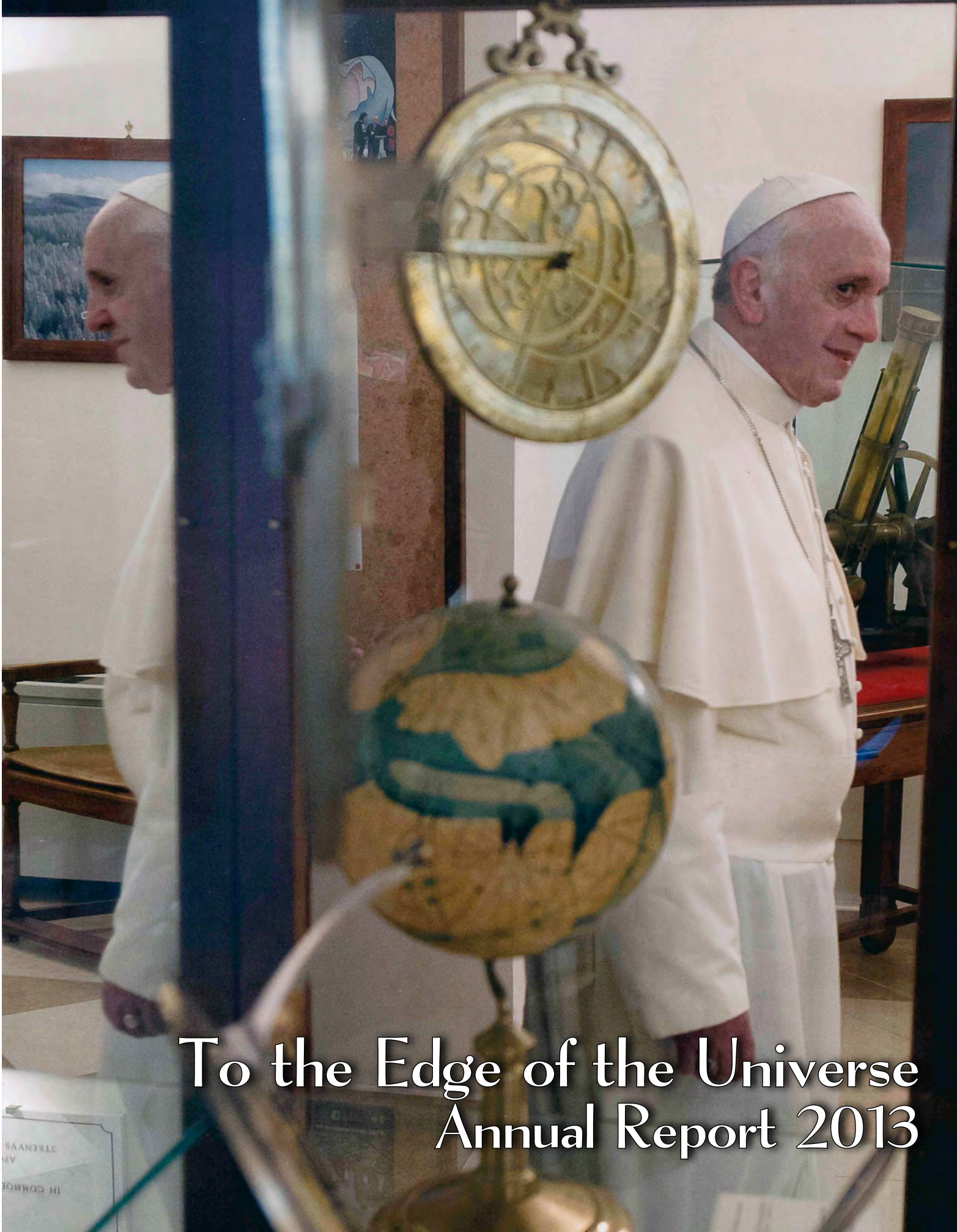


The Vatican Observatory



To the Edge of the Universe
Annual Report 2013





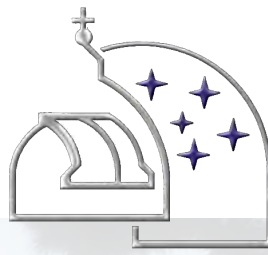
SPECOLA VATICANA Vatican Observatory

ANNUAL REPORT 2013

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Cover: Pope Francis visited the Vatican Observatory (VO) in July; he is seen here through a display case of antique astronomical globes and instruments, including a 16th century astrolabe and a hand-painted globe of Mars from 1915. (credit: L'Osservatore Romano)

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FROM THE DIRECTOR

God of Surprises

March 13. It was about 11:10 a.m. in Tucson when the white smoke from the chimney of the Sistine Chapel announced to Saint Peter's Square and to the world that a new Pope had been elected. I was following events as they unfolded online like many of you. It was a surprise that the cardinals had resolved the election so quickly but, for me, the surprises did not end there. I was surprised and shocked when I heard the name of the elected cardinal. Father Jorge Mario Bergoglio was one of the Jesuits who examined my vocation when I asked to join the Jesuit Order.

July 14. Another memorable day. We had the great honor and joy of welcoming Pope Francis to our headquarters. Another surprise and another first time. The Holy Father had lunch with the Jesuit community. It was the first time that a pope had eaten lunch with his astronomers. The meal gave us the unique opportunity to discuss our activities and projects directly with Pope Francis. We will give more details of this illustrious visit in our section Observatory Visitors.

To the Edge of the Universe

From the beginning of his pontificate, Pope Francis has encouraged the Church to move out to the margins. Not just the geographical outskirts, but also the existential ones. His teaching is very important for the mission of the Vatican Observatory (VO); his words encourage us to go out to the outskirts of the universe, to explore the universe, its origins and its future. It also means to come out of ourselves to ask the deepest human questions about science and faith.



The Holy Father, Pope Francis, in conversation with Vatican Observatory director, FUNES during his visit to the VO headquarters in Castel Gandolfo, July 2013.

We are also very grateful to Pope Benedict XVI for his support and his teachings. I remember his words at a colloquium sponsored by the VO on the occasion of the International Year of Astronomy in 2009. Benedict XVI invited those in attendance “to consider the immense progress of

scientific knowledge in the modern age and, in a particular way, to turn our gaze anew to the heavens in a spirit of wonder, contemplation and commitment to the pursuit of truth, wherever it is to be found.” Inspired by these words and aware of the swift progress of our understanding

of the universe, the VO staff has prepared a document to chart a scientific roadmap for its quest to address the big questions of astrophysics and cosmology.

We are enthusiastic about our mission. Like all astronomers our deepest desire is 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?

Sometimes I am asked if the Vatican officials give us an agenda for our research goals. Our only goal is to do good science; our only commitment is to pursue truth, wherever it is to be found.

In outlining the role of the VO in the future, we have produced a document with a prioritized set of scientific objectives that are balanced and cost-effective, gleaned from the most compelling questions and ideas that have emerged from contemporary astrophysics and cosmology. Our aim is to determine the path to the best scientific return for the Observatory, given the constraints of budgetary considerations, available human resources and collaboration, realistic timelines and technical readiness, which build on research already in progress or completed.

This document outlines six research areas and works: Planetary Sciences, Stellar Astronomy, Extragalactic Astronomy, Cosmology, the VATT and Instrumentation, and Education and

Public Outreach. In addition to these topics, members and affiliates of the VO are also active in the scholarly study of the history and philosophy of science, and of issues in science and theology. Those topics are not addressed in this document.

In this report we present a summary of the *Science Priorities of the VO for the Next Decade*.

This enterprise would be impossible without the support of many colleagues, benefactors and friends and especially of the Governatorate of the Vatican City State. To all of them goes our deepest gratitude.

The exploration of the Universe is a journey for all people of good-will, not only for the Vatican astronomers. I hope you will join us on this journey.

Jose' G. Funes, S.J.
José G. Funes, S.J.
Director



The Holy Father, Pope Francis, views a parchment which bears the signatures of his predecessors who have visited the VO headquarters.

SCIENCE PRIORITIES

The VO is set to publish a document titled “*Science Priorities of the VO for the Next Decade*”.

In the document we outline six research areas and works: Planetary Sciences, Stellar Astronomy, Extragalactic Astronomy, Cosmology, the VATT and Instrumentation, and Education and Public Outreach. Here we present a summary of those objectives:

I Planetary Sciences, Astrobiology and Exoplanets

Group: CONSOLMAGNO, GABOR, KIKWAYA and MACKE, with contributions from BOYLE and CORBALLY.

With the recent addition of three young Jesuit scientists (Gabor, Kikwaya, and Macke), the Planetary Sciences group at the VO is now poised to pursue an unprecedented range of activities. Its work is primarily centered on the nature of small bodies within our own solar system, and the discovery of planets around other stars.

Meteor work: A project of setting up a fireball network in Tucson is already underway by Kikwaya in collaboration with colleagues and institutions in the field. NASA will provide four all-sky cameras, which should be ready by the end of 2014.

NEO Observations: The major difficulty in characterizing Near Earth Objects is that they are small, faint, and fast-moving. The time from discovery to when they are no longer able to be observed may be as short as one week.

Most of these objects are discovered during dark time, often before new Moon. Howell and Nolan (Arecibo Observatory, and recent visitors to the VO) have proposed reserving a

regular period of time on Arecibo after new moon to try to capture with radar observations whatever NEOs are newly discovered. We could complement such observations by simultaneously observing these newly-discovered NEOs using three different instruments on three Arizona telescopes with current instrumentation: the f/9 Ritchey-Chretien focus at the 90 inch Bok telescope on Kitt Peak, the 61 inch LPL telescope on Mt. Bigelow, and the VATT.

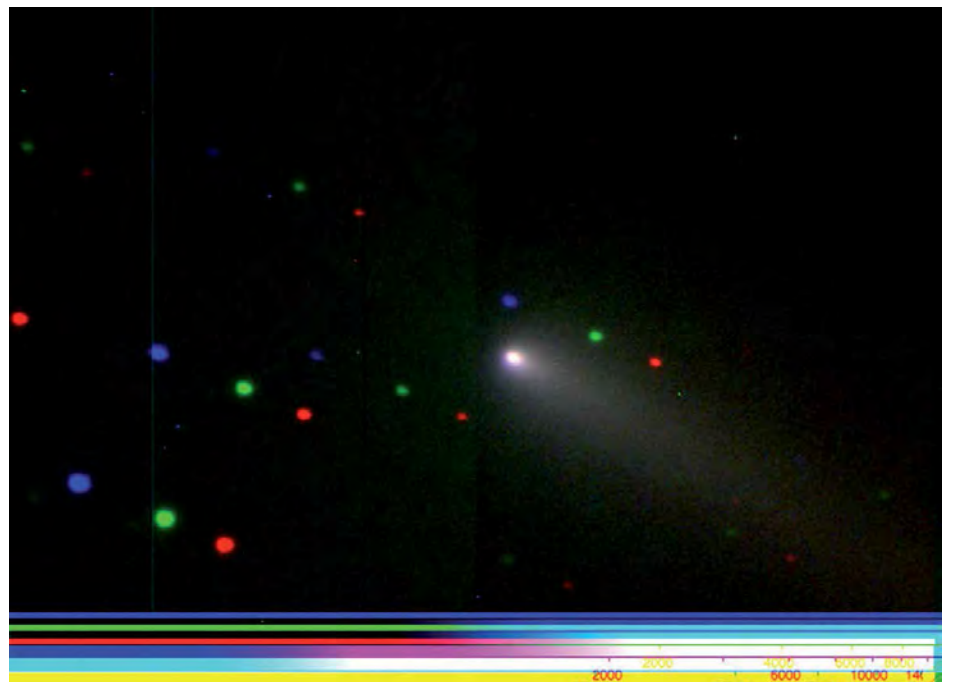
The process of coordinating these telescopes, being carried out by Gabor, is now well underway. Work in the coming year will begin on the automation of these telescopes and determining which detectors are best suited for each telescope.

Meanwhile, VATTSpec has already been successfully tested by Kikwaya

and Corbally for asteroid observations. With an improved guider, they expect to be able to obtain visible and near-IR spectra for objects as faint as 20th magnitude.

With this project we will be able to start to collect physical characteristics (composition, color, size, structure, albedo...) of NEOs, allowing us to elaborate a list of backup targets for OSIRIS-Rex mission or just a list of possible targets for likely future asteroid return missions. We would also resolve a significant question concerning how closely the NEO population mirrors that of the asteroid belt itself.

