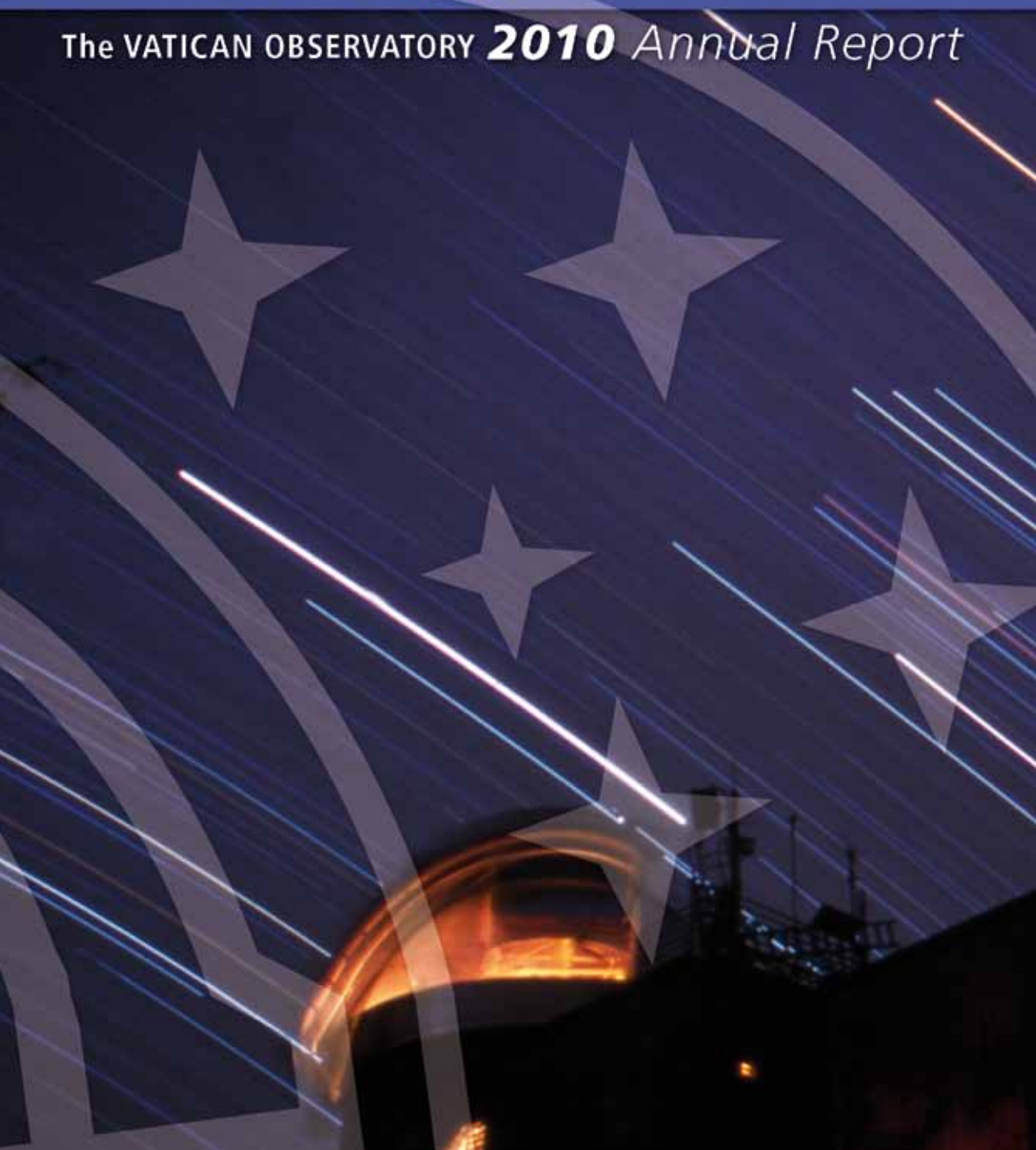
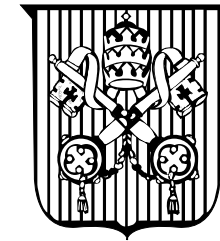


At the *crossroads* of science and faith



The VATICAN OBSERVATORY **2010** *Annual Report*







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Cover: VATT with Vatican Observatory logo superimposed.
Photo credit: Roelof de Jong, astronomer at Space Telescope Science Institute

Editor: Emer McCarthy
Design and layout: Claudia Santellani



The International Year of Astronomy was a wonderful occasion to communicate to our friends and the general public our enthusiasm for our mission and our desire to be on the frontier of astronomical research. We share with our colleagues the same excitement in seeking answers to the fundamental questions about the Universe. Are we alone? Are there other Earths? How do stars and planets form and evolve? How do galaxies form and evolve? What is dark matter and dark energy? What do we know about the Universe in its first instants? Are there many universes?

VOSS

In organizing the Summer School in Observational Astronomy and Astrophysics the Vatican Observatory tries to offer to young scholars the opportunity to address these fundamental questions with the help of a notable faculty drawn from leading observatories and universities around the world.

The 12th Vatican Observatory Summer School (VOSS 10) was held from May 30 to June 25 and the topic of the school was "the Chemistry of the Universe". The faculty was formed by Prof. Brad Gibson, Chair, (University of Central Lancashire, UK), Prof. Sofía Cora, (Universidad Nacional de La Plata, Argentina), Prof. Susan Lederer, (California State University, USA), and Prof. Susan R. Trammell, (University of North Carolina, USA). I would like to point out that all are VOSS alumni and we are very proud to see how the community of VOSS (faculty and alumni) is active in proposing and organizing new schools.



The academic program covered the role that chemistry plays in astrophysics in a holistic way. As Prof. Brad Gibson, chair of the academic program, pointed out; students were exposed to real-world applications of "chemical astrophysics", ranging from the "local" (meteoritic abundances, planetary chemistry, laboratory and nuclear astrophysics, solar photospheric and coronal abundances, star formation), the "intermediate" (Milky Way, Galactic Archaeology, the interstellar medium, high-velocity clouds, the Local Group), to the "distant" (intergalactic and intracluster media, stellar populations, Big Bang Nucleosynthesis) scale.

For the first time the school was held at the Vatican Observatory's new headquarters. In order to host faculty and students in the best possible way, we carried out some renovation work on the building in order to offer a comfortable study environment. We were a little anxious to see how the new Vatican Observatory premises would contribute to the life of the school, and indeed, it proved to be a great success.

This success would have been impossible to achieve without the generosity and competence of the faculty and the dedication of students. Our gratitude goes to all of them.

To this end, we have decided to dedicate a section of this Annual Report to VOSS 10 and to introduce the Vatican Observatory headquarters.

Our Research

Of course, we also address the big questions of Astrophysics and Cosmology in our research. A description of our work can be found in the section dedicated to Research Highlights. Science is hard and daily work, and progress is made from year to year. That progress is published in journals

that are recognized by the scientific community. Among our publications I would like to underline the paper published on the very early inflationary period of the universe by Father William Stoeger, S.J. and his colleague Fulbright Fellow, Dr. Krzysztof Bolecko (Nicolaus Copernicus Astronomical Center, Warsaw, Poland) that won the 5th prize in the Gravity Foundation 2010 Awards for Essays on Gravitation.

Science and Faith

Alongside collaboration with our colleagues in exploring the universe, we at the Vatican Observatory are also called to explain how Science and Faith can live in harmony. Our efforts in this regard are visible in the section dedicated to Staff Presentations, in the many lectures given by members on the complementarity of faith and reason in the service of an integral understanding of humanity and its place in the universe. It is an ongoing process of dialogue and reflection. In the section Science, Philosophy, and Theology, you will also find the topics our staff has been involved in this year. In a cultural context in which Science and Religion are often presented as being at war, we can offer a privileged perspective, the one offered by those who are scientists and religious men at the same time. Thus, the Vatican Observatory is at the crossroads of Science and Religion. This is a challenge for us.

Quoting the Holy Father Benedict XVI in his address to Catholic Schools in his visit to England, we believe that: "The world needs good scientists, but a scientific outlook becomes dangerously narrow if it ignores the religious or ethical dimension of life, just as religion becomes narrow if it rejects the legitimate contribution of science to our understanding of the world."

The scientific perspective can help religion in the understanding of the world and religion can help science to integrate its progress into the big picture of human culture. The role of Astronomy in human culture is to provide the big picture of the Universe. This is something we love doing.

Jose' G. Funes, S.J.

José G. Funes, S.J.
Director



• The Director P.Funes
Photo: Federico Balzoni

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VOSS 2010 poster
Layout: Claudia Santellani



From 30 May to 25 June, the Vatican Observatory organized and hosted the 12th Summer School bringing together 27 students from 24 countries. The Summer Schools are an important opportunity to deepen students' background in one of the burning issues of modern astrophysics and observational cosmology. The topic assigned to the school last year was *"The Chemistry of the Universe"*, in short, the physical processes governing the evolution of the universe and its basic constituents, the chemistry of galaxies and star clusters and of molecular clouds, planets and comets. The school involved both theoretical lessons and practical exercises.

The first ever Vatican Observatory Summer School was held in 1986, and since then takes place every two years, hosting about 25-30 young men and women graduates in astronomy from various countries. The selection of participants tends to favour students from developing countries and to ensure a certain equity in the geographical distribution of countries of origin.

In gathering students from diverse countries, cultures and religions at its new headquarters in the Pontifical Villas of Castel Gandolfo, the Vatican Observatory not only hopes to create an opportunity to express the Pope's concern for human development in general, but especially to give witness in the field of contemporary scientific research to openness to dialogue between faith and science.

The purpose of this initiative is to provide a group of outstanding students, who have come to the end of their university courses, an excellent opportunity to expand on some topics of their study of astronomy, and to forge new professional friendships between professors and students in the international arena in order to foster that encouragement and enthusiasm that young people especially need as they embark on their career.

For the first time the 2010 Summer School was completely organized and taught by alumni of previous schools. They included **Brad Gibson** (U. Central Lancashire, UK) and **Susan Trammell** (U. North Carolina), who attended the 1988 school; **Sofia Cora** (La Plata Observatory, Argentina), an alumna of the 1993 school and **Susan Lederer** (Cal. State University), of the 1997 school.

Notable guest lecturers included **Remo Ruffini** (U. of Rome, ICRA Net), **Roberto Maiolino** (Rome Observatory), **Piero Benvenuti** (U. of Padua ASI), **Humberto Campins** (U. of Central Florida), **Jonathan Lunine** (U. of Arizona/U. of Rome Tor Vergata), and **Luigina Ferretti** (Bologna Observatory). **Fr. Rich Boyle, S.J.** served as dean of the school.

The effectiveness of this initiative is clear in the testimony that both students and professors gave to the Pope's own newspaper, *L'Osservatore Romano*.

