Canton, New York, USA

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

ALISON ROSE, Inigo Films, Toronto, Canada

SARA RUSSELL, Natural History Museum, London, UK

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

JULIUS SPERAUSKAS, Astronomical Observatory of Vilnius University, Vilnius, Lithuania

FRANK YOUNGER, Hertzberg Institute for Astrophysics, Victoria, BC, Canada

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

ANGEL ABBUD-MADRID, Colorado School of Mines, Colorado, USA; DANIEL M. DAVIS, SUNY Stony Brook, New York, USA; WILLIAM MERLINE, Southwest Research Institute, Boulder, Colorado, USA; ROBERT PAPPALARDO, University of Colorado, Boulder, Colorado, USA

VATICAN OBSERVATORY





This new tower for studying the stars
has been erected on this peaceful site
so fit for such studies and it has
been equipped with a new large mirror
for detecting the faintest glimmers
of light from distant objects during
the XV year of the reign of John Paul II.
May whoever searches here night and day
the far reaches of space use it joyfully
with the help of God.

English translation of Latin inscription
on the dedicatory plaque of the
Vatican Advanced Technology Telescope,
dedicated 18 September, 1993,
Mt. Graham, Arizona.