The most successful NEO discovery program of the last ten years has been the CSS, run from the Catalina Observatory in Arizona. But an important part of this discovery program is the recovery of these objects



Three separate images of Comet ISON, taken in red, green, and blue filter at the VATT in October by KIKWAYA, were combined to make this color picture. Because the comet moved significantly from image to image; combining the comet images into one color picture means that each background star shows up as a separate colored dot.

within a day of their discovery so that an accurate orbit can be determined. As midnight in Castel Gandolfo occurs 16 hours after midnight in Arizona, having a wide-field camera in place in Castel Gandolfo to complement the discovery in Arizona would be very useful. This would be an ideal project for a revamped and automated Schmidt telescope. Ideally such a program would be integrated into the Catalina program, with the capability of controlling the telescope and downloading the data from Arizona, and using their data pipeline to automate the astrometry of the asteroids' positions.

Meteorite lab: Meteorite physical property measurements will continue to be the primary work done at the newly-upgraded laboratory in Castel Gandolfo.

The measurement of meteorite heat capacity via liquid nitrogen boil-off is well underway. Future work looks forward to improving the precision of the technique and systematically measuring appropriate samples from the Vatican meteorite collection. This work alone will likely require five years to complete.

In the future, MACKE hopes to explore the interaction between icy meteorite/asteroid analogs, to see what role water ice plays in adhesion of small objects under collision. This would involve a developing a new setup in the Castel Gandolfo meteorite lab; at the beginning it could be assembled from mostly off-the-shelf pieces over a few years.

Last but not least is the continuing important work in meteorite curation and loans. More than half of papers (25 of 42, according to the NASA Astrophysics Data System) published in the past ten years analyzing the unique Martian meteorite

Chassigny have been based on thin sections provided from the VO collection. It is expected that the curatorial work of the Vatican collection will be handed over from CONSOLMAGNO to MACKE in 2014.

In connection with curation, one item that needs to be incorporated into our long-term goals is developing a strategy for acquisition of new samples. It will be important in the future to be able to continue to obtain new scientifically interesting specimens, particularly fresh falls, and we need to develop the means to do that.

Exoplanets: An important initiative in the field of exoplanets to be carried out by the VO in the coming year is the upcoming conference organized by GABOR, "Search for Life Beyond the Solar System: Exoplanets, Biosignatures & Instruments" to be held in Tucson in March 17-21, 2014. This conference will bring together an interdisciplinary community to examine the interface of exoplanet observations, early and extreme forms of life on Earth, atmospheric biomarkers, and planet-finding telescopes. GABOR's expertise in this area up to now has been in the development of the instrumentation used in these studies. One hoped-for result of this meeting should be suggestions for a pathway to proceed in this research. GABOR and LPL graduate student Zelle (VOSS 2007) have proposed another way that the VATT could play a crucial role in a long-term study of importance to exoplanet research.

The VATT could be used to study the photometric brightness of a few key planetary systems over a long period of time (at least for a season, initially). Eventually, depending on how the initial study goes, we would

invest in some additional filters to better constrain the starspot sizes. For example, one could use filters sensitive to the lines of TiO: one expects TiO to photodissociate at higher temperatures, so if a spot had less TiO, it was a large, hot spot, instead of a smaller, cool spot. Such a study would be of high importance to the exoplanet community.

A rapidly growing field of exoplanet research is the detection and characterization of exoplanets transiting M-class stars by observing the relative photometry of those stars. A revamped Schmidt telescope in Castel Gandolfo might be ideally suited for such research, especially if it is automated and integrated into an already-existing data processing pipeline.

II Stellar Astronomy Group: BOYLE, BROWN and CORBALLY.

Our goal is to develop a coordinated and integrated approach that staff members of the VO can follow in their study of stars. We can identify two specific approaches toward this goal that build on the current research and strengths of the VO in this field.

The first is to coordinate the ongoing spectroscopic, photometric, and asteroseismological results with theoretical work. The combination of such observations with theoretical tools such as up-to-date stellar evolution, population synthesis, and stellar atmosphere computer codes, together with isochrone libraries and N-Body codes, should lead to a better understanding of the astrophysics of stars on every level – internal structure, interaction with companions, cluster dynamics.

The second idea is to make full use of

already-existing stellar databases and archived data available, such as from HST, SDSS, Spitzer, GALEX, Kepler, and soon-to-be available GAIA data (just to name a few) with future observational projects with telescopes (such as VATT).

Asteroseismology: The Kepler and CoRoT missions have provided a wealth of data on pulsating stars (such as sdB stars); using VATT, Brown and Boyle could perform a follow-up survey using the GUFU camera to conduct an asteroseismological analysis (examining p- and g-modes) on a selection of such stars. Strömvil and Vilnius photometry and spectroscopy from the VATT spectrograph could complete photometry already obtained by Kepler in determining light curves and pulsation modes, as well as atmospheric parameters and element abundances, respectively. Collaboration could be established with groups already involved in mode determination.

VATT already possesses the necessary instruments, principally the special GUFU camera. A possible collaboration with the LAMOST mission might be fruitful as well, given that Corbally and collaborators will also be working with some aspects of LAMOST. The study could be done in 2-3 years if selected targets are chosen well, but this will also depend on how quickly BROWN and BOYLE can specify the parameters of the study and also acquaint themselves with asteroseismological methods.

Such observations could determine fundamental parameters of these objects: mass, surface gravity, envelope mass, abundance ratios in stellar envelopes, luminosity, and effective temperature. The aim is to understand better the evolutionary channels of sdB stars by comparing their

empirical mass distribution with that obtained from theoretical modeling.

Photometry and Cluster Populations: BOYLE and collaborators will continue their current work using the 1.8 meter VATT, the US Naval Observatory 1 meter telescope in Flagstaff, Arizona, and the Moltai Observatory Maksutov telescope in Lithuania to obtain Strömvil and Vilnius photometry to determine the nature of stellar populations in the Galaxy.

The Vilnius photometric system can be of immense use in a survey of multiple stellar populations in globular clusters (and some open clusters). Determining the multiple main sequences in such clusters, and finding the distribution of EHB stars along the horizontal branch in the Hertzsprung-Russell diagram (of such clusters), can help discriminate among various possible evolutionary mechanisms by which such groupings arose.

Studies on sdB stars can be developed in collaboration with Bono and D'Antona (Monte Porzio). Targets clusters would include M3, M5, M13, M22, M30, and NGC 6791. A derivative aim of this study would be to determine EHB stars in binary systems there; this would allow the comparison of the EHB binary fraction (at least for short-period binaries) in such clusters to that of the Galactic field, which is much higher. Such a project should take about five to seven years.

Spectroscopy: CORBALLY is currently participating with researchers from Belgium, China, Italy, Poland, and the USA in a spectroscopic follow-up to exoplanet surveys, such as that conducted by Kepler. The aim is to use spectral ground-based data for these stars, including data from the Chinese-administered 4-m LAMOST telescope, to determine the physical parameters of stars in the Kepler data. Gray (Appalachia State University) and CORBALLY will



The galaxies M65 (left) and M66 (right), members of the Leo Cluster, were imaged at the VATT in February by CONSOLMAGNO, Romanishin, and Tegler.

complement this effort by obtaining the stars' spectral classifications, as a check on those obtained by LAMOST. Given the high number of stars, they have developed an automatic classification code, MKCLASS, for this task. This code surpasses any previous auto-classification method in accuracy and scope. Future work by CORBALLY and collaborators will continue to shed new light on the formation channel(s) of lambda Boötis stars. Additional spectral analysis of stars in the Kepler field also will yield a better understanding of planets in binary star systems.

Solar Studies: One way the VATT can contribute to studies of our own Sun is by continued spectroscopic and photometric monitoring of activity in solar analogues. A decade of such monitoring, added to the existing data from several years, will allow analysis of such activity over a period comparable with the solar cycle.

III Extragalactic Astronomy

Group: D'SOUZA, FUNES, and OMIZZOLO

Galaxy Clusters: Galaxies are not exactly "island universes"; they don't evolve in isolation. Galaxies evolve due to the interaction with other galaxies. Spiral galaxies tend to collect in groups of galaxies, which contain up to several dozen galaxies. Elliptical galaxies are more common in clusters of galaxies.

Omizzolo studies galaxy clusters as a member of WINGS (Wide-field Nearby Galaxy-cluster Survey). WINGS is an all-sky ($|b| > 20$) survey of a complete, X-ray selected sample of galaxy clusters in the redshift range 0.04-0.07. The goal of the WINGS project is the systematic study of the local cosmic variance

of the cluster population and of the properties of cluster galaxies as a function of cluster properties and local environment. This collection of data allows the definition of a local, 'zero-point' reference against which more distant clusters can be compared, allowing us to better gauge cosmic evolution. Omizzolo plans to continue this work with the WINGS team, using 4 to 8 meter class telescopes equipped with wide field imagers and multi-fiber spectrograph to address questions concerning dark matter and the evolution of cluster galaxies.

Modeling Galaxy Formation:

D'SOUZA is a graduate student who has completed the first year of the PhD program at Max-Planck-Institut für Astrophysik, Garching, Germany working with Guinevere Kauffmann as supervisor. He is expected to join the VO staff after the conclusion of his doctorate.

D'SOUZA and his collaborators are working on semi-analytic galaxy formation models to study galactic accretion and the outer structure of galaxies in the cold dark matter cosmology. The simulations cover scales from the stellar haloes of Milky Way-like galaxies to the cD galaxies (galaxies that can be found near the centers of some rich galaxy clusters), and resolve low surface brightness substructure such as tidal streams. This kind of approach is crucial for extragalactic studies at the VO. D'Souza will be the first member of the staff with expertise in this field.

Unanswered Questions: Given this overview of extragalactic research at the VO one can outline the open questions that deserved to be addressed in the next years.

There is still a need to bring together

the knowledge that we possess regarding the Milky Way with what we can study of other galaxies. A great amount of progress has been reached since the first Vatican Conference on galaxies in 2000, when members of two communities (Milky Way and other galaxies) exchanged ideas. We need to understand better the nature and formation mechanism, stellar populations, galaxy components, the role of mergers for the Milky Way and other galaxies. The VATT with the other small Steward Observatory telescopes using their optical and near-IR imaging and spectroscopic capabilities can be used to address these topics.

IV COSMOLOGY

Group: GIONTI and STOEGER.

The VO has been involved in cosmological research over the past 30 years through the theoretical work of STOEGER and his collaborators in South Africa and in Brazil. Most of that has centered on the standard isotropic and spatially homogeneous (Friedmann-Lemaître-Robertson-Walker (FLRW)) zeroth-order model.

One effort is to develop a mathematical framework in which cosmological models closely related to, but much more general than, FLRW can be fit to presently available data. Another such effort is to fit data from new, more precise independent observables, such as redshift drift and the maximum of the angular-diameter distance and its redshift. The basic idea here is to see if some of these inhomogeneous cosmological models fit the available better or just as well as the concordance model. Once such models are identified, one can then attempt to identify new observables that would be able to break this best-fit degeneracy, and show which model is best supported

by the observations.

STOEGER and his collaborators (particularly Ellis, University of Cape Town) have also done related cosmological work clarifying certain conceptual issues related to inflationary models, multiverses, and in estimating the boundary between local and cosmological gravitational influences.

More recently GIONTI has been pursuing research in Quantum Gravity and Quantum Cosmology. In particular, he has published interesting results dealing with discrete formulations of general relativity. He has also investigated key issues in super-string theory, most recently concentrating on the phenomenon of T-duality. These results are oriented toward eventually developing an adequate description of the universe during the Planck era – before the Big Bang – when all the physics we know has broken down and where we must replace it with a complete quantum-gravitational description of reality.

In this survey, we shall first briefly summarize some of the basic background necessary for understanding those areas of cosmology in which the VO has been involved and is involved, and then look to the future of what the Observatory can and should be able to do in this challenging area.

V VATT and Instrumentation

VATT's science in the next ten years will be the result of an imminent and significant change: the VATT is in transition to becoming robotic, by the fall of 2015. Its robotization will be coordinated with that for the Steward Observatory's other medium-sized telescopes, the 90-inch Bok telescope on Kitt Peak and the 61-inch LPL tele-

scope on Mt. Bigelow. When all three are robotic, simultaneous observations in different modes for the same program can be achieved. This will make the three telescopes into a powerful and unique consortium, the TriTelescope Facility (TTF).

In the robotic mode each telescope will employ one or at most two instruments. It is currently not clear which instrument(s) will be most suited to which telescope. Now is precisely a time for instrument trials and assessments.

While initially VATT was not foreseen as a part of the VO's presence at the University of Arizona, it has become a very significant locus for collaboration in engineering advances and for scientific output. Particularly as part of the TTF, its significance to the VO and to Steward will grow over the next ten years.