VOSS Students speak

"To study astronomy with students from all over the world was an extremely humbling experience," said Tara Hufford of the United States. *"This is truly a priceless, once-in-a-lifetime experience, and I know that I have lasting connections across this world."*

Students Daniel Cunnama from South Africa and Andrew Ekpenyong from

Nigeria, describe VOSS as an *"eye-opener"*. *"We lack words to express our gratitude...for everything including the 75% scholarship for those from developing countries. Studying with students from 24 other nations, being exposed to the frontiers of astronomical and astrophysical research, interacting informally with faculty and with one another, etc... We'll return home resolved to redouble our efforts in astronomical and astrophysical investigations"*.

Indeed, for Mexican student Faustino Gijón VOSS has marked a turning point in his personal life and professional career. *"At VOSS I've learned to live with people with different backgrounds, cultures and ways of thinking"*, he says. *"It has allowed me to expand my horizons, learn about the different alternatives that I have for my future academic and professional research. Science and religion have no valid reasons to be separated, they can coexist peacefully together, and also the people who believe and those who do not. This summer school is an example of that."*

"I find VOSS to be one of the best experiences I've ever had", states Vladimir Bozhilov, a student from Bulgaria. *"We have the unique chance of learning from outstanding international lecturers and faculty alike. The importance of direct contact with the faculty, as well as with fellow students, is of great importance for me. Science is essentially a team work and that's what the VOSS is all about"*.

Ronald Ballouz, a student from Lebanon says, the school has been an excellent exercise in how to deal with scientists from different backgrounds. *"Not only is there a language barrier that you have to overcome, but you also have to adapt to the different methods and mannerisms that other scientists go through when doing their science. But regardless of the differing customs, doing science seems to inspire all of us with the same feeling of satisfaction"*.

From India, Binoy Jacob, S.J. speaks of VOSS as having enriched his mission. *"As a Jesuit priest, my participating in the Summer School is enriching in many ways. The meticulous planning, systematic execution and the scholarship of the faculty are praiseworthy. The input sessions, library research, projects, presentations, visits to places of scientific/historical significance etc. enable me to interpret the theological mysteries from a scientific perspective, which I believe, is a challenging mission in the contemporary times"*.

From Thailand, student Supachai Awiphan says the VOSS experience is invaluable: *"I am very happy to be one part of it, because it shows that different people from all over the world can live together. I gain not only knowledge in astrophysics but also a wonderful friendship. I would regard VOSS training as invaluable"*.

But what about the academic faculty? Does VOSS have the same impact on them? Professor Susan Trammell from the United States: *"I was a student at the Vatican Observatory Summer School in 1988. At the summer school, I made friends that I still keep in touch with today, more than 20 years later. I have returned this year as faculty for the summer school. I still enjoy the same things about the school: the chance to meet different people from*



• Daniel Cunnama and Renee Mateluna
• Andrew Ekpenyong
• Vladimir Bozhilov
• Ronald Ballouz
Photos: Students



different backgrounds, learn new things about astrophysics and see Italy. The students are bright and eager to learn. It has been a pleasure to interact with them”.

Along with the traditional trips to Florence and Siena, and the weekend excursions to Subiaco and Ostia Antica, VOSS 2010 was held during the football (soccer) World Cup. Caught up in the general excitement, students organised a football tournament among themselves and with the classroom video projector, were able to see their national teams play during the evening. Every time there was a match between two teams from nations represented by students at the school, the match ended in a tie!



Finally, during VOSS 2010, a special session and a memorial Mass were held in honour of the late Fr. Martin McCarthy, S.J. His idea for the schools inspired their organization in 1986. Today they are named in his honour.

Study, dialogue, discovery, friendships and encounter; all of this takes place at the Vatican Observatory, within the walls of the Pontifical Villas in Castel Gandolfo; a fittingly close proximity between the world of science and the world of faith, signifying a desire that has never dwindled for synergy and for a knowledge and formation that is not sectarian but multi-disciplinary.



- Susan Lederer
- Fr. Chris Corbally
- Brad Gibson
- Kate Pilkington
- Gustavo Adolfo
- Cruz Diaz
- Group in Siena
- Piazza del Campo
- School session
- Group in the
- Pontifical Villas of
- Castel Gandolfo

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Group in Saint Peters
with Card. G. Lajolo,
President of the
Governorate of
Vatican City State
Photos: Students





Cosmology

Theorists have developed elaborate models to describe the opening moments of the universe and how it evolved after the Big Bang, but can these models be constrained by observing the universe as we see it today? This has been the thrust in recent years of work by William Stoeger and his collaborators. As has been recognized for decades, the universe today appears homogeneous – smooth – on very large length scales. The very early universe, in contrast, must have been very inhomogeneous – lumpy. When the size of the observable universe, a fraction of a moment after the Big Bang, was not all that different from the size of an atom, what is called the Planck era, then the inherent “graininess” of space described by quantum physics would have resulted in quantum fluctuations at the very earliest moments of its existence.

But in a system controlled by gravity, lumpiness almost always increases with time; only very rarely and then only under special conditions does it decrease. So where did our present homogeneity come from?

Usually a very early inflationary period (an extremely brief period of exponentially rapid expansion) – almost immediately after the Big Bang – is invoked to homogenize the universe. However, inflation itself requires a small perfectly smooth patch to get started. What process could make that initial inflationary patch smooth?

During his three-month visit from March to May, visiting Fulbright Fellow Krzysztof Bolejko (Nicolaus Copernicus Astronomical Center, Warsaw, Poland) worked with Stoeger to examine this question. They showed that, for large densities in the early universe, significantly broad initial conditions involving viscous shear and pressure gradients can produce homogeneous regions from inhomogeneous ones rather quickly. An essay outlining the details of this work won 5th prize for the Gravity Foundation 2010 Awards for Essays on Gravitation.

But does the observed smoothness of the universe extend beyond the regions of space that we can observe today? We can only observe what we can see with light, and so we are limited in our observations (such as galaxy redshifts, the average overall mass and number of the galaxies, and their angular-diameter or luminosity distances) to that region of space within our “light cone”: that part of the universe close enough to us that light can have reached us within the age of the universe. For a 14 billion year old universe, this is a volume inside 14 billion light years from us.

For a number of years, Stoeger, Marcelo de Araújo (Universidade Federal do Rio de Janeiro) and their co-workers have been developing a framework for using astronomical observations to reveal the detailed structure and evolution of the universe without presupposing that it is spatially homogeneous (smooth and not lumpy) on the largest scales. Towards the end of last year Stoeger and de Araújo finally succeeded in demonstrating within this framework how to move the solution to the Einstein field equations (the mathematical description of the shape of the universe as expressed in Einstein’s theory of General Relativity) on our past light cone to all earlier times. This allows theorists to use those data – to the extent they are reliable – to model precisely the structure and evolution of that part of the universe to which we have observational access.

As part of this approach the density of vacuum energy (dark energy) can also be determined, if we have data giving us the maximum of the angular-

diameter distance and the redshift at which that occurs. Acquiring such data is just beginning to be possible with space telescopes measuring the light curves of distant type Ia Supernovae (at redshifts higher than 1.5).

More recently, de Araújo and Stoeger have succeeded in incorporating the drift of cosmological redshifts into this solution framework. These cannot be measured yet. But with the advent of extremely large telescopes and very high precision spectrographs, such crucial data will eventually be available to us. Redshift drift is the degree to which the redshift of a distant galaxy changes with time – the redshift of such a galaxy will, in general, be slightly different in, say, 10 years from what it is now.

It turns out that redshift drift is a parameter that can give us a lot of useful information about the nature of the universe. The famous cosmologists Alan Sandage and George McVittie first realized in 1962 that it gives us the mass-energy density of the universe at each redshift, independently of any details about galaxy counts, average masses, or evolution, or assumptions about dark matter content. But in the course of their research, de Araújo and Stoeger have also discovered that using redshift drift as a key element in their data set (instead of galaxy number counts and average mass per galaxy counted) also lets us quickly determine the functional relationship between redshift and the radial coordinate measure of light down our past light cone.

That is the key first step in determining the structure of the universe from data. At present it can only be done in a somewhat imprecise way, using estimates of galaxy masses along with galaxy number counts together with angular-diameter distances. Currently de Araújo and Stoeger are in the process of comparing the advantages and disadvantages of their technique with those of the methods previously used by cosmologists to approach this problem.

The Bolejko essay can be found in *General Relativity and Gravitation* 42: 2349-2356 (2010) and available online at arxiv.org: 1005.3009v1. The work by de Araújo and Stoeger has been published in *Physical Review D* 80, 123517 (2009) [with an erratum in *Physical Review D* 81, 049903(E) (2010)], and on the internet at [arxiv](http://arxiv.org): 1009.2783v1.

Gabriele Gionti, who joined the staff of the Observatory following his ordination in June, is now continuing his research on topics of Quantum Gravity.

Our current best understanding of the nature of gravity, one of the fundamental forces of the universe, is Einstein’s theory of General Relativity. This theory has a singularity, a point where it is clear that classical concepts of physics no longer hold, corresponding to the origin of the universe – what is popularly known as The Big Bang. This singularity suggests the necessity of a quantum mechanical approach to gravity, Quantum Gravity, in the same way that quantum mechanics underpins our understanding of the other fundamental forces of nature.

There are two main approaches to Quantum Gravity: Loop Quantum Gravity and String Theory. Loop Quantum Gravity has a “conservative” approach to quantum gravity; it treats gravity as an independent force from other interactions. On the other hand, String Theory attempts to unify all physical interactions, hypothesizing that there exist one-dimensional objects (called “strings”) more fundamental than particles, which propagate in time.

Gionti's expertise is mainly in discrete quantum gravity. This is a technical tool to treat Space-Time as discrete object. But there also exists an interpretation of Quantum Gravity that considers Space-Time discrete because of a fundamental length (Planck's length). His research is applying these discrete quantum techniques to understanding both Loop Quantum Gravity and String Theory.

Stellar Astronomy

Stars are dynamic objects in an ever-changing universe. While supernovae are the most spectacular example of how stars change themselves with time, even our own sun varies on a variety of time scales from a five minute radial oscillation up to the eleven year sun-spot cycle and beyond. These pulsations have also been observed in stars outside our solar system with periods ranging from a few minutes to several years and amplitudes from fifty percent of a star's light output down to below our ability to measure.

Stellar variation is interesting scientifically because it allows us to infer things about the interiors of stars, which are normally hidden from us. For example, the period of the slowest (or fundamental) radial pulsation of a star is proportional to the star's average density. Once the period of the pulsations and the average brightness of a star has been measured, one can then turn around and calculate the mass and distance to the star.

Measuring these small variations, however, requires maximizing the accuracy of every measurement. To this end, Jonathan Stott has spent the last year improving the calibration of the images made with the Vatican Advanced Technology Telescope (VATT). Some of this was routine, such as measuring the precise exposure variation as the camera shutter moves across the face of the CCD.

Other calibrations were more complicated, for example combining ten years' worth of observations of the open cluster M67 at the VATT (by Boyle and others) with the Vilnius filters into a single high-precision catalog that can be used as a standard calibration field for precise photometry.