Outreach is covered elsewhere in the whole report. Here it should be noted that VATT's impact for this part of the mission of the VO, through both the media and general visitors, has been outstanding and unique – as many anecdotes of the staff can confirm.

VI Education and Public Outreach

An important part of all research efforts is education and public outreach. This fulfills a core part of our mission, as expressed originally in our founding documents by Pope Leo XIII, to show the world that the Church supports true science.

We plan to build a visitor center in the Vatican Gardens of Castel Gandolfo. The Garden Domes are ideally situated to be used as a museum where organized tours of small groups or, possibly, members of the general public could visit during a limited number of hours in the week to learn about astronomy

and the Vatican's role in its history. The two telescopes in these Domes are both instruments that make photographic images of stars. Thus we propose to establish within the Garden Domes an exhibit on Photographing the Sky. Here we could display large prints of images taken with Vatican telescopes, along with a description of how these images were taken, and an explanation of what science is learned from them.

In addition to talks at the VO headquarters or in schools, a new aspect to public outreach is the use of the internet, in particular links to schools and other groups via webcams (Skype, FaceTime, etc.) and the use of social media like Twitter and Facebook. Consolmagno has already given a number of presentations via Skype from Castel Gandolfo to classrooms in the United States and the United Kingdom; this is a far more efficient use of time than actual travel to these schools.

A proposal being developed with the Vatican Observatory Foundation would bring webcams into the control room of the VATT to link students in schools with observers doing real-time research; such a link up was successfully established this fall with observations of Comet ISON. In the future, such links could also be made available to active supporters of the Vatican Observatory Foundation. This sort of connection would allow university and even high school students to see Jesuit astronomers at work, and present not only what we do but also how we do it.



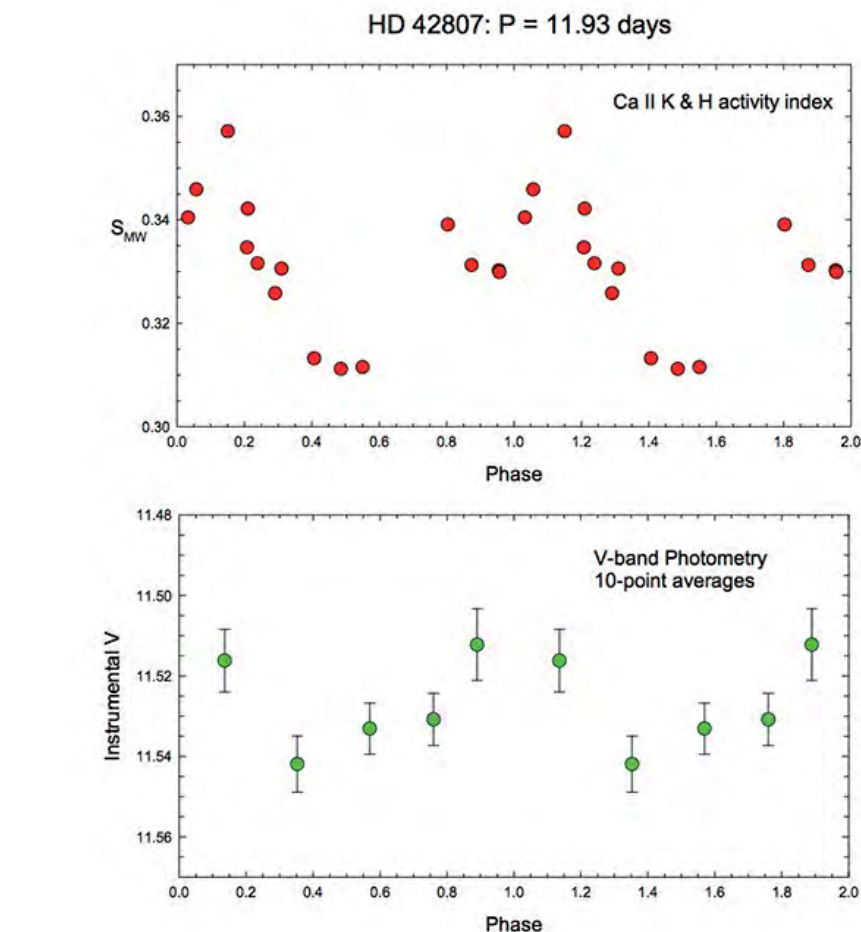
For decades, the site of the Schmidt and Carte du Ciel photographic telescopes in the Papal Gardens have been home to a number of remarkable events in the history of the VO. In the near future the VO plans to convert these domes into a visitor center.

STELLAR ASTRONOMY

Young Stars: The Young Solar Analogs project is a long-term spectroscopic and photometric program of Father Christopher CORBALLY S.J., Richard Gray (Appalachia State University) and Jon Saken (Marshall University) to monitor a set of 31 Young Solar Analogs (YSA).

The ultimate goal of this project is to give insight into the conditions in the early solar system by observing youthful solar-type stars with ages corresponding to the critical first 1.5 billion years when life was establishing a foothold on the Earth. Of course, our interest these days is not only in the origin of life on Earth but also the possibilities for life on exoplanets. Thus the Young Solar Analogs project has been studying not only youthful solar twins, but young stars in the spectral-type range from late F- to early K-dwarfs. These are the stars most likely to possess solar systems similar to ours, and thus also the closest Earth analogs. It is hoped that our study will lead to a clearer understanding of the meaning of a “habitable zone” and how that habitable zone evolves with time.

The Young Solar Analogs project began in earnest in 2007 with spectroscopic monitoring of a set of YSAs identified from the Nearby Stars Project using a spectrograph on the 32-inch telescope at Appalachian State University’s Dark Sky Observatory. A robotic photometric telescope at that observatory saw first light in March 2012 and has recently completed its 200,000th science exposure. In 2012, spectroscopic observations began at the Vatican Advanced Technology Telescope (VATT) with the commissioning of the VATTspec spectrograph.



The spectroscopic activity of a star surveyed by the Corbally team, compared with the star’s brightness, over a rotation period of 11.930 days. Note that the star is brightest at the point in its rotation corresponding to its highest activity.

That instrument (as of writing) has now been used on 12 nights for this project, and has concentrated on high-cadence time series observations in order to detect short-term phenomena such as flares.

Their first results can be organized according to the timescale of the phenomena observed: long-term (years), medium-term (days to months), short-term (minutes to hours).

Long-term phenomena: Roughly half of the observed stars appear to have long-term sunspot cycles

with periods in the range of 5 – 10 years. Most of the remainder of the observed stars have chaotic activity behavior; very few have flat activity plots. The star HD 76218 may be undergoing an entirely novel type of activity cycle, cycling between a state in which the activity is spread among a number of small spots distributed more or less uniformly with longitude (resulting in little or no rotational modulation), and a state in which the activity is concentrated in one large active area.

Young solar-type stars show an inverse correlation between photome-

tric brightness and activity; they are faintest at activity maximum, opposite to the sun which is brightest at activity maximum. The photometric variation with change in activity level can be large: in 2011, HD 209393 brightened by 0.1 magnitude (about 10%) while its activity declined. This brightness change is two orders of magnitude greater than our sun shows during its activity cycle! A 10% change in the irradiance of the sun would have a catastrophic effect on the Earth's climate, but this may have been commonplace for the early Earth. On a short timescale – years – the change in the climate would be buffered by the thermal inertia of planetary oceans, but on a longer timescale – centuries – such changes in irradiance could lead to enormous climate changes.

If YSAs shift from cycling to non-cycling on a, say, multi-century basis, in analogy to the behavior of the sun, then it seems likely that that shift is accompanied by a similar change in brightness. The implications for the climate stability of the early Earth (and by extension an Earth analog circling a young solar-type star) are profound, and suggest climate shifts more dramatic than any of those experienced by the Earth during the past 500 million years.

Medium-term phenomena: The team has been able to determine rotational periods for a number of stars, with evidence for differential rotation. Previous studies of the relationship between the age and the rotation period of a star have not paid adequate attention to the fact that an observed period for a star may not correspond to the (shorter) equatorial rotation period, and so such “gyrochronological” ages, for this reason, will have a systematic bias.

When an active area of an early star

rotates onto the visible hemisphere, the star brightens. This, again, is opposite to what we see on our sun – when a large sunspot group rotates into view, the sun dims. So, it is interesting that on a year-to-year basis, YSAs dim as they become more active, whereas on a rotational time scale, they brighten when an active region rotates into view. Both behaviors are contrary to the behavior we observe for the sun. Untangling this behavior will help us to learn more about the areal coverage of spots and photospheric faculae on our young suns.

Many of the stars observed by this program show significant “long” periods on the order of 20 – 60 days in length. These periods are much too long to be related to the rotation of the star, or even typical lifetimes of spots (roughly 30 days). When those “long” periods are plotted against the star's color (and thus temperature) there is a clear and significant correlation in the sense that cooler stars have longer “long” periods. They suggest that these “long” periods are showing the convective overturn timescales within these stars, such that the periodic mixing of the convective zone alters the spot distribution on the surface.

Short-term phenomena: The occurrence of strong flares could have had devastating consequences for life on the early Earth, and so they should be taken into consideration when determining the habitability of “habitable” zones around young solar analogs. Despite the fact that the observing technique of this project is not particularly designed to detect and characterize flares, the program did manage to capture a powerful

flare on HD 76218. This flare qualifies almost for “superflare” status; the fact that the survey picked it up at all suggests that such flares may not be uncommon.

Flares may also be detected spectroscopically by observing short-term enhancements in the certain emission lines in the star's chromospheric. The VATT, with its newly commissioned spectrograph (VATTspec), is ideal for this task. So far, it has observed flares on HD 82885 and HD



Young stars begin their existence in open clusters of stars like this one, the cluster NGC 5053, imaged at the VATT.

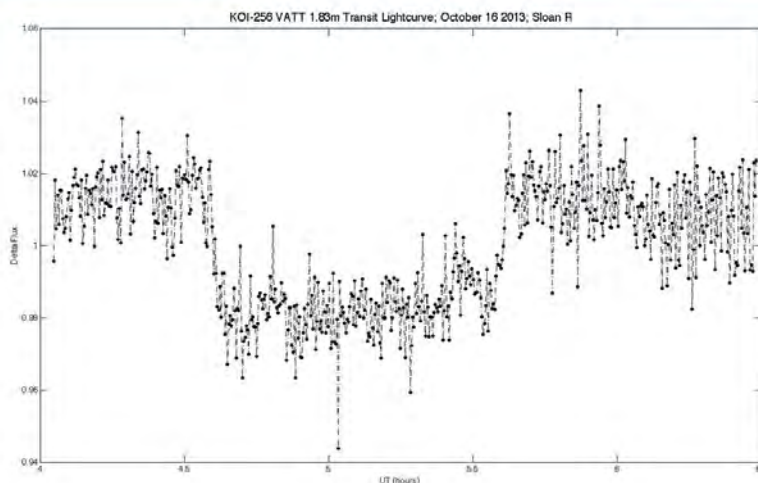
101501. The team hopes to be able to obtain similar data for many of other stars over the next few years.

Stellar Cluster Observations: BOYLE is continuing his successful collaborations with astronomers in Poland and Lithuania, including JANUSZ (Akademia Ignatianum) in Cracow and Straizys, Laugalys, and Kazlauskas at Vilnius University, to observe a number of stellar clusters and other stars of interest with the Vilnius filter system at the VATT. A number of accomplishments of this

team were presented and published during 2013.

This team reported results of CCD photometry in the Vilnius seven-color system down to 18th magnitude (in the V filter) for 242 stars located around the young open cluster IC1805. This cluster is in the active star-forming region W4 in the Cassiopeia OB6 association. One important question is whether these stars are actually part of the cluster, or merely by chance in the same line of sight of the cluster itself. The team solves this issue by using their filters to classify stars into spectral and luminosity classes, and to determine how far away those stars are by how much the light from those stars has been turned red by passing through clouds of interstellar gas and dust. One test of this system is that it confirmed that the cluster itself is located close to the front side of the Perseus arm, at a distance about 2.0 kiloparsecs, a distance that had been determined independently by the CH₃OH and H₂O maser VLBA parallax results.