Standard fields are regions of the sky that have been measured multiple times and can serve as a common reference point for different observatories and instruments. High-quality standard fields are important because without a common reference, it's virtually impossible to compare measurements made on different nights, or even at different times in the same night, with each other.

To compare measurements made over the course of many years, however, it is important that none of the stars used as standards should be variable, otherwise the calibrations will drift with time. Identifying variable stars, therefore, is an important part of constructing a usable standard catalog. Stott's work to create an improved Vilnius catalog for M67, therefore, also doubles as a search for variable stars within the cluster.

Because it is near to us and relatively unobstructed by dust, M67 is an extremely well-studied cluster. However, while numerous short-term studies (ranging from days to weeks of observations) have been done to look for variable stars in M67, no one has ever had the data to look for stars which vary over a period of several years. Thus, as part of preparing the standard catalog, Stott has also made an improved search for variable stars in M67. That's scientifically interesting in its own right.

An example of the varying nature of stars can be seen in a number of ultracool dwarf stars that have been unexpectedly detected producing periodic

pulses in the radio over the last decade. More recently, two of these pulsing dwarfs have also been found to be pulsing periodically in visible light. The detected periods of the light pulses match the periods of the radio pulses, which are known to be associated with the rotation period of the dwarf. For at least one of these objects, the optical and radio periodic variability are inextricably linked. Is this true of the others? If so, that would suggest that the mechanisms responsible for these observed emissions are related to each other right across the electromagnetic spectrum.

To measure the variations in the visible light emitted by these stars, for the past 18 months Richard Boyle has been working with colleagues Leon Harding, Ray Butler and Aaron Golden (National Observatory of Ireland, Galway) and Gregg Hallinan (University of California, Berkeley) using the GUFi instrument (Galway Ultra-Fast Imager) on the 1.8m VATT telescope. More than 200 hours of I-band (near infrared) photometric monitoring observations have been completed, to collect data from every known ultracool dwarf detected in the radio thus far.

They have identified newly discovered optical variability in two pulsating ultracool dwarfs, with three further dwarfs requiring another epoch for confirmation of stable periodic behavior. The optical data shows strongly correlated emissions in terms of phase and temporal variability. They have also shown these variable signals to be extremely stable over a number of years. Furthermore, this stability has been seen in both radio and spectroscopic data; the mechanisms driving these processes are now thought to be fundamentally linked. This level of agreement has been identified for one dwarf in particular, TVLM 513, right across the electromagnetic spectrum. The origins of this ever-present emission process may be similar to auroras; it remains to be seen through further observation whether it is a phenomenon observed for all emitting dwarfs.

This work was reported in a paper presented by Leon Harding at the 16th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun, 29 Aug. - 2 Sept. 2010, Seattle, Washington.

Dante Minniti and his collaborators have started their own observations and analysis of variable stars in Milky Way. They have embarked on a 5-year long public survey at the European Southern Observatory (ESO) to map the inner disk and bulge of the Milky Way using the VISTA 4m telescope at ESO Paranal (Chile) Observatory, in five near-IR passbands, using multiple epochs in Ks in order to find variable sources. They are calling their survey the VVV Survey: VISTA Variables in the Via Lactea. (Via Lactea is, of course, the Latin for "Milky Way".)

One important product of this survey will be a three-dimensional map of the central bulge of the Milky Way. This will be possible by finding and measuring variable stars of the RR Lyrae type: the brightness of these stars as a function of their variability is well known, and so one can use this information to calculate their precise position, and thus the overall structure of the inner bulge and disk of the Milky Way.

In addition, the VVV plans to study variable stars belonging to known clusters and find large numbers of eclipsing binaries, and the counterparts of high energy sources and rare types of variable sources. In addition, other phenomena that result in stars changing their brightness, such as microlensing events (when the gravity of an object acts as a lens to focus the light of



• In order to measure the brightness of stars accurately to one part in a thousand, it is necessary to know exactly how long each part of the image has been exposed. Stott's work, illustrated here, shows that the motion of the camera shutter slightly overexposes some parts of the image compared to other parts, and allows him to account for this variation from place to place on the image itself. Photo: Jonathan Stott

a star by moving directly in front of that star; in this way moving minor bodies of our Solar System (like main belt asteroids and trans-Neptunian objects) can be discovered. The survey will monitor variability around the Galactic center; search for new star clusters of different ages and identify their variable star members; identify pre-main-sequence clusters and young associations; identify high-proper motion objects (such as high velocity stars); and provide other on-going surveys with complementary near-IR multi-color information. Finally, this survey should also reveal variations in the light from other galaxies, including variable stars in nearby "local group" galaxies and, for more distant galaxies, reveal the light echoes from supernovae and variations in background quasars and active galactic nuclei.

Observations for the VVV Survey began in February 2010. The survey will take 1929 hours of observations in total with the VISTA telescope, covering about a billion point sources across an area of 520 square degrees in five different infrared filters, including 33 known globular clusters and hundreds of known open clusters. The survey will also detect hundreds of star formation regions and open clusters.

When the survey is completed, it will have produced a ZYJKs atlas of the Milky Way bulge and inner disk, catalogues of about a million variable point sources, and catalogues of hundreds of high proper-motion objects.

Details of this work can be found in Minniti et al., 2010, arXiv:0912.1056). The first results obtained from the VVV Survey as well as the current status of the observations are described by Saito et al., 2010, The Messenger, Sept. Issue. See the survey web site (vvvsurvey.org) for more details.

How has our own sun changed since its formation? Not only is this an interesting question in its own right, it is an important parameter in understanding the early conditions and evolution of the planets that orbit the sun. It is especially interesting for understanding conditions on our own planet, at a time about 3.8 billion years ago when life was gaining a foothold on the young Earth.

One way to answer this question is to observe young nearby stars that are the same sort of star as our own sun. Since 2007, Chris Corbally and his colleagues Richard Gray and Jon Saken (Appalachian State University) have been monitoring the spectra of a set of 23 young solar analogs (YSA). These stars, carefully selected from the Nearby Stars database produced by these collaborators (as reported in previous annual reports), have roughly the same size and brightness as our sun, but they are much younger, with ages between 300 million years and 1.5 billion years (as compared with our sun's age of 4.6 billion years). Of particular interest are observing the long-term cycles of stellar activity, determining how fast they spin, and detecting short-term phenomena such as stellar flares.

The team began taking spectra of these stars in 2007, and just recently they have added a to the project a program of monitoring the stars' brightness in several colors.

In addition, Corbally, Gray, and R.E.M. Griffin (Dominion Astrophysical Observatory, Canada) are studying a peculiar type of star known as the "lambda Boötis" type, which have an unusually low abundance of iron refractory elements. That abundance is difficult to explain with standard theories of stellar formation and evolution. One possibility is that these are actually close binary stars, and so our observations are blending two

different types of star into one spectrum. To test this, Griffin is observing a sample of 12 non-binary, non-varying stars, which are suspected by some to be variable and binary (and so pseudo lambda Boötis type) stars. The 6-year long observations of high resolution, high signal-to-noise spectra are almost complete. These spectra are being compared with synthesized spectra from models. So far the analysis supports the hypothesis that lambda Boötis stars are not merely binaries too close to be optically distinguished. If this proves to be the case, lambda Boötis stars show a real discrepancy from ordinary stars, something that stellar formation and evolution theories still need adequately to explain.

The results on the YSAs will be presented in January, 2011, at the annual meeting of the American Astronomical Society.

The way a star evolves depends on its initial mass. David Brown has been studying extreme horizontal branch (EHB) stars, which form after a star ends its life as a red giant. At that time, a red giant star can lose most of its outer layer of gas, leaving only the inner core, which burns helium, not hydrogen. Low mass EHB stars where core helium-burning has just started are known as subdwarf B (sdB) stars. If the helium core is surrounded by a very thin layer of hydrogen, it is called an extreme helium burning star.

But it is not known how a red giant star loses most of its outer envelope to become an EHB star. One theory proposes that such stars form from binary systems (two stars in orbit around each other) where one star, the progenitor to the EHB, loses most of its mass to the companion star because of their gravitational interaction. Likewise, one of the ways by which subdwarf B stars are thought to form is through binary star interactions. The metallicity of the sdB progenitor stars in such binary systems should not seem to be a major factor in the formation of sdB stars.

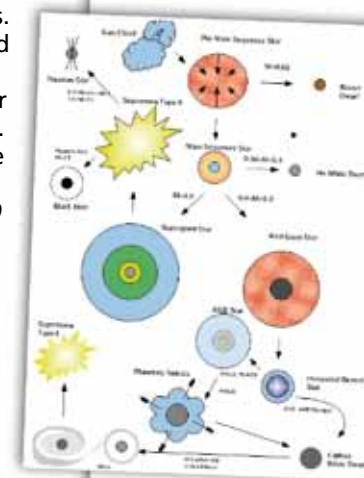
Brown has been running complex computer models of binary star evolution in the different environments in which sdB stars are found. These models examine how metallicity might be a subtle factor in the formation of sdB stars in such environments.

This work is reported in *Astrophysics & Space Science* (2010) 329: 33–39

Planetary Sciences

The thermal properties of stony meteorites are an important fundamental physical characteristic of these materials, an indication of both their chemical and physical natures. Furthermore, knowing these thermal values can put important constraints on the thermal response of asteroids to heating from the sun, an important parameter that affects asteroid orbital and spin perturbations. But perhaps most importantly, the thermal evolution both of asteroids and of comets, icy satellites, and other icy bodies thought to have a significant meteorite-like rocky component will obviously depend on the thermal properties of their constituent materials, for which meteorites are our best known analogs. An asteroid's orbit and spin can gain or lose energy due to the infrared re-radiation of absorbed sunlight. The strength of this effect depends on the **thermal inertia** of the surface of the body, defined as $\sqrt{\rho C k}$, where ρ is the density of the material, C is the heat capacity, and k is the thermal conductivity. In addition, the internal thermal evolution of a body can be thought of as a diffusion process with a thermal diffusivity κ defined as $(k\rho^{-1}C^{-1})$, the ratio of

• David Brown is modeling the evolution of stars; such evolution can take many different paths depending on how massive the star was when it was formed.
Figure: David Brown



the thermal conductivity to the volumetric heat capacity. Note that the same three quantities define both thermal inertia and thermal diffusivity: density (ρ), heat capacity (C), and thermal conductivity (k). In recent years, the densities (mass per unit volume) of more than a thousand different meteorites have been measured by Consolmagno, Britt, and Macke (see previous annual reports), and as a result today a good understanding exists of the typical ranges of densities for most meteorite types. But the heat capacity and thermal conductivities of these meteorites are almost completely unknown. To that end, Consolmagno and his colleagues Cy Opeil SJ (Boston College) and Dan Britt (University of Central Florida) have begun a program of measuring the thermal properties of meteorites at temperatures ranging from room temperature down to just 5 degrees above absolute zero. This past year, they published the conductivities of six meteorites representing a range of compositions, including the ordinary chondrites Cronstad (H5) and Lumpkin (L6), the enstatite chondrite Abee (E4), the carbonaceous chondrites NWA 5515 (CK4 find) and Cold Bokkeveld (CM2), and the iron meteorite Campo del Cielo (IAB find). All measurements were made at Boston College using a Quantum Design Physical Properties Measurement System, Thermal Transport Option (TTO) on samples from the Vatican collection. These measurements are among the first direct measurements of thermal conductivity for meteorites.