In the color–magnitude diagram, the youngest stars of the cluster extend to spectral class A0. The extinction values for the majority of the cluster stars are between 2.2 and 2.7 mag, with a mean value of 2.46 magnitude. This extinction originates mainly between the Sun and the outer edge of the Local arm, in accordance with the distribution of clouds rich in carbon monoxide. In the Perseus arm and beyond, the extinction was investigated using the classification and reddening determination for A0–F0 stars. The extinction within the Perseus arm ranges from 2.5–4.5 magnitudes at the front edge, to 3.0–5.0 magnitudes at the far edge. Thus it is possible that one can identify about 20 early A-type stars located in the Outer arm. The photometry data



Kepler Object of Interest 256 (KOI-256) is a cool white dwarf orbiting an active red star. The Kepler space telescope detected a dip in its brightness originally thought to be due to a large transiting planet, but later analysis shows it is really due to the white dwarf's gravity bending the light of its companion star – one of the first detections of this phenomenon in a double star system. On October 16, BOYLE at the VATT recorded this dip, a remarkable feat for a small ground-based telescope. (The image above is the star itself, as seen at the VATT).

from space-based telescopes for red giants gives much higher extinction values (up to about 6 mag), which would correspond to the stars located behind dense clouds of both arms.

*This work appeared in the journal *Astronomy and Astrophysics*, Volume 554, id.A3, 9 pp.*

Optically Active Stars: A fraction of very low mass stars and brown dwarfs are known to be active sources of radio waves, and in some cases these stars produce periodic radio pulses. Extensive studies of two such objects have also revealed that these stars also pulse in visible light, but the nature of this variability remains unclear. Recent work by a team of astronomers including BOYLE, headed up by Leon Harding (Cal Tech), monitored the brightness in visible light of six radio-detected dwarfs stars, spanning

the M8 - L3.5 spectral range. Their goal was to determine if such variations are common or rare for such radio detected ultracool dwarfs.

This survey was the most sensitive ground-based study carried out to date in search of periodic optical variability from late-type dwarfs. They obtained 250 hours of monitoring, with a photometric precision as low as 0.15%. Five of the six targets showed clear periodicity, in all cases likely associated with the rotation period of the dwarf; there was a marginal detection found for the sixth star. These data point to a likely association between radio and optical periodic variability in late-M/early-L dwarfs, although the underlying physical cause of this correlation remains unclear.

In particular, this team has now

monitored the archetype of pulsing radio dwarfs, the M9 TVLM 513-46546, for five years. The fluctuations are quite regular, occurring once every 1.95958 ± 0.00005 hours. This phase stability may be associated with a large-scale stable magnetic field, further strengthening the correlation between radio activity and periodic optical variability.

This work is appearing in the Astrophysical Journal, arXiv:1310.1367

Hot Subdwarf Stars: One area of current research in which BROWN is currently engaged deals with the production of EHB/sdB stars in both the Galactic field (non-cluster stars) and in globular clusters. These stars are observed to exist in both types of environments. But the challenge in dealing with these objects is that the precise evolutionary mechanism for the production of such hot stars remains unknown. Likewise, the fraction of EHB/sdB stars found in binary systems differs markedly in both environments, with sdBs in binary systems accounting for 70% of sdBs in the Galactic field whereas the sdB binary fraction in globular clusters is about 4-10%. One hypothesis for the production of sdB/EHB stars maintains that they result from single star progeny whose evolution is drastically affected by their chemical environment, namely by metallicity and/or helium enrichment. Another hypothesis suggests that hot subdwarf objects are the result of binary interactions. BROWN has conducted several binary population synthesis simulations at various metallicities to investigate the production of hot subdwarf stars in globular clusters and in the Galactic field. Two results are noteworthy: 1)

metallicity is not a major factor in the production of EHB/sdB stars, though there are some second-order effects; and, 2) the disparity in binary fraction between the Galactic field and clusters is not found to depend strongly on metallicity, and, in fact, simulations at different metallicities indicate that it could be more of an age-effect resulting from the merger of two white dwarf stars to produce a single EHB/sdB star. Future research in this area needs to account for dynamical interactions (which to current simulations ignore) in globular clusters in order to present a more realistic simulated environment using N-BODY as the code of choice to do this. Also from an experimental perspective BROWN, BOYLE, and CORBALLY have in mind to use the VATT telescope to probe particular globular clusters, such as M13, for binarity among EHB stars.

This work was presented in a poster paper at the 221st Meeting of the American Astronomical Society (Long Beach, CA, January 6-10, 2013).

PLANETARY SCIENCES

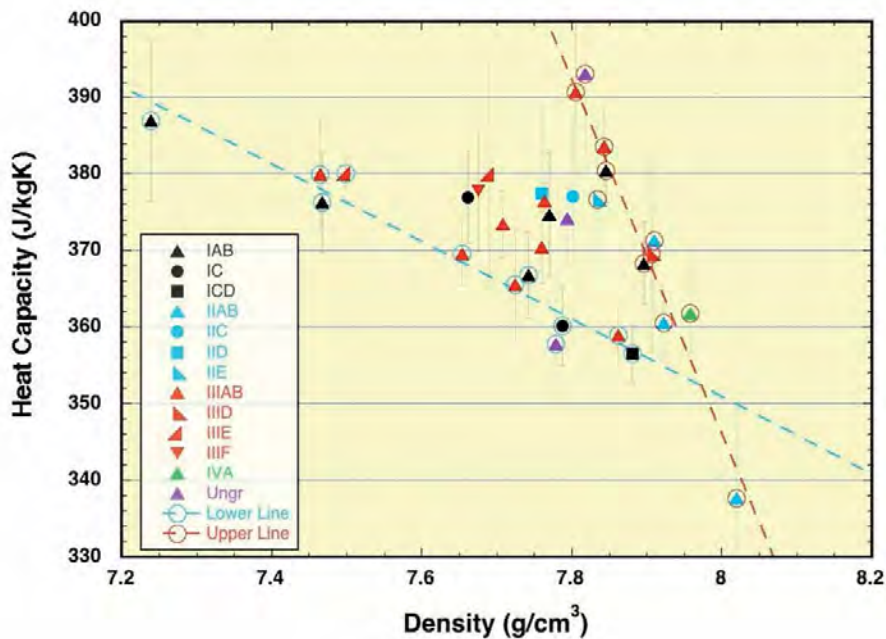
Meteors: Density is an important physical property of meteoroids, the bits of dust that produce meteors ("shooting stars") when they hit Earth's atmosphere. Knowing the density of meteoroids helps to determine their physical structure and gives insight into the composition of their parent bodies. The density of meteoroids can provide clues as to whether they come from comets or asteroids. Density is also an important parameter when characterizing the risk that meteoroids may pose to artificial satellites.

Calculating the density of meteo-

roids is difficult, but there have been several successful studies. In an invited review talk at the triennial Meteoroids meeting held this past summer in Poznan, Poland, KIKWAYA with coauthors BROWN and Campbell-Brown (Western University, Ontario) described some of these attempts, their different results, and their contributions to the understanding of the physical properties, composition, and the orbital evolution of meteoroids.

The estimated density of meteoroids depends strongly on the assumptions in the model used to describe how these samples ablate in the Earth's atmosphere. These authors developed a robust model to describe how a meteorite decelerates, and applied it to observations of nearly 100 sporadic meteors. From these observations, they computed the orbit of each meteoroid and determined its Tisserand parameter, a measure of how comet-like the meteor orbits were before they hit the Earth. They found that meteoroids with asteroidal orbits have bulk densities ranging from 3 to 5 grams per cubic centimeter, while meteoroids whose orbits are consistent with long period comet parents have much lower bulk densities, ranging from 0.4 to 1.6 grams per cubic centimeter. (Water has a density of 1 gram per cubic centimeter.) However, meteoroids with orbits similar to Jupiter family comets were found to have surprisingly chondritic-like bulk densities, suggesting either the sintering of the meteoroids through evolutionary processes, or the original radial transportation of chondritic materials up to the Kuiper Belt region.

This work was presented as an invited review paper at the triennial Meteoroids meeting held in Poznan, Poland, August 26-30.



The density and heat capacity of iron meteorites, as measured in the VO meteorite lab, indicate the presence of sulfide inclusions, weathering product, and differing nickel content. These data were presented at the annual Meteoritical Society meeting in August.

Meteorite Heat Capacity: Heat capacity is an essential parameter in many aspects of asteroid models, from determining interior thermal evolution to calculating the changes in motion of the asteroid due to reradiating absorbed solar heat (known as the Yarkovsky and YORP effects). Furthermore it can provide a non-destructive way of indicating the bulk composition of a whole meteorite.

To date, however, only a handful of meteorite heat capacities have been published, virtually all at temperatures at or above 300 K. After several years of development, this year CONSOLMAGNO, MACKÉ and a team of researchers from the University of Central Florida, Louisiana State University, and Arecibo Observatory have published a novel procedure for measuring the heat capacity of meteorites at low temperatures that is rapid, inexpensive, and non-destructive.

The method uses a tabletop laboratory setup with a dewar of liquid nitrogen resting on an electronic balance, which records the mass of the setup at regular intervals over the duration of the experiment. As a sample is dropped in the dewar, the liquid nitrogen rapidly boils as the temperature of the sample drops from room temperature (about 300K) to the boiling point of liquid nitrogen (77K). Using the data recorded from the balance, the total mass of liquid nitro-



Iron meteorites like this sample of Augustinovka can contain both terrestrial weathering (rust) from having been exposed to Earth's atmosphere, and large inclusions of sulfides (see the dark lump in the left hand side of this piece.) A new technique pioneered in the VO meteorite lab uses heat capacity and density measurements to determine the amount of these materials are hidden inside a sample.

gen boiled away due to cooling the sample is determined, and from this the heat capacity of the sample can be calculated. The value derived is a good representation of the heat capacity of materials at temperatures typical of the asteroid belt (around 200K). To correct for any systematic errors, the results are calibrated against samples of electronics-grade quartz.

The data to date show important and statistically significant trends in heat capacity with meteorite composition. In particular, it confirms that the average heat capacity of meteorites at temperatures appropriate to the asteroid belt, and further out in the solar system, is about half that of materials measured at room temperature. Metal rich meteorites are significantly lower in heat capacity than stony meteorites, while it appears that hydrated meteorites (and asteroids) will have a higher heat capacity than anhydrous samples.

This work was presented at the European Planetary Sciences Congress in London, September 9–13, and published in Planetary and Space Sciences, volume 87, pp 146–156.

Iron Meteorites: Particularly intriguing results for various iron meteorites led these researchers to look further into their heat capacities and densities. Up to now, the strength and the impenetrable nature of iron meteorites have made them difficult to characterize in bulk. Furthermore, these meteorites are marked by an inhomogeneous distribution of large (millimeter to centimeter scale) non-metal inclusions, and a varying vulnerability to terrestrial weathering. Both sulfides and rust are difficult to detect when hidden within the sample itself. However, it is hoped that bulk measurements of the density and heat capacities of these samples may help to untangle these different variables.

The grain density of three dozen iron meteorites was measured via ideal-gas pycnometry using nitrogen gas in a Quantochrome Ultrapycnometer 1000, and their heat capacities were measured with the new technique described above. The sample masses ranging from 20g to 120g, covering the four major groups (I to IV) and thirteen subgroups. Unlike the small pure iron samples measured by previous workers, these larger natural samples contain inclusions of sulfide and weathering product. The dominant factor in the observed variation of density and heat capacity from sample to sample is the presence of these inclusions. Both sulfides and oxides of iron can have similar densities (4.9 g/cm³ and up to 5.2 g/cm³ respectively) so differentiating between the two via density alone is not feasible. There is an inverse correlation between density and heat capacity, as expected: inclusions have a

much higher heat capacity, but much lower density, than metal. Among the lower density (inclusion rich) samples there appear to be two trend lines, suggesting that a difference in samples whose inclusions are rich in sulfide can be distinguished from those that are more weathered.

This work was presented at the annual meeting of the Meteoritical Society, Edmonton, Alberta, July 29 – August 2.

Asteroid Thermal Properties: The thermal inertia of an asteroid's surface determines how its orbit can be perturbed by solar insolation (via the various Yarkovsky effects) while its internal thermal diffusivity controls its thermal evolution. To quantify these effects, however, one must have reliable data for the material's thermal conductivity, heat capacity, and density. Over the past ten years CONSOLMAGNO, MACKE, and collaborators have conducted a detailed survey measuring density in

meteorites and conductivity, as reported in previous annual reports. As described above, they now have data for meteorite heat capacity as well.

For asteroid studies, it is sufficient to estimate typical average values of these quantities to within about 10%. The most important variable controlling density and thermal conductivity is porosity, while heat capacity is a strong function of temperature. With the data now in hand, CONSOLMAGNO, MACKE, and Britt (University of Central Florida) have determined empirical relationships to estimate values of these thermal properties for meteorites (and thus asteroids) as functions of temperature and porosity. From these formulae representative values for thermal inertia and diffusivity can be derived, to see how they vary as a function of porosity and temperature values appropriate for most asteroids.