The conductivities found so far are three to five times lower than what has been assumed previously for solar system material. This low conductivity appears to be due to the heterogeneous nature of these materials, which are made of many small grains of rock and metal, not well-formed crystals, and are heavily shocked with many cracks and voids to inhibit the conduction of heat.

If the rocky material that makes up asteroids, and provides the dust to comets, Kuiper Belt objects, and icy satellites, has the same low thermal conductivities as the ordinary and carbonaceous chondrites measured here, this would significantly change our ideas of their thermal evolution. These values would also lower their thermal inertia, thus affecting the evolution of the orbits and spins of these objects.

These results were published in Opeil C. P., Consolmagno G. J., Britt D. T., 2010, Icarus 208, 449-454.

But is the material in icy bodies such as comets really similar to that seen in meteorites? One way to tell the composition of the rocky material in these bodies is to determine the density of the dust from these objects. That can be measured when such dust enters the Earth's atmosphere and produces the streaks of light we call meteors.

Jean-Baptiste Kikwaya and his colleagues Peter Brown and Margaret Campbell-Brown (University of Western Ontario) have reported precise metric and photometric observation of 111 optical meteors simultaneously recorded at multiple stations using three different intensified video camera systems. The goal of their work was to estimate bulk meteoroid density, thus linking small meteoroids to their parent bodies based on dynamical and physical density values expected for different small body populations, and understanding and explaining the dynamical evolution of meteoroids after release from their parent bodies.

The density of each meteoroid was estimated by simultaneously fitting the observed deceleration and lightcurve using the ablation model of Campbell-

Brown and Koschny, a model based on thermal fragmentation and the conservation of energy and momentum. All the free parameters within the model were explored for each event to find ranges of values which fit the observations within the measurement uncertainty. The physical parameters used in the model covered the range of type CI carbonaceous chondrites, interplanetary dust particles, ordinary chondrites and iron meteorites. The sets of values that most often gave good fits are the ones deemed to be the most likely quantities that describe the physical nature of these particles.

They found that the average density of meteoroids whose orbits belong to asteroidal and chondritic orbits was 4.2 grams per cubic centimeter, suggesting that they are asteroidal, rich in iron. Meteoroids with orbits belonging to Jupiter family orbits had an average density of 3.2 grams per cubic centimeter; this is also the average bulk density for the 5 meteoroids with ecliptic shower orbits. Both categories are likely similar to chondritic meteorites. Meteoroids of Comet Halley type orbits have a minimum bulk density value ranging from 0.3 to 1.5 grams per cubic centimeter; they are mostly cometary bodies. (Note that the density of ordinary water ice is just under one gram per cubic centimeter.) Meteors whose orbits approached close to the sun had a spread of densities, ranging from 1 to 4 grams per cubic centimeter.

This work makes up a part of Kikwaya's Ph. D. Thesis, to be defended at the University of Western Ontario.

Galaxies

Alessandro Omizzolo is working with a team of international astronomers at the INAF - Osservatorio Astronomico di Padova to study the evolution of the nearest clusters of galaxies, in the hopes that this can shed light on the problem of the formation of the galaxies and on how their evolution depends on the environment to which they belong. The project is called WINGS: This Wide-field Nearby Galaxy clusters Survey. The primary goal of this project is to study the galaxy populations in clusters in the local universe and the influence of environment on their stellar populations. This survey has provided the astronomical community with a high quality set of photometric data for 77 nearby galaxy clusters and spectroscopic data for 48 clusters. This past year they have published a catalog containing the properties of galaxies observed by the WINGS survey.

With the WINGS data, they have used a spectrophotometric model to reproduce the main features of observed spectra by summing the theoretical spectra of simple stellar populations of different ages. From this they derive the stellar masses, star formation histories, average age and dust attenuation of galaxies in their sample. The comparison with the total mass values of the same galaxies derived by other authors confirms the reliability of these new methods and data.

One interesting result is their study of the "mass function" of different galaxies. The mass function is the term that describes the distribution of how many massive galaxies, compared to less massive galaxies, that one finds within a given population of galaxies. When they investigated the total mass function of these galaxies, and found that it evolved noticeably with the distance (and thus the age) of the galaxies observed. The proportion of the more massive galaxies stays constant throughout the observations, but the

• *Most of the specks of light in this image each are a galaxy of billions of stars, part of a cluster of galaxies, one of seventy-seven clusters imaged and studied by Omizzolo and colleagues. Photo: Alessandro Omizzolo*



number of less massive galaxies in the distant, ancient clusters differs from those observed in our local universe. The population of smaller galaxies (those with only about ten billion stars) must have grown significantly in more recent epochs.

They went on to analyze the mass functions of different morphological types of galaxies (ellipticals, S0s and late-types), and found that also each of them evolves with the age of the universe. All types have proportionally more massive galaxies at more ancient times than at more recent times, and the strongest evolution occurs among S0 galaxies. Examining the way the proportion of galaxies of different morphological types changes with galaxy mass, they find it strongly depends on their age. For both the older and the younger galaxies, ~40% of the stellar mass is in elliptical galaxies. Another ~43% of the mass is in S0 galaxies in local clusters, while it is in spirals in distant clusters.

To explain these observed trends, they conclude that mass growth due to star formation plays a crucial role in driving the evolution. It has to be accompanied by infall of galaxies onto clusters, and the mass distribution of infalling galaxies might be different from that of cluster galaxies. However, they do not find conclusive evidence for such an environmental mass segregation. Their results suggest that star formation and infall directly change the mass function of late-type galaxies in clusters and, indirectly, that of early-type galaxies through subsequent morphological transformations.

The team studied the shapes of bright cluster galaxies and normal ellipticals in nearby clusters. They compared the apparent axial ratio distributions of Brightest Cluster Galaxies (BCGs) and normal ellipticals in their sample of 75 galaxy clusters from the WINGS survey. Most BCGs in their clusters (69%) are classified as type cD galaxies. The sample of cDs has been completed by 14 additional cDs (non-BCGs) found in these clusters. They found that normal elliptical galaxies have triaxial shape, the triaxiality sharing almost evenly the intrinsic axial ratios parameter space, with a weak preference for prolateness. The BCGs have triaxial shape as well; however, their tendency towards prolateness is much stronger than in the case of the ellipticals. Such a strong prolateness appears entirely due to the sizable (dominant) component of cD galaxies inside the WINGS sample of BCGs. In fact, while the "normal" (non-cD) BCGs do not differ from the elliptical galaxies as far as the shape distribution is concerned, the axial ratio distribution of type cD galaxies among the BCG group is found to support quite prolate shapes. This result turns out to be strongly at variance with the only similar, previous analysis, where BCGs and elliptical galaxies were found to share the same axial ratio distribution. The data suggest that the above discrepancy is mainly caused by the different criteria used in selecting the cluster samples, coupled with a preference of cDs to reside in powerful X-ray emitting clusters. The prolateness of the BCGs (in particular the cDs) could reflect the shape of the associated dark matter halos. **The results of the WINGS project can be found in the WINGS-SPE II: A catalog of stellar ages and star formation histories, stellar masses and dust extinction values for local clusters galaxies**

Funes and his collaborators I. Finkelman and N. Brosch (Tel Aviv University), and A. U. Kniazev and P. Väisänen (South African Astronomical Observatory) have reported the results of multicolor observations of 30 elliptical and S0 type galaxies with dust lanes. For each galaxy they obtained broad-

band images and narrow-band images using interference filters isolating the hydrogen and nitrogen emission lines that indicate the amount and morphology of dust and ionized gas. To improve the wavelength coverage they retrieved data from the Sloan Digital Sky Survey and Two Micron All Sky Survey and combined these with their data. Ionized gas was detected in 25 galaxies and in most cases it shows a smooth morphology, although knots and filamentary structure are also observed in some objects. The extended gas distribution closely follows the dust structure, with a clear correlation between the mass of both components. An extinction law by the extragalactic dust in the dark lanes was derived and used to estimate the dust content of the galaxies. The derived extinction law was then used to correct the measured colors for intrinsic dust extinction and the data were fitted with a stellar population synthesis model. They found that the emission and colors of most objects are consistent with the presence of an "old" stellar population (about ten billion years old) and a small fraction of a "young" population (10 to 100 million years old). To check this they closely examined the galaxy NGC5363, for which archived Spitzer/Infrared Array Camera and Galaxy Evolution Explorer data are available, as a representative dust-lane galaxy of the sample.

This work was published in *Monthly Notices of the Royal Astronomical Society*, Volume 407, Issue 4, pp. 2475-2500

Science, Philosophy, and Theology

In interdisciplinary studies relating to issues involving the natural sciences, philosophy and theology, Stoeger has been working on developing an enriched concept of "the soul," building on the traditional Aristotelian/Thomistic idea of the soul as the substantial form of the body, and then elaborating this in terms of a centered network of dynamic constitutive relationships which make something what it is. Some of these relationships are accessible to scientific investigation; but some, such as an entity's fundamental relationship to God as Creator, are not. This general idea of the soul as a centered relational network receives strong indirect support from much of contemporary biology, some recent non-reductionistic work in consciousness studies, and some contemporary research and writing in Catholic philosophy and theology. As such it complements nicely the best of the Catholic philosophical tradition with insights and support from the natural sciences – strengthening a radically incarnational theology, while at the same time avoiding the dangers of substance dualism.

In October 2010 the Vatican Observatory project of hosting an inter-religious research conference on "*Creatio ex Nihilo* Today" reached its fulfillment with the publication of the papers from it as *Creation and the God of Abraham*, edited by David B. Burrell, Carlo Cogliati, Janet M. Soskice and William R. Stoeger (Cambridge: Cambridge University Press, 2010), 274 pp. The Conference itself had been held at Castel Gandolfo July 9-15, 2006, and involved scholars in the natural sciences, philosophy and theology from all three of the monotheistic traditions, Judaism, Christianity and Islam. David Burrell, Janet Soskice and Bill Stoeger organized it, with continual help and encouragement from George Coyne, who was Observatory Director at that time.

Before Gabriele Gionti joined the staff of the Vatican Observatory Research Group, he was completing his four years theological training (prior to



• Stott has worked on refining the images of the open cluster M67 taken over many years by Boyle and collaborators. This open cluster provided stars of many different colors and brightnesses for standardizing the measured response of the VATT detector chip. Photo: Jonathan Stott

ordination) at the Jesuit School of Theology of Santa Clara University at Berkeley. He finished his theological studies by defending his S.T.L. (Sacred Theology Licentiate) thesis, "Theology in a Multiverse?" which deals with some hot topics on the possibility of existence of many universes as String Theory is addressing. This fosters the "Revival" of the "Anthropic Principle", which has fueled the debates on the Intelligent Design as in the book of Susskind "The Cosmic Landscape: String Theory and the illusion of the Intelligent Design". These things are having tremendous influence on the contemporary movements of new atheism.

In 2010, Michael Heller presented a series of lectures in Tenerife on the topic of Cosmology and Creation. These began with a brief history of 20th century cosmology, from the static world to the expanding universe, and explored the topics of the geometry and history of the Universe, the discovery of the microwave cosmic background radiation and its cosmological significance, dark matter and dark energy, and outlined some open questions. Further lectures discussed Big Bang and the initial singularity problem, various attempts to neutralize singularities, the Hawking and Penrose singularity theorems, "malicious" singularities, and the search for the final physical theory, all leading to the fundamental question: Is the Universe singular? A third lecture gave a brief history of the creation concept. Does creation occur *in* time or *with* time? What is the concept of creation and the concept of beginning? How does our understanding of the creation of the universe fit with modern cosmology? Did God create the Universe in the Big Bang? Or is putting it that way merely a "God of the gaps" strategy?

All of this, he concluded, leads us to contemplate a deeper question: why is the Universe comprehensible?

At the 11th International Congress of Musical Signification at the Cracow Musical Academy, Heller presented a paper on "The Symphony of the Universe". In the Pythagorean concept of the music of the spheres, he noted, the interval between the earth and the sphere of the fixed stars was regarded to be a diapason, i.e. the most perfect harmonic interval. More specifically, from the sphere of the earth to the sphere of the moon – one tone; from the sphere of the moon to that of Mercury – one half-tone, etc. The sum of all intervals between the sphere of the earth and the sphere of the fixed stars equals the six whole tones of the octave. The theory of proportion and the theory of music were born together, and the Ancient and Medieval cosmologies combined them into one model of the Universe. But as Heller noted, the world of modern cosmology is also mathematical and can also be thought of in musical terms. In this way, the Universe is a Great Symphony inspiring deep philosophical questions.

History of Astronomy

Paul Mueller is presently investigating whether some well-established tools and concepts from biblical textual criticism, which were used to discriminate reliable manuscript evidence from unreliable, were brought over into the natural sciences during the early modern period to discriminate reliable empirical evidence from unreliable. If this is true, it would help explain some puzzling aspects of early modern scientific practice. Also, there would be some interesting philosophical implications, first with respect to the ontological and epistemological status of individual observation-events, and second with respect to how such events could be aggregated to identify and

designate regular natural phenomena.

January 16th saw the closing of the successful exhibition Astrum 2009 on the Italian astronomical heritage curated by Ileana Chinnici. This exhibit, described in last year's annual report, was held at the Vatican Museums and promoted by INAF, Specola Vaticana and the Vatican Museums. The final official count of visitors was 11,000, a number which is considered noteworthy by the Vatican Museums, given the unusual kind of exhibition by their standards.



• NGC 3351
Photo: VATT images



4. Instrumentation and Technical Services

Vatican Advanced Technology Telescope (VATT)

The technical work at the Vatican Advanced Technology Telescope continued in 2010 under Bob Peterson, Steward Observatory's assistant director of mountain operations, and Ken Duffek, the VATT manager. Christopher Corbally, remains director for the VATT, while Richard Boyle, is the telescope scientist and scheduler. Michael Franz, Dave Harvey, Chris Johnson, and Gary Gray comprise the rest of the VATT's regular engineering team.

Telescope

The VATT engineering team performed design, Altitude axis testing, documentation and re-configuration of the Telescope in preparation for VATT Spectrograph (VattSpec) commissioning. The important highlights of this work include:

Franz designed and Gray manufactured a handling fixture for the VATT Spectrograph. This fixture will be used to transport the 250lb instrument from the instrument room to the observing floor as well as serving as a tool for safe mounting of the instrument to the Telescope.

Duffek and Harvey designed a test for determining the Altitude axis moment of inertia. This information was needed to evaluate whether the Altitude axis brake had enough braking torque to stop the axis with the VATT Spectrograph mounted on the Telescope should a runaway condition occur. After evaluating the data, the moment of inertia is 35,875 lb-ft-sec² which translates into a 1.6s deceleration from full slew. This is a very safe stop for personnel and the primary mirror.

Johnson backed up all Xterminal configurations, DNS name and addresses onto a flash drive. This is part of our ongoing documentation updates and recovery system.

Johnson upgraded the VATT Spectrograph GUI to include the dark slide status after Duffek designed new electronics to control this stage. A safety issue found during testing prompted the re-design of the original Astronomical Consultants and Equipment Inc. controller.

Franz designed and Gray manufactured new controller mounts to re-locate the guide camera and 4K-CCD controllers. The existing mounting scheme for these controllers interfered with the Spectrograph.

Harvey, Johnson, and Boyle have continued observer training and support during the observing season.

Microwave Grounding

Since the repair of the microwave tower grounding system MGIO and Duffek have implemented a yearly check of the ground impedance. The specification we need to meet is 25 ohms or less. Again, with another year of service, three in total, we are experiencing a total of 1 ohm which is only a .5 ohm increase since the fix. It is apparent that the fix is working well.

Safety Program

Our safety program continues with great success. With our safety manager, Dale Web, and the assistant director of mountain operations Bob Peterson, walk-throughs continue on six month intervals to identify any potential safety issues. Currently, this year, we had one issue arise in the area of storing propane bottles. This has been an issue at other Telescopes on Mt. Graham, so a storage facility has been established with the help of MGIO personnel. This problem has been rectified and no other issues identified.

This year Gray manufactured a ramp for the observing floor. This ramp will aid in safely loading the facility instruments on to the scissors lift when instrument changes occur. During the summer shut down we were able to give this ramp a real workout when the team mounted the Spectrograph to the Telescope for the first time to test fit, balance, and check slit view guiding.

The engineering team continues to work towards a safer work environment.

Telescope & Building Maintenance

The Telescope primary mirror had its yearly hard wash by Gray. This yearly maintenance has extended the period between mirror re-aluminizations as well as keeping the reflectivity high.

This year Gray performed maintenance on our UPS systems. A complete battery change and cleaning was accomplished to guarantee uninterrupted power for the control room and computer systems.

When Gray is not busy fabricating instrument handling fixtures, controller mounts, maintaining power systems and other projects as needed, he can be found performing routine building maintenance. This year the control room floor near the south door had to be completely replaced due to moisture damage over the years. It was found that the door seal was not able to prevent wind driven rain from entering the building. A new seal was designed, installed, and most certainly will be tested this coming winter.

Deck resurfacing was also completed this year. With the snow and ice accumulation from last year's winter storms the concrete on the east and south side decks took a real beating from shoveling snow and chipping ice. So, a new concrete sealer was applied with traction grit in preparation for winter. Also, this year Gray implemented a wind break on the lower patio to prevent snow drifts from piling up against the sliding glass door of the living room. Hopefully, this winterization will result in less snow removal.



• Ramp to load the vacuum pump and instrumentation safely onto the scissors lift and up to VATT telescope. Photo: Gary Gray
• The Vatican Observatory Jeep buried after a week of severe snow storms, January 2010. Picture taken from the safety of the Bannan Astrophysics Facility and before the MGIO crew rescued it so the photographer could leave the mountain. Photos: Richard Boyle



Instrumentation

Camera GUF1

The Vatican Observatory Research Group and the Centre for Astronomy, National University of Ireland Galway (NUI Galway), renewed a memo of understanding whereby the Galway Ultra Fast Imager (GUF1) would be located at VATT for another year starting on June 1st, 2010. The installation of this L3CCD instrument, based on a DV887 iXon Camera, with practically zero downtime between exposures, was described in last year's Annual Report. Leon Harding (NUI Galway) and Richard Boyle, S.J., have used Camera GUF1 extensively in the fall of this year.

VATT Spectrograph

This year the VATT engineering staff (Franz, Harvey, Johnson, and Duffek), with input from Corbally, have been finalizing software and hardware on the new Spectrograph. Major challenges were found in modifications needed to the slit design, the grating rotator table, and the camera focus mechanism. The team transported the VATT Spectrograph to the Telescope this summer for trial tests on fitting, using the handling fixture, Derotator balancing, and slit view guiding. We succeeded in mounting the Spectrograph and balancing the Telescope and Derotator.

Problems we encountered there were few but none the less head scratchers. The guide box welds interfered with VATT Spectrograph's mounting flange and the slit stage mirrors were not aligned. A field modification to the Spectrograph mounting flange with a grinder solved the interference problem. The guide camera and VATT 4K-CCD controllers had to be re-located due to the controllers occupying the same mounting location as the Spectrograph. After many discussions the engineering team formulated a cautious plan to move the controllers, keeping in mind balance issues and aligning the guide box mirrors.

Our custom made instrument handling fixture worked great. We were able to hoist the instrument into place with full control over the x, y, and z positions.

At this point we were ready for guiding tests. However, due to weather this summer we were only able to get on the sky for a couple of minutes. This was just enough for a successful

guide test. It turned out that the temporary, hand polished slit was sufficient for guiding.

We brought the VATT Spectrograph down for final assembly and alignment. In the final months of the year, we are testing the performance of the Spectrograph in the lab with the science camera before we commit to commissioning the instrument on the Telescope. If all goes according to schedule, we should be in commission mode in January, 2011.

Sloan Filter Set

A significant contribution was made by the Department of Physics at the University of Notre Dame to help observations at VATT. In consultation

with Peter Garnavich (UND), a regular user of VATT who had promoted this gift, and Rolf Jansen (ASU) it was decided to put the \$10,000 towards the purchase of a set of the Sloan Digital Sky Survey u' , g' , r' , i' , z' filters. They came from Asahi Spectra Company, Ltd., in Japan and were a special order of 3.48" x 3.48" square filters with a uniform thickness of 5 mm. Corbally conducted the bidding process and purchase, while Franz arranged for holders to mount the filters in the VATT guide box. The Sloan filters were commissioned at VATT by Jonathan Stott, in December 2010.

Vatican Observatory Website

The Vatican Observatory website, redesigned using the content management system (CMS) Joomla and launched for Christmas 2009, is proving robust to our demands. Its webmaster, Ayvur Peletier, continues to make major changes, while minor updates are made by Corbally, overall website manager, and the section managers. These latter were Alessandro Omizzolo and Francesco Rossi for the "Specola Vaticana" section, which includes the Vatican Observatory Summer School website, and Colleen de Keratry of Petrus Development for the Vatican Observatory Foundation section. The "giving" for this last section is now powered by eTapestry.

- The VATT Spectrograph, without optics, being fitted to the telescope during summer engineering.
- Another view of VATT Spectrograph, with Ken Duffek (left) and Michael Franz (right).



- VATT Spectrograph on its handling fixture, which was designed by Michael Franz (left) and built by Gary Gray (right)
Photos: David Harvey

- On April 16, members of the science team for the NASA Dawn mission to asteroids Ceres and Vesta visited the meteorite lab at the Specola to view samples of meteorites thought to represent material from these two asteroids.