These formulae show that surface



MACKE at the petrographic microscope in the new Meteorite Laboratory. The plans for this lab, outlined in last year's annual report, became a reality in January.

porosity has the largest effect on thermal properties: thermal diffusivity drops by nearly two orders of magnitude from 0 to 20% porosity, more slowly at higher porosities. Thermal inertia (at 200K) varies from 3000 (in SI units) near zero porosity down to 3 as porosity approaches 100%; 10% porosity has a thermal inertia near 1000 while 90% porous is about 60. In recent years, infrared detectors have been able to measure the thermal inertias of various asteroids; they range from as high as 1000 to below 30. From this, one can now conclude that asteroid thermal inertias below 100 demand an extremely porous (>80%) surface.

This work was presented at the annual meeting of the Division for Planetary Sciences of the American Astronomical Society, in Denver, Colorado, October 7-11.

Kuiper Belt Objects: BOYLE was a member of a team of researchers headed by Wesley Fraser (Herzberg Institute of Astrophysics, National Research Council of Canada) who observed large Kuiper Belt objects to derive their astrometric positions with a precision of 0.04–0.08". This team has developed a new technique to predict the future occurrence of stellar occultations by Kuiper Belt objects, which makes use of a maximum likelihood approach to determine the best-fit adjustment to cataloged orbital elements of an object. Using simulations of a theoretical object, they explored the merits and weaknesses of this technique compared to the commonly adopted ephemeris offset approach, demonstrating that both methods suffer from separate weaknesses, and thus together provide a fair assessment of the true uncertainty in a particular prediction. They calculated possible occultations for these seven objects up to the year 2015, using both methods. Finally,

they described observations of three separate close passages of the large Kuiper Belt object Quaoar to field stars, which reveal the accuracy of the element adjustment approach, and which also demonstrate the necessity of considering the uncertainty in stellar position when assessing potential occultations.

This work appeared in the Publications of the Astronomical Society of the Pacific, volume 125, pages 1000-1014.

COSMOLOGY

Gravity in the Planck Era: During the instant up to 10^{-43} seconds after the Big Bang, which is called the Planck Era, the laws, experiments and consequences of Quantum Mechanics strongly support the idea that the gravitational field very probably had a quantum mechanical behavior, which is called "Quantum Gravity." In fact, the initial singularity of the gravitational field can be "cured", we think, only through a quantization procedure. Unfortunately, there are no signals or experiments which points out to the existence of this quantum period of our universe; the Cosmic Microwave Background Radiation acts like a barrier, blotting out any electromagnetic signal before 380,000 years after the Big Bang. Furthermore, we do not have a well established theory capable of describing these early beginnings of our universe.

There are many proposals for a theory of Quantum Gravity. Quantum Mechanics shows that, at the atomic level, physical quantities (such as energy and momentum) of physical systems exhibit a discrete spectrum: there are "jumps" from one admissible value of energy to the next one of a quantum mechanical system. This may suggest that Space-Time, which is interpreted as a physical entity

in the Einstein's Theory of General Relativity, could likewise be a discrete (technically "Piecewise-Linear") entity, not a continuous one, during the Planck Era. Discrete Quantum Gravity starts from this assumption, but that the Physics beyond the Planck Era is recovered through a continuum limit. Another interpretation of Discrete Quantum Gravity maintains that the structure of Space-Time is discrete mainly because from a computational point of view it is easier to deal more with discrete quantities than with continuous ones, in analogy with the finite element method in engineering.

Quantum Regge Calculus is one approach to Discrete Quantum Gravity, as proposed by a seminal paper by T. Regge in 1961. Spin Foam is a discrete approach to Quantum Gravity, which is a direct derivation from Loop Quantum Gravity, a continuous approach to Quantum Gravity. It has been shown that Regge Calculus converges, in measure, to Einstein's General Relativity in a particular limit (a limit in the sense of "measure"). However, it is not clear whether Spin Foam converges to Einstein General Relativity. Thus GIONTI is studying the possibility that Spin Foam is a particular case of Regge Calculus (a version of Regge Calculus which is locally invariant under the $SO(N)$ group of rotations, N being the number of physical dimensions); a simplification in the sense that Spin Foam geometrical constraints look like a simplified version of the analogous (Local) Regge Calculus Constraints.

The results of this research have been published in the proceedings of the 3rd Galileo-XuGuangqi International Meeting held in Beijing (China), International Journal of Modern Physics: Conference Series Vol. 23 363-372". Another approach to quantum gra-

vity is String Theory. String Theory assumes that the fundamental objects in nature are one-dimensional entities called Strings. A String can be closed or open. The fundamental particles in nature are derived as fundamental excitations of Strings. The underlying idea is that all fundamental forces are unified through String Theory. The gravitational field is contained in String Theory since a spin-two massless particle emerges in the first excited level of a closed string, which has been identified as the fundamental “quanta” of the gravitational field and is called Graviton. Gravitons are, for gravity, as photons for the electro-magnetic field.

For technical reasons, String Theory makes sense in 26 (bosonic) or 10 (fermionic) physical dimensions. Since our world is only four-dimensional, one must understand that the extra-dimensions are “compactified” around circles with very small radii. This process of compactification in String Theory implies the emergence of new symmetry called T-Duality (Toroidal duality). In short, this symmetry suggests that if we wrap one dimension of a String around a circle of radius R , we get the same energy spectrum of wrapping the same string around a circle of radius $/R$. These two compactifications define two strings, which are, respectively, T-dual each to the other.

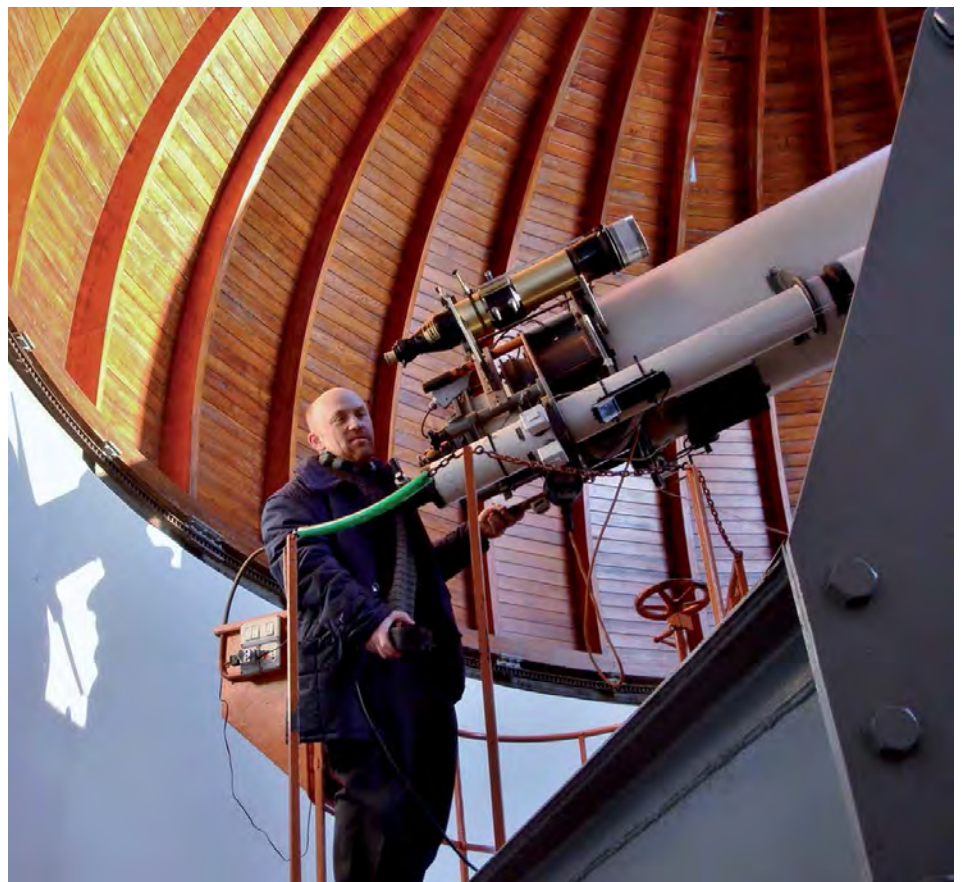
GIONTI's latest research has been to study the possibility to formulate a new theory for Strings in which these two dual strings are put together in one string theory formulation, where the string coordinates are doubled, and the T-duality symmetry will become an internal symmetry of this new String Theory formulation. The goal of this new formulation of String Theory is to be able to calculate new scat-

tering amplitudes (with respect to scattering amplitudes obtained with ordinary String Theory) for Gravitons. These could imply that the effective theory, associated with these scattering amplitudes, could force a modification of Einstein-Hilbert action with introduction of extra terms, that could fit the cosmological data.

Dark Matter: Einstein's General Relativity does not explain alone the cosmological data; thus Dark Matter has been introduced to explain the discrepancy between the theoretical prediction and the observational data. However, many researchers are testing whether these data can be fit using extended theories of gravity instead of adopting the Dark matter

hypothesis, without an a-priori justification for the introduction of these theories. The T-Duality invariant formulation proposal of String Theory would justify these extra terms modifications of Einstein General Relativity, showing that they come from an early Quantum behavior of our universe. This past year, GIONTI has worked with Dr. Raffaele Marotta-INFN (National Institute for Nuclear Physics, Naples), Dr. Franco Pezzella (INFN Naples), and a Ph.D. student, Luca de Angelis (University of Naples Frederick II) on a project of comparing two different doubled String Theory actions.

The results of this research were presented during a talk given by GIONTI at a Meeting organised in Pescara by



GIONTI displays one of the telescopes in the Papal Palace, Castel Gandolfo, to a group of visitors to VO headquarters.

ICRAnet, 3–21 June 2013, for the 50th anniversary of the Kerr Solution for Einstein's General Relativity and will be published soon, <http://arxiv.org/abs/1312.7367>”.

Cosmic Inflation: During the past year Krzysztof Bolejko (Sydney Institute of Astronomy, U. of Sydney, Australia) and STOEGER completed work showing that temporary intermediate homogenization or smoothing in the very early universe, almost immediately after the Big Bang, is assured in a variety of spherically symmetric models. In these cases the model initially has significant inhomogeneities, which rather quickly damp away yielding a temporarily homogeneous (smooth) universe. Further cosmic evolution, however, typically leads to the generation of new inhomogeneities.

Why are these results important? For the last 30 years it has been almost universally agreed that soon after the Big Bang (which is better described as exiting from the Planck Era, as described above, when the universe was completely dominated by quantum fluctuations and too hot for space and time to exist as they do today) the universe must have undergone cosmic inflation. In a split second it expanded by a factor of at least twenty-nine orders of magnitude. Without such inflation (probably driven by a large initial vacuum energy density) it seems impossible to account for the long-range causal connectedness of the universe. This “connectedness” is evidenced in the smoothness of the cosmic microwave background radiation (CBR). Inflation is also necessary to account for the near flatness of the universe, and the spectrum of irregularities seen both in the CBR and in overall structure of the superclusters, clusters of galaxies, and galaxies in the current universe.

However, it is extremely difficult or impossible to trigger inflation unless the initial cosmic patch is homogeneous, that is, very smooth. But it is almost certain that the universe emerging from the Planck era would have been very irregular and lumpy, because of quantum fluctuations. Until recently, it had been thought that such an early smoothing process would have a probability zero. And without a smooth patch of a certain size, inflation is probably impossible to realize. Thus this process of very early cosmic homogenization, demonstrated by Bolejko and STOEGER, provides a way of obtaining a smooth cosmic patch within which inflation could begin.

Bolejko and STOEGER provided a preliminary argument for this conclusion in 2010; these new results expand and deepen that work, showing that a variety of inhomogeneous spherically symmetric models – some without pressure and some with large pressures and viscosity – undergo this early temporary homogenization. This happens in these models as long as the spatial curvature is much less than the Ricci curvature generated by the mass-energy density.

In another part of their work on this subject, they investigate several different competing definitions of gravitational entropy (the measure of disorder in gravitating systems). This has continued to be an area of uncertainty in the field. Bolejko and STOEGER show that all of them so far considered involve density gradients. Therefore, during periods of early spontaneous homogenization, the gravitational entropy will always decrease. Thus, according to these definitions gravitational entropy will not always remain the same or increase, as is the case with thermodynamic entropy.

This work has been published in Phys. Rev. D88, 063529.

Cosmology and Mathematics: As seen above, our ability to understand the earliest moments of the universe depend on the strength of our mathematics to describe physical conditions during those epochs. To approach this goal HELLER and collaborators have constructed a model unifying general relativity and quantum mechanics based on a noncommutative algebra A , and then apply this mechanism to study the generalized general relativity. In this approach, generalized Einstein's equation assumes the form of the eigenvalue equation for the Einstein operator on the module of derivations of the algebra A , and no matter sources are a priori assumed.