Among them was Dr. Michael Kelley (center right), Planetary Science Division Scientist at NASA Headquarters in Washington, D.C.

- Viewing the meteorites here is Dr. Carle Pieters (center right) of Brown University, principle investigator of the NASA Moon Mineralogy Mapper and co-Investigator for Dawn.

Technical services:

The meteorite collection received four donations in 2010. A 25g piece of the rare pallasite meteorite Huckitta was given to the Specola by Joe Minafra of the NASA Ames Research Center. Robert and Marta Baker donated a 17 gram slice of the H6 chondrite La Cienga following a talk in Connecticut by Br. Consolmagno, and Lyon College, Arkansas, presented a 4 gram piece of the Delaware (Arkansas) L4 chondrite following a talk given at the college. Ingrid "Twink" Mondrad, one of the explorers of the Gold Basin meteorite field in Arizona, donated a 5 g piece of an L4 Chondrite she had recovered.

In addition, thin sections of a number of rare samples have been prepared at the Natural History Museum (London) for distribution to researchers in the US and Europe. Among those so prepared were the shergottite meteorite Los Angeles, which is believed to come from Mars, and the diogenite meteorite Shalka, thought to come from asteroid Vesta. Vesta is the target of the NASA Dawn Spacecraft, due to arrive in 2011.



Awards and appointments

On 1 September Father Paul Gabor, S.J. and Father Gabriele Gionti, S.J. joined the Observatory staff.



Father Gabor is a member of the Czech Jesuit Province. In 1995 he obtained his MSc in particle physics at Charles University (Prague). In 2009 he earned his doctorate in Astrophysics at the Université de Paris XI working on a study of the performance of a nulling interferometer testbed preparatory to the Darwin mission. He also has a Bachelor degree in Philosophy from the Ignatianum (Krakow) and in Theology from the Centre Sèvres (Paris). He will be working in Tucson.

Father Gionti belongs to the Italian Jesuit Province. In 1993 he earned a first-class honors degree in Physics from the University of Naples "Federico II" working on Constraint Theory and General Relativity. He obtained his doctorate in 1998 in Mathematical Physics from the International School for Advanced Studies (SISSA-ISAS), in Trieste, with a thesis on the "Discrete Approaches Towards a Definition of Quantum Theory of Gravity". In 1999 he was a postdoctoral researcher at the Physics and Astronomy Department of the University of California at Irvine and from 2004 to 2006 he worked at the Vatican Observatory in Tucson. He has a bachelor degree in Philosophy from the Pontifical Gregorian University (Rome) and a Master in Divinity from the Jesuit School of Theology in Santa Clara University, Berkeley.

On July 31, Father Andrew Whitman returned to the New Orleans Jesuit Province. In 1982-83, Father Whitman, S.J. took a sabbatical year at the Vatican Observatory where he joined the staff as an adjunct scientist in 1983. During this period he worked with Fr. William Stoeger, S.J. of the Vatican Observatory staff. In 1996, he joined the staff of the Vatican Observatory and was stationed at the Vatican Observatory Research Group at the University of Arizona as a research scientist. In 1998, he was appointed as a permanent member of the staff of the Vatican Observatory. As a staff member of the Vatican Observatory Research Group at the University of Arizona he also served as administrator. We owe our deepest gratitude to Father Whitman for his generous service at the Vatican Observatory.

In Memoriam

We are very saddened to report the death of Miguel Angel Funes on 28 December. He was the father of Fr. José Funes, the director of the Vatican Observatory. We are saddened by the death of Prof. Nicola Cabibbo who served as President of the Pontifical Academy of Sciences. We remain deeply saddened by the death of Maria Piazza Scordo. She was a devoted member of the staff of the Observatory at Castel Gandolfo for 32 years.



Awards

On June 12, at the 159th Commencement of Santa Clara University, Santa Clara, California Fr. George Coyne, S.J. was awarded a doctorate in science honoris causa for "his encouragement of young scientists, his research into young and old solar systems and his endeavor to harmonize faith and science." On 18 June at Lucca, Italy, he was awarded the International Liberty Prize for Science of the Società Libera Italiana for "his dedication to the autonomy of scientific research."

Fr. Michael Heller was awarded an honoris causa doctorate from the Agricultural University, Poznań, as well as the "Phoenix" prize of Catholic Publishers.

Also this year, Father Chris Corbally S.J. was elected to the Council of the Institute on Religion in an Age of Science for the 2010-12 term.

Presentations, Conference Participation and Academic Activities

Boyle presented a paper at the 215th Meeting of the American Astronomical Society Washington, DC, 3-7 January • participated at Workshop on CCD Photometry Moletai Observatory, Lithuania 27 September - 5 October.

Brown gave a presentation on "Binary Population Synthesis and sdBs at Different Metallicities" at the University of Arizona in Tucson, March 3 • presentation on "Binary Population Synthesis and sdBs at Different Metallicities" at the University of Padova at Padova, Italy, April 22.

Caruana presented a research paper entitled "Faith evolving" at the Research Seminar of the Center for Philosophy of Religion, University of Notre Dame, Indiana, USA.

Chinnici presented a paper "Scienza e Scienziati a Palermo tra Borbone e Savoia" Palermo, 5 June • presented a paper at the Scientific Instruments Commission Symposium, October 4-9, Florence.

Consolmagno: presented a paper and co-authored another at TNO 2010, International Workshop on Trans-Neptunian Objects. Philadelphia, PA., June 27 - July 1 • presented a paper and co-authored two others at Annual Meeting, The Meteoritical Society. New York City, NY, July 26-30 • participated and chaired a panel discussion at SETI at 50, Workshop on the Search for Extraterrestrial Intelligence. Greenbank Observatory, West Virginia, September 13-15 • served on the organizing and program committees, presented two papers, chaired a session, and gave a public presentation in Italian and English at European Planetary Science Conference. Rome, Italy, September 20-24 • presented a paper and co-authored two others at Annual Meeting, The American Astronomical Society Division for Planetary Sciences, October 4-8.

Corbally presented a paper, "Is Hiddenness Natural?" at the European Conference on Science and Theology XIII, 7-10 April, in Edinburgh, Scotland • gave a talk on the theme of the ECST conference, "Is Religion Natural?",

April 14, at the St. Albert the Great Forum, Tucson, Arizona • participated in the Council meetings of the Institute on Religion in an Age of Science, July 23 and 28, Portsmouth and Star Island, NH • at the invitation of Dr. Alexander Nava gave a lecture on extraterrestrials and religion to 'The Question of God' course, October 14, at the University of Arizona • paid working visits to Dr. Robert Garrison, August 1-4, at South China, ME, and to Dr. Richard Gray, 8-9 December, at Appalachian State University, NC. The latter visit included Dr. Elizabeth Griffin • contributed a poster paper and co-authored a second at the American Astronomical Society meeting #215, Washington, DC, January 3-7 • participated at the National Optical Astronomy Observatory, 50th Anniversary Symposium, Tucson, March 17 • participated at the NH. Institute on Religion in an Age of Science, Annual Conference, Star Island July 24-30.

Coyne gave a paper at the International Union Symposium 269 in Padua, Italy, January 8-9, on "Galileo's Telescopic Observations" • presented a lecture on "Galileo and the Church: Lessons Learned" at the Closing Ceremony of the International Year of Astronomy in Padua, Italy, January 10 • to the Board of Directors of the Woodstock Theological Center, Washington, DC, USA gave a lecture on April 21, on "Evolution on a Grand Scale: The Fertile Universe" • June 10, at the celebration of the 10th anniversary of the Center for the Study of Christianity at the Hebrew University, Jerusalem he participated in the symposium, "Genesis: Three Theological Approaches," with a paper on "Origins of the Universe and of Humankind: Religious Belief and Science" • at the celebration of Science Career Week at Loyola University Chicago gave a lecture on October 20, on "Determining the Age of the Universe" • at the California Academy of Sciences, San Francisco, California gave a talk on November 1, on "The Age of the Universe" • on November 18, in Cincinnati, Ohio at the USA National Meeting of the Christian Brothers was the keynote speaker with a lecture on "Religion and Science in Today's America" • participated at Meeting of the American Astronomical Society Washington, DC, January 3-4 • participated and gave an invited paper at International Astronomical Union Symposium 269, Padua, Italy, January 6-8 • participated in Seminar at the Gruber Cosmology Prize Award, Chicago, Illinois, October 14-15.

Funes presented a poster paper at the 215th meeting of the American Astronomical Society, Washington DC, January 4-7 • participated in the meeting "JWST and the ELTs: An Ideal Combination" organized by the European Southern Observatory, Garching, April 13-16 • gave a seminar on science and faith at the School of Mathematical and Physical Sciences at Catholic University in Brescia, April 23 • participated in a panel discussion on the subject: "From the Heavenly Skies to the Cosmos of Science", at the University of Potsdam organized by the Leibniz Association, May 5 • gave a lecture on "L'Universo è conoscibile: La corrispondenza tra ragione e realtà", at the University of Milan, May 25 • invited by the System of Jesuit Universities of Mexico held the *Eusebio Francisco Kino, S.J.* Chair on Dialogue between Faith and Culture. He gave a series of lectures on "Science and Church in Dialogue. The Perspective of a Vatican Astronomer", at the Universidad Ibero Americana, Mexico City and Torreon. The lectures were broadcasted in video conference to the other universities of the System of

• Outside CERN and Inside CERN
 • Group of Korean-Italian participants at Ricci-Guangqi meeting at Sogang Jesuit University-Seoul.



Jesuit Universities, October 12-14 and 19-21 • participated in the Plenary Session of the Pontifical Academy of Sciences. He gave a summary of the Study Week in Astrobiology organized by the Academy in 2009, Rome, October 28 - November 1 • gave a seminar on Dark Matter in Galaxies, Vatican Observatory, part of a worldwide event "Dark Matter Awareness Week" whose aim is to make the complex but much-telling observational phenomenology of the dark matter distribution in galaxies more known to astrophysicists and cosmologists. To this purpose a seminar on this topic was delivered in many institutions around the world during the period December 1-8.

Gabor participated in the workshop "Challenges to the Giant Magellan Telescope" in Melbourne, Australia, June 15-16 • presented a paper at the European Planetary Science Congress in Rome, Italy, September 19-24 • gave a seminar at the Optical Development Laboratory in Turnov, Czech Republic, October 4 • presented a paper at the IAU Symposium 276 on the "Astrophysics of Planetary Systems: Formation, Structure, and Dynamical Evolution" in Torino, Italy, October 11-15.