They define the Einstein-Hilbert action and deduce from it Einstein's field equations. They show that for a special class of metrics containing, besides the usual metric components, only one non-zero term, the action reduces to the O'Hanlon action that is the Brans-Dicke action with potential and with the parameter ω equal to zero. They also show that the generalized Einstein equations (with zero energy-stress tensor) are equivalent to those of the Kaluza-Klein theory satisfying a “modified cylinder condition” and having a non-compact extra dimension. This opens a possibility to consider Kaluza-Klein models with a non-compact extra dimension that remains invisible for a macroscopic observer. In their approach this extra dimension is not an additional physical space-time dimension but it appears due to the generalization of the derivation concept.

They also show a cosmological solution (with Friedman symmetries) to this equation, demonstrating that the

generalized eigenvalues of the Einstein operator reproduce components of the perfect fluid energy-momentum tensor. The representation of the algebra A is found that reveals random properties (in a generalized sense) of the model. Owing to these properties the initial and final singularities are probabilistically irrelevant.

This work appeared in the Canadian Journal of Physics, vol. 91, pp. 757-763; and in: Multiverse and Fundamental Cosmology, American Institute of Physics Conf. Proc. 1514, 2013, 55-59; doi: 10.1063/1.4791725

GALAXIES

OMIZZOLO has continued his collaborations in the study of the nearby clusters of galaxies as a member of the international group WINGS, the Wide-field Nearby Galaxy cluster Survey.

comparable to distant massive and compact galaxies represent 4.4% of all galaxies more massive than 30 billion solar masses in the field. Most of them are S0s (70%) or ellipticals (23%), are red and have intermediate-to-old stellar populations, with a median luminosity-weighted age of 5.4 billion years and a median mass-weighted age of 9.2 billion years.

The velocity dispersions and dynamical masses of these galaxies are consistent with the small radii and high stellar mass estimates. Compared with the WINGS sample of cluster galaxies at similar redshifts, the fraction of superdense galaxies is three times smaller in the field than in clusters, and cluster SDGs are on average 4 billion years older than field SDGs. Most of them are early-type galaxies with intermediate to old stellar populations. There is a trend of smaller radii for older lumi-

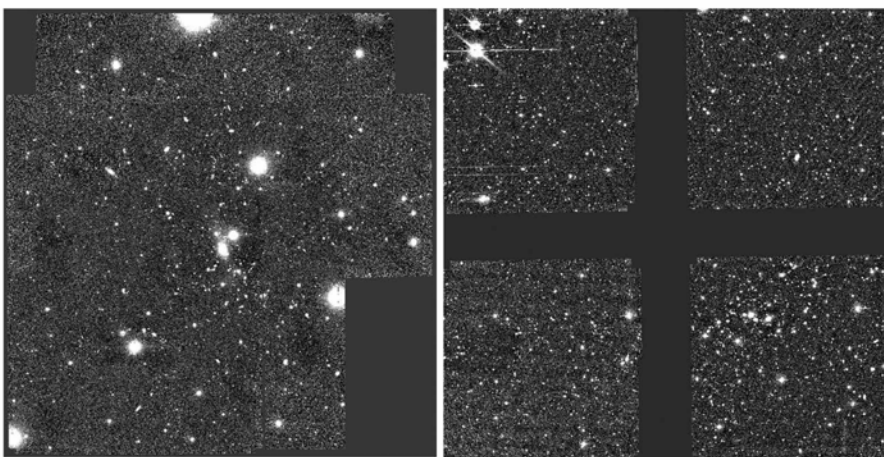
a universal trend of smaller radii for older luminosity-weighted ages at fixed galaxy mass. On top of the well known dependence of stellar age on galaxy mass, the luminosity-weighted age of galaxies depends on galaxy compactness at fixed mass, and, for a fixed mass and radius, on environment. This effect needs to be taken into account in order not to overestimate the evolution of galaxy sizes from distant to nearby galaxies. Their results and hierarchical simulations suggest that a significant fraction of the massive compact distant galaxies have evolved into compact galaxies in galaxy clusters today. When stellar age and environmental effects are taken into account, the average amount of size evolution of individual galaxies between distant and nearby galaxies is mild, a factor ~ 1.6 .

This work appeared in the Proceedings of the IAU S295: The Intriguing Life of Massive Galaxies and was published in the Astrophysical Journal, volume 762, p. 77; available at arXiv:1211.1005

HISTORY and PHILOSOPHY

Causality: HELLER continues to explore the nature and limits of causality in physics. The doctrine on causality due to the philosopher David Hume is well known; since all our knowledge comes from experience, we are able to know that “B follows A,” but not that “B is caused by A.” All the rest comes from our mental habits. If we limit ourselves only to sensual experience, nothing more can be claimed on causality.

However, such a strategy is very far from what is done in physics. HELLER, in a work that appeared in *Études de cosmologie philosophique*, points out that one cannot forget about the mathematical structures that physics employs for modeling the world, and there are mathema-



Images of Clusters of Galaxies of the WINGS research team. The pictures were exposed through the Bok telescope (Abell 2256 - right) and the LBT telescope (Abell 1795 - left).

This team of collaborators has made a study of galaxy sizes in the local Universe, to determine galaxy size as a function of galaxy environment comparing galaxies in clusters with those in the general field. They found that galaxies with radii and masses

nosity-weighted ages at fixed galaxy mass. They found a relation between size and luminosity-weighted age for galaxies of different stellar masses and in different environments.

This work confirms the existence of

tical structures that model what is transparent for sensual perception but what is essential for causal interaction. This is also true as far as Newtonian physics is concerned; but to see this, a more sophisticated philosophy of physics is needed than what Hume had at his disposal. In contemporary physics, causal interactions, as modeled by mathematical structures, can be drastically different from our every-day imaginations. For instance, causally related events can be space-like separated.

In a further paper, which appeared in the book *The Causal Universe* (edited by HELLER and George Ellis), Heller argues that it is false to argue that physics cannot grasp the truly causal dependencies but only temporal sequences of events, taking into account both theoretical and experimental sides of the physical method. From this, he reviewed the interaction of bottom-up and top-down causalities, and its role in shaping the structure of the world (based mainly on George Ellis' works). Finally, he ponders how this account of causality could be modified by the advent of the theory of quantum gravity.

Time and UTC (Coordinated Universal Time): The Greek philosopher Timaeus, according to Plato, argued that the Demiurge made our material world as an image of eternal perfection, and in this context "time is a [circularly] moving image of eternity." In fact, the ceaseless motion of heavenly spheres is time. Plato here merely described what humanity has always believed and practiced. Of course, atomic clocks and careful observations of extremely distant cosmic objects (quasars) tell us that the "heavens move", or rather, that the Earth spins, somewhat irregularly. The symbolic value (and institutional inertia) of linking civil timekeeping to the heavens, however, is so strong

that the international community still requires the International Radiocommunication Union to broadcast time signals that follow Earth's rotation. The trick is that once in a while a supernumerary "leap second" is added or subtracted from the otherwise perfectly regular sequence of seconds defined by atomic clocks on the recommendation of a network of specialized astronomical institutes known as the International Earth Rotation and Reference Systems Service. As a result, every so often, there is a minute with 61 or 59 seconds.

The benefit is that civil time follows astronomical phenomena with an acceptable accuracy. The disadvantage is that when you want to know how many seconds elapsed between, e.g., midnight of Jan 1, 2001 and midnight of Jan 1, 2011, you must know how many leap seconds were added to the regular time sequence which contained $(10 \cdot 365 + 2) \cdot 24 \cdot 60 \cdot 60$ seconds.

The workshops on *The Future of UTC* have brought together a small but influential group of experts who are concerned about a proposal to abolish the leap seconds, decoupling civil timekeeping from Earth's rotation. The concern of this group was one of the factors which led government representatives gathered in Geneva in January 2012 to postpone a vote on the proposal. Continuing the tradition of the VO's interest in timekeeping, GABOR has taken part in these colloquia in 2011 and in 2013, his contributions focusing on the broader historical and philosophical context, as well as on some issues of regulatory practice of the European Commission.

History of astronomy and astrophysics:

CHINNICI continues to work on the contributions given by Fr. Angelo Secchi S.J. (1818-1878) to the development of early astrophysics. The correspondence between Secchi and Pietro Tacchini (1838-1905), astronomer at Palermo Observatory, edited by CHINNICI with A. Gasperini (INAF-Osservatorio Astrofisico di Arcetri), provides a crucial source to understand the development of the astrophysical researches in Italy and abroad as it deals with many topics of scientific and historical interest. Moreover, in deepening the study of other documents of his archives, Secchi confirms to be a valuable example of how science and faith are synthesized in a modern approach to theology, taking into account current theories and ideas of that time, rather than in an apologetic approach, questioning about past philosophies. CHINNICI is also still studying Secchi's spectroscopic equipment by exploiting new sources recently found abroad. As a consequence of the publication of the book on Secchi edited last year by A. Altamore and MAFFEO, there is a growing attention of the historians' community towards the life and activity of Secchi and an invited talk on this subject has been given by CHINNICI at the 2013 meeting of SIF (Società Italiana di Fisica).

INSTRUMENTATION & TECHNICAL SERVICES

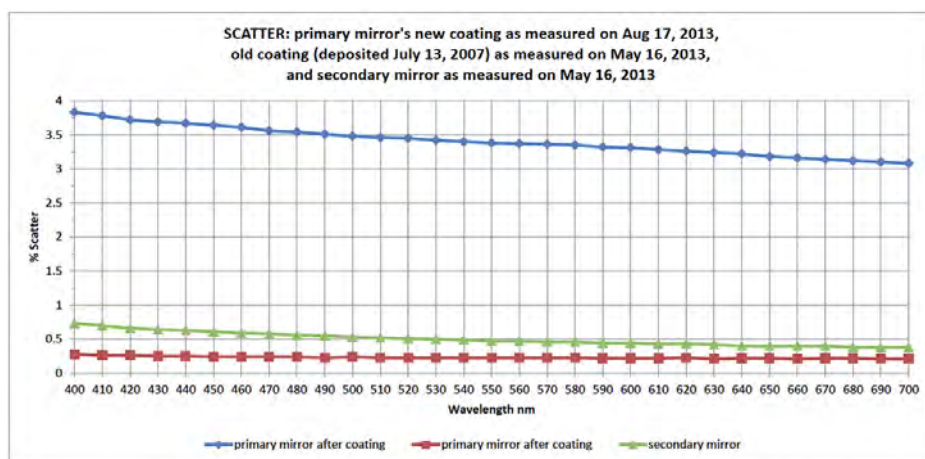
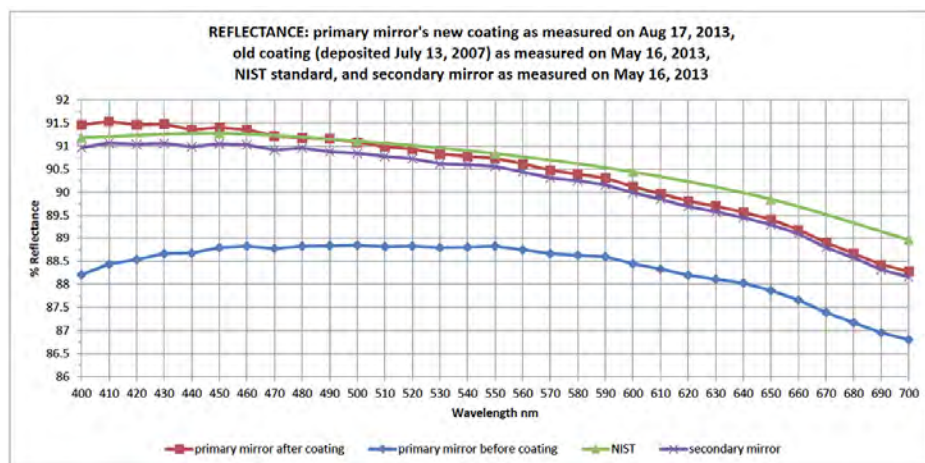
The VO's research infrastructure is embarking upon a period of substantial development with the commissioning of the spectrograph, with the brand new Fireball Network, and twenty years after its dedication, on September 19, 1993, with a commitment to a global overhaul of VATT. 2013 can be seen as a year of negotiations, preparing the ground for future action. With a 20-year old facility, the emergency maintenance is a growing liability. What is more, with the increasing availability of larger telescopes, the scientific competitiveness of smaller and medium sized instruments can be maintained only if new observing modes are provided. VATT with its remote observing capability does justice to its legacy of pioneering new methods. This year, VO and Steward Observatory have committed to creating the Arizona Robotic Telescope Network (ARTN), a robotic facility with three telescopes: the 61" Kuiper Telescope on Mt Bigelow, the 72" VATT on Mt Graham, and the 90" Bok Telescope on Kitt Peak. ARTN will allow for synoptic observations (synchronous observations of the same object with different instruments), opening a range of new and exciting possibilities for cutting-edge research.

Vatican Advanced Technology Telescope (VATT)

Maintenance:

Primary Mirror Aluminization

The VATT primary mirror was last aluminized at the Sunnyside coating laboratory in July 2007. On May 16, 2013, Gary Rosenbaum and Ricardo Ortiz performed measurements of surface reflectance on VATT's primary and secondary mirrors. Although a visual inspection of the primary mirror showed the typical gray hazy appearance of an old bare aluminum coating, the degradation



was less significant than what could have been expected after 6 years. It would appear that the soap and water washes performed by the VATT crew are done very carefully with minimal damage.

On the basis of the quantitative assessment, however, it was decided to re-aluminize the primary mirror during summer down time. It was also decided that the secondary mirror, which has never been re-aluminized since its installation at VATT, did not require a new coating yet, and a new reflectance measurement will not be needed until 2015.

The re-aluminization of the primary mirror represented the single, most complex maintenance operation of

2013. The secondary mirror with its supporting struts had to be taken down, the primary mirror had to be lifted up, and transported to Tucson, re-aluminized, transported back to Mount Graham, hoisted to the dome, sat down on its supports, the secondary had to be attached, and the telescope had to be re-aligned. The operation, which took 20 days, required the full VATT team, as well as assistance from Steward Observatory's Mountain Operations and from the Mount Graham International Observatory.

Another scheduled maintenance item concerned the Telescope Control System compiler. Long-term maintenance of software represents an engineering challenge in its own

right because it has to be maintained using compilers that evolve on computers running operating systems that evolve. The policy choice at VATT is to maintain dedicated computers with software environment frozen in the state identical to the moment when the Telescope Control System (TCS) was first compiled. In this case, the only remaining issue is the maintenance of the computer hardware. This summer, the compiler computer was replaced, and the software environment in it recreated to be identical with the original.

Unscheduled maintenance is often performed in a crisis management regime. Apart from some minor issues regarding the encoders, VATT's one major subsystem failure concerned the uMAC temperature-sensor controller. This microcontroller, which was more than 20 years old, had to be replaced: it became unstable and its software was lost. Because of lacking documentation, this operation required some reverse-engineering. The replacement, however, is a system which was envisaged for the planned overall upgrade of the telescope (see below).

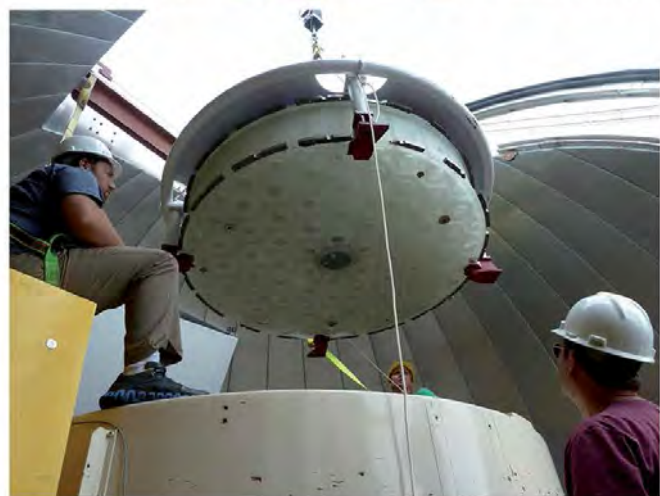
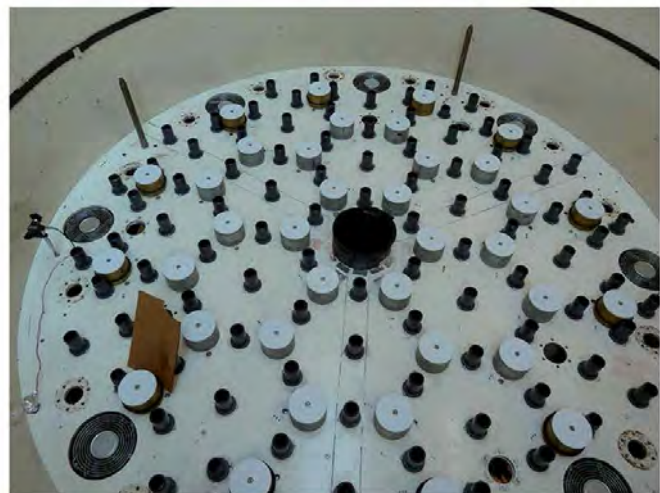
VATT Upgrades:

VATT's remote observing capability attracted a following among Steward Observatory telescopes. A new remote observing room was dedicated to VATT as well as to the MMT and other telescopes whose remote observing capability is under development. Chris Johnson prepared a utility facilitating education and public outreach programs with VATT. The observers (regardless of whether they are on Mt Graham or in Tucson) can easily allow students and the general public to follow the observations in real time, talking to them while showing them views of the all-sky camera, the finder scope, the guider, the TCS, the camera Graphical User

Interface (GUI), as well as VATT images taken by the science instrument.

In early November 2013, Large Binocular Telescope Observatory (LBTO) performed the first on-sky tests of Advanced Rayleigh guided Ground layer adaptive Optics System (ARGOS), its laser guide star system. Negotiations between the VO and the LBTO continued, and protocols on communication of target coordinates were studied.

The work on the Arizona Robotic Telescope Network commenced this year. Negotiations about the science cases, engineering options, and finances were conducted. The project's first proposals, budgets and timelines were drafted. The VATT team continued to prepare one of the key prerequisites: the transition from the legacy TCS to the Next Generation TCS. A breadboard was built to study and debug the NG TCS with proposed new telescope motor drives. Specifications for new absolute encoders were prepared, one encoder was purchased and its testing commenced. Options for the high level software (the "brains" of the robotic facility) were studied. The Astrophysical Institute in Potsdam has purchased optical fiber with the view of supplying LBT's spectrograph Potsdam Echelle Polarimetric and Spectroscopic Instrument (PEPSI)



Images of the primary mirror aluminization, one of the major maintenance operations to take place during the year at VATT.

with starlight gathered by VATT. Laboratory studies in Potsdam have shown promise, indicating that the fiber throughput is satisfactory even considering the distance (310 meters line-of-sight, i.e., more than 400 meters of fiber). In November 2013, the optical fiber cable was laid between the LBT and VATT buildings. Feasibility studies are scheduled for the second half of 2014.

Instrumentation and New Equipment

Spectrograph:

The commissioning of VATT's optical spectrograph, VATTspec, has been brought to a close. Guiding on split light from the image on the slit had been tested successfully already in 2012. To make the instrument attractive to a larger user community, allowing for more science cases, an Apogee Aspen CG2000 guider camera and new transfer optics were installed. These represent a considerable improvement in terms both of sensitivity and of the field of view. They also mean that the spectrograph and direct imaging modes now have separate guide cameras, making instrument changes more efficient.

Fireball Network:

As a part of KIKWAYA's research, the VO (also acting on behalf of the University of Arizona) became a partner in NASA's Fireball Network, envisaging the installation of dedicated all-sky cameras on Mt Graham, Mt Lemmon, Kitt Peak, and Mt Hopkins. Preparatory work got under way in 2013, scoping the sites and the available infrastructure.

Re-aluminization of the Zeiss Double Astrogaph Mirror

There has been significant news of late with regard to the Double Astrogaph telescope, located on the roof of the Apostolic Palace in Castel

Gandolfo, the traditional residence of the Pope during summertime. On December 4, 2013, the primary 60-cm mirror of the telescope was dismantled in order to be re-aluminized. The last major over-haul and re-aluminization of the Double Astrogaph mirror had been done in 2001. On a slightly cold morning, an expert crew, consisting of members of the current staff and emeritus members and longtime collaborators of the VO, arrived to undertake a task that would eventually take all of the morning and most of the afternoon. The members were Claudio Costa, Salvatore Lamina, Francesco Rossi, Romano Reggio, Federico Balzoni, and BROWN. Extensive records and photographs of the previous dismantling of the mirror were used to guide the crew this time around. It took about 3 hours to disassemble most of the upper barrel of the telescope and the secondary mirror in order to extract the primary mirror, done with a system of cables and pulleys. Once extracted,

visual inspection of the 60-cm mirror indicated a drastically opaque and speckled mirror surface, the result of considerable degradation of the previous aluminum coating, dust accumulation, damage from a previous imperfect cleaning, and staining due to exposure to the elements, especially humidity. Surprisingly, the most difficult part of the operation involved the transport of the mirror itself from the dome, down the stairway, and into the truck. With a mass of approximately 150 kg (mirror + carrying-case), it required the strength of four grown men, each straining already with effort, to carry the mirror. Then on December 11, MAJ (Vice-Director of the VO), together with Romano Reggio (chief technician and mechanic at the VO), travelled to Asiago to the astronomical observing station at Cima di Ekar, which is owned by INAF and managed by the Astronomical Observatory of Padua. There the mirror was re-aluminized by the technical staff of the observatory (Aldo Frigo



Images of VO staff dismantling the Zeiss mirror. The mirror was later re-aluminized by Asiago observatory staff.

and associates), which thanks to their generosity, was done at minimal cost to the VO during December 11-12. MAJ and Romano returned to Rome with the newly-refurbished mirror on December 12. As of now, the plan is to re-mount the mirror onto the telescope sometime in January 2014 when it is possible to re-assemble the staff/members who dismantled it initially. This will be a considerable labor. The VO wishes to thank all of the people who have contributed to the various stages of performing this important maintenance on the mirror.

Meteorite Laboratory

New Lab

The new meteorite lab, whose plans were described in the previous annual report, is now a reality. Features of the new lab include a secured glass-enclosed walk-in closet for the collection, with new sample drawers able to hold the larger samples; meter-high workbenches topped with a chemically impervious surface; and a significant expansion of storage areas for materials used in sample measurement, preparation, and curation. The lab now has workspace and desks for two meteorite scientists, a welcome addition with the arrival of MACKÉ to the staff.

New Pycnometer

Ideal-gas pycnometry has become a standard technique for non-destructive and non-contaminating measurement of meteorite grain densities. However, many lunar and martian meteorites are only available cut into large but fragile thin slices (sometimes ~ 1 mm thick) to maximize the surface area per gram. To accommodate these large samples and thin slices, MACKÉ has designed and built a new pycnometer with a much larger sample cell than commercial pycnometers: 12.7 cm (5 inches) deep and 10.2 cm (4 inches)

in diameter, with inserts designed especially to allow thin-sliced samples to lay flat and fully supported. Besides supporting fragile materials, these inserts also improve measurement precision. They increase the relative size of the sample to the cell, which in turn allows for a greater difference between initial and final pressures. This minimizes the uncertainty due to imprecision in pressure measurements. This is especially true for the thin-slice insert, since a sliced meteorite is dwarfed by any cylindrical chamber large enough to contain it.

Early test measurements performed with the thin-slice insert were conducted on two plastic credit-card-sized sheets, which together have a caliper-determined volume of 7.76 cm³. The pycnometer-measured volume of the two sheets together was accurate to within 0.05 cm³ (a difference of 0.6%). Measurements on rhodonite and unakite slabs exhibited very small variances (< 1% over ten measurements apiece) and were consistent with typical densities of these rocks.

The new pycnometer design, particularly with its adaptor for thin-sliced meteorites, presents the opportunity to measure meteorites of a range of sizes and shapes that do not fall neatly into existing pycnometer designs. When used in conjunction with the Quantachrome Ultrapyc for smaller samples, we can now measure grain density for meteorites ranging from about 1 cm³ to over 400 cm³.

New Samples

The highlight of the new acquisitions to the collection in 2013 is a 2.7 kilogram etched slice of the iron meteorite Mount Dooling, originally found in Australia in 1909. This beautiful specimen provides an excellent display of Widmanstätten

patterns. Other gifts to the collection include a 1.8g fragment of the rare Leighlinbridge chondrite, which fell in Carlow, Ireland, in 1999, and a subgram chip of Peekskill, which fell in New York in 1992; both were gifts of John Flannery and the South Dublin Astronomical Society.