Gionti visited the theoretical division of CERN at Geneva hosted by John Ellis and Alvarez Gaume, July 25 - August 1. He had many discussions with both of them on issues of Quantum Gravity. This was a first visit of a stable collaboration the Vatican Observatory and CERN want to continue • attended a meeting in Castiglioncello, Tuscany, Italy "Space-Time-matter" on fundamental issues of quantum mechanics, September 13 - 17 • participated at the Fall 2010 meeting of the Korean Society of Physics in Jang-Pyeong in South-Korea with prof. Remo Ruffini of the University of Rome "La Sapienza", president of I.C.R.A. (International Center for Relativistic Astrophysics)-NET of which the Vatican Observatory is member, October 21 • October 22 Italian-Korean lecture of prof. Ruffini on Matteo Ricci, Galileo, Xu Guangqi at the Sogang (Jesuit) University of Seoul. The event was



sponsored by the Italian embassy in Seoul and by Sogang University in the framework of the celebrations for the 400th anniversary of the death of the famous Jesuit missionary Matteo Ricci • gave a talk on "Quantum Gravity and String Theory" at the vatican Observatory, Castel Gandolfo, November 30.

Heller presented a paper on "Human Time" in Cracow, at the Pharmacology Workshop, February 16 • gave a series of lectures in Tenerife, Canari Islands, Universidad Internacional Menendez Pelayo on: "Cosmology and Creation: 1. The Evolution and the Structure of the Universe: 2. The Origin of the Universe: 3. Creation of the Universe, March 22-25 • gave a lecture on "Big Bang and the Beginning of the Universe" Gdańsk, Naval Academy, April 22 • Gdańsk, Concert Hall, gave a public lecture on "Symphony of the Universe" combined with concerto (Bach, Penderecki), April 22 • Sopot, Ergo Hestia, gave a public lecture on "Big Bang and the Beginning of the Universe", April 23 • Bydgoszcz, gave a public lecture on "Big Bang and the Beginning of the Universe", April 24 • delivered a paper at Ruhr Universitat, Bohum, on Theologie und Naturwissenschaft. Ein Dialog. Paper "Big Bang and the Creation of the Universe", May 5 • May 17-19, organized International Conference "Road to Reality with Roger Penrose", and delivered a paper on "General Relativity and von Neumann Algebras", Warszawa, 20-21 Kraków, Institute of Mathematics of the Polish Academy of Science (Warszawa), Jagiellonian University, Polish Academy of Science and Art (Kraków), Copernicus Center for Interdisciplinary Studies (Kraków) • gave a paper at Zakopane Conference on Nuclear Physics • participated in "Lemaître's Primeval Atom and Contemporary Standard World Model", August 30 - September 5 • delivered a paper at 11th International Congress on Musical Signification, Kraków Music Academy, on "The Symphony of the Universe", September 27 - October 2 • Department of Mathematics, Technical University, Warsaw, gave a public lecture on "The Universe as a Mathematical Structure", October 1.

Maffeo gave a lecture on the History of the Vatican Observatory to a group of students from "Collegium Mater Ecclesiae" in Castel Gandolfo, Italy, March 15 • gave a lecture on Fr. Angelo Secchi to a group organized by the National Library of Rome, April 21 • gave a lecture on "Science and faith in Fr. Angelo Secchi" to a group of amateur astronomers in Grosseto, Italy, April 30 • participated in the festival "Universus" organized by the amateur Observatory "Camillo Gloriosi" in Montecorvino Rovella, Salerno, Italy, July 23-25 • gave a lecture on: "Schiaparelli and Fr. Angelo Secchi" as part of meeting "Schiaparelli and his Legacy" organized by the Astronomical Observatory of Milan to commemorate the 100th anniversary of the death of G.V., October 19-21 • October 26, invited by the director of the Master "Scienza e Fede" organized in the "Ateneo Pontificio Regina Apostolorum", gave a lecture on "Scienza e Fede in P. Angelo Secchi".

Stoeger gave two days of workshops on Theology and Science to the seminarians and faculty at Mt. Angel Monastery and Seminary (Archdiocese of Portland) in Mt. Angel, Oregon, April 22 - 23 • participated in and gave two invited presentations on Relating Physics and Astronomy to Catholic



• Entrance door at CERN
 • Screen for monitoring L.H.C. activity located at CERN Cafeteria.
 Photos: Gabriele Gionti

Philosophy and Theology at the Substantial Catholic Seminar for Catholic High School Teachers at Marin Catholic High School, Kentfield, California, June, 8 – 9 • was a facilitator and respondent at The Henry Luce III Fellows in Theology Conference, in Pittsburgh, Pennsylvania. He responded to and facilitated discussion of the research paper, "Telling the Universe Story/ies: Christian Theology and Scientific Narratives of Origin," by one the Luce Fellows, J. Matthew Ashley, University of Notre Dame Department of Theology, who was recently appointed Chair, November 12 – 13 • attended the annual convention of the Catholic Theological Society of America, where he helps with the parallel sessions dealing with theology and the natural sciences. In 2010 it was held in Cleveland, Ohio, June 10-13.

Educational and public outreach

Brown gave a presentation to undergraduate students of the Bernardi House Campus in Rome of the University of St. Thomas (St. Paul, MN) on "The Vatican Observatory and Science", May 25 • gave a presentation to the undergraduate students of the Roman Campus of the University of Dallas on "The Importance of Matteo Ricci, S.J.", April 13 • gave presentations to selected science and theology classes of students at Jesuit High in New Orleans, August 30, 31, September 2, Strake Jesuit High School in Houston, August 24, 25, and Tampa Jesuit High School, September 7-8 in Tampa on "Some Aspects of The Vatican Observatory".

Carreira had invitations to speak on matters related to Science and Faith in Universities in Spain, Ecuador and Peru. In the latter two countries he spent 6 weeks with a total of 60 talks.

Consolmagno gave 57 public lectures on astronomy and the issues of church and science to school and church groups in the US and Great Britain. Among the most noteworthy of these events were the Prize Day Address to the students of St. Aloysius Gonzaga College, Glasgow, Scotland, where he was guest of honor • an invited talk at the British Science Festival in Birmingham, UK, "Discarded Images: Astronomical Ideas that were Almost Correct" • officially opened two school astronomical observatories in the UK. The first was on 26 January at Ardingly College, Haywards Heath • the second was the South Staffordshire Observatory at Cardinal Griffin High School on September 18, in Cannock • Consolmagno's alma mater, the University of Detroit Jesuit High School and Academy, named him one of their two "alumni of the year" in 2010. The award was given at a luncheon for the senior class and alumni in Detroit on April 28, at which he spoke.

Corbally answered questions at St. Ambrose Elementary School, Tucson, in Anna Alderman's science classes on January 25 and on February 3, celebrated Mass at the same school, blessing its new science classroom afterwards • gave talks to the Sun City Astronomy Club, Arizona, on "The Puzzling Iam Boötis Stars", March 18 • to the Green Valley Forum on "The Vatican and Astronomy", May 12 • about "The Cloak-and-Dagger Stars — Maybe!" in the Third-Thursdays Star Talks series at Prescott Public Library, Arizona, September 17 • was the Astronomy guest speaker at Primland, Meadows of Dan, VA, and spoke on "Rock Stars and the L & T Dwarfs" and "Will Religion Survive An Encounter With Extraterrestrials?", December 10-11 • helped the Southern

Arizona section of the International Dark-Sky Association with an Arizona-Sonora Desert Museum Astronomy Night in August, and with a Star-Party of the Desert View High School, Tucson, in October • participated occasionally by teleconference in discussions with the St. Agatha's Faith/Astronomy Dialogue program, Portland OR, and was joined in August by Consolmagno.

Coyne spoke on "The Dance of the Fertile Universe" at St. Thomas Aquinas Church, Avondale, Arizona, February 21 • gave a luncheon talk on "The Evolutionary Universe" to the Wiseguise, 19 February in Scottsdale, Arizona • March 17-19 at St. John's Abbey lectured to several classes and gave a public lecture on the interaction of chance and necessity in the evolution of the universe • conducted a visit of students from Verbum Dei High School, Los Angeles, California on April 7 to the Vatican Observatory Research Group in Tucson, Arizona and gave them a talk on "Astronomy Today" • April 14-15 lectured to the physics students and to the Newman Club at Colgate University, Hamilton, New York on Galileo and on the interaction between science and religion. He gave a public lecture at Colgate on "The Evolutionary Universe" • lectured on "the Evolutionary Universe" at the University of St. Thomas, Houston, Texas, April 26, and participated at Strake Jesuit High School, Houston, April 27, with Francisco Ayala at a symposium on scientific evolution before more than 600 students from the Houston area high schools • September 15, gave a talk on cosmology at Corpus Christi Church, Tucson, Arizona • October 1, at the Christian Brothers University, Memphis, Tennessee gave a public lecture on "The Dance of the Fertile Universe."

Funes gave public lectures at the Newman Center of the University of Toronto, in Brescia in the series of lectures "Bible, School, Education", at Universidad Ibero Americana in Mexico City • on the November 5-6, participated in the Festival of Sciences in Genova • gave a lecture on "The evolving Universe" and participated in a debate with Paolo Flores d'Arcais on the relationship between Faith and Science • November 19, participated in Festival of Ideas 2010 organized by the University of Alberta, Edmonton • gave a lecture with the title "Why Science and Faith Matter to Each Other" and participated in "Astrobiology Panel". He also gave the sermon in the religious service at the Chapel of Augustana campus of the University of Alberta • December 10, organized by the Pontifical Council of Culture, Funes participated in panel with John Barrow and Piero Benvenuti on "What Modern Cosmology tells us about our Place in the Universe".

Gabor gave a series of talks in South Australia, Adelaide, Port Pirie, Port Augusta, Whyalla, Crystal Brook, Port Hughes, in June-July, and in the Czech Republic, Prague, Milevsko, Trebic, Zelezny Brod, Vsetin, Kyjov, Mlada Boleslav in October.

Maffeo during the course of the year has accompanied about 35 groups of people visiting the Vatican Observatory in Castel Gandolfo.

Omizzolo gave talks on the subject of "Science and Faith" by relating between the cosmological description of the origin of the universe and the biblical approach to the creation of the world at the Studio teologico di Piacenza,



University of Novara, University of Roma 3, Scuola di Perfezionamento per insegnanti di Scuola Media Superiore, Orvieto, Centro Culturale sant'Adalberto a Montevarchi, Liceo Scientifico Tombetta, Verona, in 2010.

News and media coverage

Boyle was interviewed and filmed by Juri Koester, journalist of Munich, Germany, at VATT to make an hour long film documentary in German titled "God and Space" about the Vatican Observatory and the relation of science and faith. It was televised in Austria and Germany in January • interviewed in July by Anna Artymiak for a brief article including photography by Gregorio Galazka for the journal "Inside the Vatican."

Consolmagno participated in a dozen different media interviews during the year. The most noteworthy were the interview with George Coyne on the NPR radio show Speaking of Faith (see Coyne) and two days of filming with a television crew from Bavarian Television; material from that time was broadcast in the UK as "Vatican: The Hidden World" on BBC4 during the Pope's visit to the UK in September.

Corbally was interviewed for the Drew Mariani Show, Relevant Radio, on 11 January, about "exoplanets, astrobiology, and ETI life", and on 24 May about "Copernicus's reburial and Galileo" • was interviewed by Leo W. Banks for the Tucson Weekly on possibilities of ETI life, 18 February • answered questions on the Vatican Observatory by Eugenie Reich, for a Knight science journalism fellowship at MIT, 4 May • was featured in the US Catholic, guest blog, "Quantum leaps of faith", 3 September, <http://uscatholic.org/blog/2010/09/quantum-leaps-faith> • coordinated a filming visit to the Vatican Observatory Advanced Technology Telescope by Father Robert Barron and Father Stephen Grunow, from the Word on Fire Catholic Ministries, who interviewed Coyne for "The Catholicism Series".

Coyne together with Consolmagno was interviewed by Krista Tippett on "Speaking of Faith," American Public Media, St. Paul, Minnesota, February 24 • 6-7 May, gave a TV interview to Jörg Burger for his program "Focus at Infinity" being produced by Mischief Films, Vienna, Austria • October 22, interviewed by Kathleen Wong, Science Writer for "Natural Hazards," Oakland, California.

Funes gave interviews to Agence France Presse, RAI Due, Italia 1, Studio Aperto, El Mundo, El Siglo de Torreón, La opinión Milenio de Torreón, JESUS magazine, Nuestra Tele – NTN 24. An Interview with Funes was published by The New Scientist • April 11, participated in a broadcast by RAI International commenting the message of Benedict XVI.

Books

In October 2010 the Vatican Observatory project of hosting an inter-religious research conference on "Creatio ex Nihilo Today" reached its fulfillment, with the publication of the papers from it as *Creation and the God of Abraham*, edited by David B. Burrell, Carlo Cogliati, Janet M. Soskice and William R. Stoeger (Cambridge: Cambridge University Press, 2010), 274 pp. The Conference itself was held at Castel Gandolfo July 9-15, 2006, and involved scholars in the natural sciences, philosophy and theology from all three of the monotheistic traditions, Judaism, Christianity and Islam. David Burrell, Janet Soskice and Bill Stoeger organized it, with continual help and encouragement from George Coyne, who was Observatory Director at that time. We convey our profound gratitude and appreciation to David, Janet and Carlo – and to all who participated in the Conference – for their wisdom, dedication and hard work in making the Conference itself such a success, and in co-authoring such an outstanding volume.

Under the guidance of P. A. Abell, and in conjunction with over 253 authors from the The LSST Collaboration, Dante Minniti contributed to the "LSST Science Book", version 2.0, 2010, arXiv:0912.0201



Sabino Maffeo, at the closure of the Galilei Year, made ready for press the third Italian Vatican Observatory edition of Annibale Fantoli's book: "Galileo - Per il Copernicanesimo e per la Chiesa".

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The Vatican Observatory headquarters derives its present layout from a building that was originally conceived as a monastery. The word monastery is used here in its traditional sense and not in the broader context of a religious house. Monasteries, and in particular cloistered monasteries, have specific architectural and spatial requirements dictated by the rules that govern the rhythm and demands of monastic life: prayer, work and rest all confined to a territory designed to be a world of its own, a cloistered world. The decision to transfer the Vatican Observatory to a building that was not designed for its own needs, but that could be transformed and adapted to meet these needs, while respecting the peculiarities of the existing construction, was a challenge. Particularly for the community of the Vatican Observatory whose task it was to transform the old Basilian monastery into a structure adapted to the needs of an institution devoted to research in the field of astronomy.

One year on from the transfer, it can be safely said that the former monastery has been successfully restructured. It now meets the needs for scientific research, while perhaps, still falling a little short of meeting residential requirements. Two classic spaces of monastic life - the cloister and the nuns garden - have also been adapted. While the former remains unchanged and still today fulfils its role as a green lung and a place of rest, meditation and inspiration, the latter - that is the garden - which in the past provided the nuns all sorts of vegetables, has become the Observatories central square with the coming and going of people and cars. Yet, while it may now serve a different purpose we have tried to keep a little of its original character,



7. Vatican Observatory Headquarters

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Cloister, Vatican
Observatory Castel
Gandolfo.

Photo: Federico Balzoni



embellishing it with various plants and trees. Since the nuns were devoted to work and prayer, the garden where they worked also had an outside chapel where they could pray. This we left in place and have sought to restore it as much as possible. This chapel, although small, stretches towards the sky helping us too, after hours of work, to raise our eyes and minds to the Lord, the Creator



- Central square
- Detail apse, prayer chapel Vatican Observatory Castel Gandolfo. Photos: Guy Consolmagno

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(R to L) Fr. Funes, S.J.,
Msgr. Carlo Maria Viganò,
general secretary,
Governatorate of
Vatican City State,
Roberto and
Maria Buffetti.
Photo: Guy
Consolmagno

of the heavens and the stars, centre and end of all of the research carried out with great devotion by the staff of the Vatican Observatory.



Visitors to the Vatican Observatory Castel in Gandolfo

On December 4 the lecture room of the Vatican Observatory, which is most notably the site of our biennial Vatican Observatory Summer Schools, was dedicated as the Aula Gabriele Buffetti. H.E. Mons. Carlo Maria Viganò, general secretary of the Governatorate of the Vatican City State, officially blessed the plaque honoring the son of Roberto and Maria Buffetti. The dedication was followed by a lunch in the community with the Buffettis and Mons. Viganò.

The Buffetti family have been friends of the Vatican Observatory for many years. Mr. Roberto Buffetti was an alumnus of the Istituto Massimo, the school run by the Jesuits in Rome; and when in turn their son Gabriele attended that school in the late 1960s, Roberto and Maria came to know Father Sabino Maffeo, at that time the rector of the Institute there. Later, at the invitation of the Vatican Observatory director, Father George Coyne, they participated in the inauguration of the VATT in Arizona in 1993. Maria Buffetti produced the beautiful photographs of the Vatican telescope that have graced the walls of the Vatican Observatory in Castel Gandolfo since then.

They visited the Vatican Observatory during the 2010 Summer school invited by Father José Funes, and they were particularly impressed there by the joy with which these young students were embracing their study of astronomy. For that reason, they were inspired to make a donation to the Vatican Observatory and in support of future summer schools. They agreed to allow the lecture hall of these schools be named for their son Gabriele.

Gabriele Buffetti was a student at the Jesuit Istituto Massimo until his death in 1972, at the age of 17, in a accident while on vacation overseas. He was one year shy of completing his Liceo degree with a concentration in science. The dedication of the Aula this year occurred one day after his birthday; he would have been 56.

We are very grateful to Maria and Roberto Buffetti for their generous gifts to the Vatican Observatory and in support of the next Vatican Observatory Summer School in memory of their son Gabriele.



Cardinal Bertone Celebrates the Feast of St. Ignatius at the Vatican Observatory.

On the eve of the feast of St. Ignatius, Friday July 30, the community of the VO in Castel Gandolfo celebrated the feast of the founder of the Jesuit order with a gathering of friends and benefactors at the new headquarters in the Papal Villas. The Guest of Honor was Cardinal Tarcisio Bertone, Vatican Secretary of State. The Cardinal blessed and visited the observatory libraries and laboratories with Fr. José Funes, SJ. Also participating at the gathering were Cardinal Stanislaw Rylko, president of the Pontifical Council for the Laity; Bishop Giorgio Corbellini, vice secretary general of the Governatorato and president of the Holy See's Labor Office; Bishop Marcello Semeraro, of Albano; Fr. Federico Lombardi S.J., director of Vatican Radio, Vatican Television, and the Holy See Press Office; Saverio Petrillo, the director of the Pontifical Villas; Domenico Giani, the director of Security and Public Safety; Dr. Patrizio Polisca, the Pope's personal doctor; Fr. Giuseppe Costa, the head of the Vatican Press; and other officials of the Vatican government.

During the course of the year the VO at Castel Gandolfo received the following visitors:

The Honourable Mr. Kim Karr, Minister for Innovation, Industry, Science and Research of Australia and H.E. Mr. Timothy Fischer, Ambassador of Australia to the Holy See; H.E. Mr. Juan Pablo Cafiero, Ambassador of Argentina to the Holy See; H.E. Mr. Luiz Felipe de Seixas Corrêa, Ambassador of Brazil to the Holy See; H.E. Mr. Emilio Marin, Ambassador of Croatia to the Holy See; H.E. Mr. Hèctor Federico Ling Altamirano, Ambassador of Mexico to the Holy See; H.E.

Mr. Jozef Dravecky, Ambassador of Slovakia to the Holy See; H.E. Mr. George Johannes, Ambassador of South Africa to the Holy See; H.E. Mr. Francesco Kim Ji, Ambassador of South Korea to the Holy See; H.E. Mrs. Tetiana Izhevsha, Ambassador of Ukraine to the Holy See; H.E. Mr. Miguel Humberto Diaz, Ambassador of United States to the Holy See.

Gabriele Gionti S.J. gave a tour of the Vatican Observatory at Castel Gandolfo to Rev. Msgr. Collins, F. Bircumshaws and Rev. Msgr. J. Terrence Fitzgerald of the Diocese of Salt Lake City in Utah.

Sabino Maffeo, S.J. accompanied about 35 groups of people visiting the Vatican Observatory in Castel Gandolfo, during the course of the year.

The following paid working visits to VO in Castel Gandolfo:

Jonathan Lunine, University of Rome Tor Vergata, Lunar and Planetary Lab (University of Arizona); Fernando Comeron, European Southern Observatory; Benjamin Martin, Student of the Boston College; Tomas Kohout, University of Helsinki; Maria Gritsevich, University of Moscow; John Stocke, University of Colorado; Ileana Chinnici, INAF/Osservatorio Astronomico di Palermo, Adjunct Scholar of the Vatican Observatory.

On 16 April, 30 members of the scientific team of the NASA DAWN mission to asteroids Ceres and Vesta visited the library and meteorite of Vatican Observatory. Dr. Daniel M. Davis, University of Stony Brook (NY), spent a two month sabbatical working with Br Consolmagno at the Vatican Observatory in Castel Gandolfo.

Visitors to the Vatican Observatory Research Group (Tucson) and VATT:

Fulbright Fellow Krzysztof Bolejko, Nicolaus Copernicus Astronomical Center, Warsaw, Poland.

The following paid working visits to the Vatican Observatory Research Group (Tucson) and VATT

Frank Younger, Dominion Astrophysical Observatory, Victoria, Canada; Philippe Eenens, Universidad de Guanajuato, Guanajuato, Mexico; Gregg Hallinan, NRAO & UC Berkeley; Leon Harding, NRAO & National University of Ireland, Galway, Ireland; A. G. Davis Philip, Union College and Institute for Space Observations, Schenectady, New York, USA; Ramarao Tata and Nicolas Lodieu, Instituto de Astrofisica de Canarias, La Laguna, (Tenerife), Spain.

Marcelo E. de Araújo, Universidade Federal do Rio de Janeiro, Brazil and Rev. Bill Mathews, S. J. Milltown Park, Dublin, Ireland, paid working visits with the Vatican Observatory research group.



• Reception for feast of St Ignatius.

• Card. Tarcisio Bertone, Vatican Secretary of State. Photos: David Brown