Digitization of Photographic Plates

The digitization of the historic astronomical photographic plates of the VO is continuing. In 2013 OMIZ-ZOLO completed the scanning of the plates of the Carte du Ciel project (about 2000 plates), and now, with a colleague of the Observatory of Roma (Monte Porzio), is working on an algorithm to remove artefacts from these plates and apply automatic astrometry to them. Once this has been done, the scanned plates can be used to derive the position of the stars, and compare those positions with modern astrographic catalogues obtained by satellite surveys such as those obtained by the Hipparchos mission and the upcoming Gaia spacecraft.

VO Website

Antonio Coretti in collaboration with the Internet Office of the Vatican City State is developing a new institutional website in English and Italian according to the needs of the Observatory and of the new technologies. We thank CORBALLY for the enormous effort in starting the website and keep it running for many years. We are also grateful to Ayyur Pelletier who freely dedicated much of her time and effort to designing and maintaining the current website.

OBSERVATORY AND STAFF ACTIVITIES

Apparent Rotation at the VO

Titled “Rotazione Apparente” or “Apparent Rotation”, the bas-relief in marble by Italian artist Marco Bagnoli was donated to the VO by the Henraux SPA Foundation. The art work describes the motion of the stars in relation to the center of the Earth.

Inspired in part by the Leonids meteor shower, the work was exhibited last spring in Pisa at the exhibition “Stories of the other world. The Universe outside and inside of us”, sponsored by the VO.

The artwork consists of Moroccan black marble and white marble from Monte Altissimo, where, in 1517, Michelangelo discovered large deposits for his sculptures. The quarry is currently owned by Henraux SPA. Speaking at the unveiling of the work at the VO headquarters in Castel Gandolfo, director Fr. FUNES compared the subject of the bas-relief and the mission of the Vatican astronomers. He said he hoped that the sculpture can be of inspiration for all visitors to the Observatory.

A mini-workshop at the VO: Cygnus OB2 and Cygnus X: the workings of a massive star complex

From May 15 to 17, the VO hosted a conference on Cygnus OB2 and Cygnus X at its headquarters in Castel Gandolfo. This is not the title of a science fiction novel by Ray Bradbury!

Cygnus OB2 is an association of stars that are among the most massi-



Fr. FUNES shows Pope Francis the newly acquired artwork “Rotazione Apparente”.

sun) and luminous (about 200,000 times brighter than the sun). This association is immersed within a larger molecular complex of star formation known as Cygnus X. The Cygnus X region is located at a distance of about 4,700 light years from Earth in the Cygnus constellation.

In recent years, new observations at all wavelengths have resulted in new information on Cygnus OB2, its content, origin, history, impact on the environment and the properties of its members.

Due to its proximity (only 4700 light years!), astronomers are able to study Cygnus OB2 in detail by comparing

predictions of increasingly realistic models of the process of massive star formation with observational data. Such studies have generated great interest in Cygnus OB2 and Cygnus X as valuable examples in our understanding of these types of associations in our and other galaxies.

However, the wealth of information currently available on Cygnus OB2 and Cygnus X and the variety of channels through which it has been obtained, make it difficult to draw up any coherent interpretative framework. In fact it is difficult to link observations obtained at different wavelengths with different techniques and integrate them into a



coherent theoretical model of star-forming region.

To address these issues, Dr. Fernando Comeron from the Southern European Observatory and CORBALLY of the VO organized the conference at the VO.

The Conference was attended by 24 scholars from Belgium, Chile, France, Germany, Italy, Spain, Sweden, UK, and USA.

VOSS 2014

We are very enthusiastic about the Vatican Observatory Summer School 2014 on “Galaxies: Near and Far, Young and Old”. The fourteenth summer school will be held in our facilities in Castel Gandolfo. We are most grateful to Prof. John Stocke (Chair, University of Colorado, Boulder, USA), and to the faculty, Dr. Christopher Carilli (Very Large Array, Socorro, New Mexico, USA), Dr. Michele Trenti (Cambridge University, United Kingdom), Prof. Jacqueline van Gorkom (Columbia University, New York, USA) for or

ganizing an excellent academic program. Our appreciation also goes to CONSOLMAGNO for accepting to serve as dean of the school. Galaxy formation and evolution is at the forefront of modern astronomy research and is a particularly timely topic now due to the powerful combination of Hubble Space Telescope imaging and ground-based 10m-class telescope spectroscopy in the optical and near-IR and the Expanded Very Large Array (EVLA) and the new Atacama Large Millimeter Array (ALMA). The near-future launch of the James Webb Space Telescope (JWST) and the development of low frequency radio arrays will soon detect and study galaxies emerging from the cosmological “Dark Ages”. At the same time sophisticated numerical modeling of galaxy formation and evolution are challenging our views of galaxies old and young. Training international students to take advantage of these exciting developments and new telescopes is foremost in faculty’s mind in proposing this topic for VOSS 14.

EBI2014: Conference and School on Astrobiology: “The Search for Life Beyond the Solar System: Exoplanets, Biosignatures & Instruments”

GABOR and Dr. Daniel Apai (Department of Astronomy and Department of Planetary Sciences, University of Arizona, Tucson) are organizing a conference and a school on Astrobiology.

Motivated by the rapidly increasing number of known Earth-sized planets, the increasing range of extreme conditions in which life on Earth can persist, and the progress toward a technology that will ultimately enable the search for life on exoplanets, the VO and the Steward Observatory (University of Arizona) announce a major conference entitled “The Search for Life Beyond the Solar System: Exoplanets, Biosignatures & Instruments” to be held in Tucson, Arizona, March 17-21, 2014.

The goal of the conference is to bring together the interdisciplinary community required to address this multi-faceted challenge: experts on exoplanet observations, early and extreme life on Earth, atmospheric biosignatures, and planet-finding telescopes.

An independently organized 3-day astrobiology school will precede the conference. The school will provide an introduction to graduate students and postdoctoral researchers to the multiple disciplines and concepts the conference builds upon.

The school will be held at the University of Arizona’s unique Biosphere 2 facility and lectures will be given by some of the invited speakers and University of Arizona faculty. The school, including accommodation and food, will be free for the participants of the EBI2014 conference.



The Dean of the Astrobiology School is Dr. Rory Barnes (University of Washington).

The Beginning and the End of the Universe: A Scientific, Philosophical, and Theological Approach

In 2014, the VO and the Pontifical Gregorian University will hold the

second session in a two session seminar on the beginning and end of the universe from the point of view of science, philosophy and theology.

In his homily on the feast of St. Ignatius of Loyola last year, the Holy Father invited Jesuits to follow creative paths of research.

Science, along

with philosophy and theology, is one of the paths that Jesuits have pursued through the centuries and in fact the Roman College was the alma mater of many famous scientists, philosophers and theologians.

Since the question of the origin and end of the cosmos does not exclude, but rather, encourages us to move beyond the horizons of science, we believe this is a good initiative for the educational community of the Gregorian University and the general public interested in these issues.

The first session took place on Monday 11 Nov 2013, and the second session will be held on Monday 31 Mar 2014. The program includes papers delivered by astronomers from the VO and professors from the Gregorian University, on subjects ranging from ‘The Big Bang Theory:

its evolution and historical perspective’ to ‘Creator and creation: the theological Significance today of *Creatio ex nihilo*’. The seminar is open to the general public.

Science and Faith: VO, CERN and Tera

Astronomers from the VO together with scientists from CERN and the Tera Foundation in Novara (which promotes the treatment of cancer by Hadron-therapy) gave birth to the first in a series of meetings that are part of the cultural program “Not just sun particles...”.

The event gathered representatives from the worlds of science, business and faith to Rome on October 1 last. Held in the splendid rooms of the Palazzo Altieri, the head-quarters of Banco Popolare, which sponsored the seminar, the interventions focused on the theme “Science and faith at the origin of the Universe”. Participants were addressed by two keynote speakers, FUNES, VO director and Professor Sergio Bertolucci, director of research at the European Centre for Nuclear Research, or CERN, in Geneva. The discussion touched on the deep issues, doubts and questions which scientists and the Church face on a daily basis. Both speakers highlighted the common dialogue that unites researchers and religious in their shared passion for the pursuit of truth.

Appointments and Awards

On July 1st MACKE joined the Observatory’s staff in Castel Gandolfo. MACKE is a member of the Missouri Jesuit Province. In 2010 he obtained a doctorate in Physics at the Department of Physics of the University of Central Florida. He also completed studies of Philosophy



MACKE at the Lunar Receiving Laboratory of the NASA Johnson Space Center in Huston, Texas, measuring the density of a moon rock returned by the Apollo astronauts. (Photo by Walter Kiefer)

at Saint Louis University and of Theology at Boston College. Past research at the University of Central Florida included a survey of meteorite physical properties for meteorites of all types, but primarily chondrites. Research at Washington University included the laboratory study of presolar grains found in meteorites, including preliminary work for non-chemical isolation of presolar grains, which has subsequently been used for isolating presolar silicates. Other research prior to graduate studies included a survey of Zn and Cr abundances in the Milky Way ISM utilizing archival IUE satellite data, and computational modeling of stellar evolution of a post-main-sequence star with a neutron-star companion. Current research interests involve measurements of the physical properties (density, porosity and magnetic susceptibility) of meteorites, in particular lunar meteorites, Apollo lunar specimens and Martian meteorites utilizing non-destructive means. MACKE measures grain densities using helium pycnometry, and bulk densities using the Archimedean bead method. He works in collaboration with CONSOLMAGNO at the new refurbished VO Meteorite



Laboratory.

On July 1st Father Sabino MAFFEO S.J. became emeritus staff after 28 years of outstanding service at the Observatory. He served as Vice-Director for Administration, Curator of the archive, Superior of the Jesuit community and Special Assistant to the Director. In addition, he was very active in public outreach welcoming many groups of visitors and giving public lectures on the history of the VO. Fr. MAFFEO continues to contribute to the Observatory with his work. This includes proof-reading volumes by Observatory staff ahead of publication, continuing work on the Observatory archive and conducting lectures and tours for visiting groups. We are deeply grateful to him.

We are also grateful to Brother John HOLLYWOOD S. J. for his devoted service to the Vatican Observatory Foundation and the Observatory in two terms (1987-1991) and (2007-2013). In the second term he played an important role in remodeling the Jesuit residence in Tucson. We wish him well in his new assignment in the Maryland Jesuit Province.



John Ratje is joined by colleagues as he celebrates his retirement.



Fr. MAFFEO greets Pope Francis

John Ratje, who was director of the Mount Graham International Observatory, where VATT is located, since its first beginnings in 1986, retired in May. We thank John Ratje profoundly for his cheerful ability to lead his team in overcoming the many start-up problems of a new observatory located at 10,500 feet elevation and the continuing day-to-day demands of keeping it running even through winter. GABOR and CORBALLY attended the dinner in honor of Ratje's retirement at Discovery Park.

In 2013, CONSOLMAGNO was appointed a member of the Scientific Committee of the Foundation Scienza e Fede, under the auspices of the Pontifical Council for Culture.

HELLER received the "Supervisor Prize" awarded by the TV Academy in Warsaw on April 7. He was also awarded the St George Medal by the Tygodnik Powszechny Weekly based in Cracow and on September 13 was given honorary membership of the ZAiKS Authors' Association.

Adjunct scholar Dante MINNITI was awarded the Premio Egresado Distinguido (Distinguished Alumnus Award), from the Universidad

Nacional de Córdoba, Córdoba, Argentina on April 12.

In Memoriam

We are very sad to report that on April 8, Fr. Juan CASANOVAS S.J., an emeritus member of the VO, was called home to the Lord.

Fr. CASANOVAS was born in Catalonia in October 13, 1928, and entered the Society of Jesus in 1944. He studied physics at Barcelona, graduating in 1957, and completed his theology studies at Weston College, Massachusetts, in 1960.

After a short residence at the Jesuit-founded Ebro Observatory in Tortosa, Spain, and a year of studies at University College, London, he moved to Tenerife, in the Canary Islands. Along with teaching courses in physics and lectures in stellar atmospheres, he founded the solar division of the newly-established observatory on La Palma, which today has developed into a primary European center of astronomical studies. In 1970 he obtained a doctorate of physics in Barcelona. As a part of the European Joint Organization for So-

lar Observations (JOSO) program, in collaboration with the Kippenheuer Institute of Solar Physics in Freiburg, Germany, he explored the possibility of developing a solar observatory on La Palma; today it is the site of a number of solar telescopes, including the Swedish Solar Telescope, the highest resolution solar telescope in the world.

He was called to the VO in 1976, where he remained until his retirement in 2009. At the VO he dedicated himself to the study of the history of astronomy, in particular the 13th century Alfonsine astronomical tables (first produced under the patronage of King Alfonso X of Castile). He also pursued an interest in founders of modern astronomy: Copernicus, Tycho Brahe, Kepler, Clavius, Riccioli and Secchi. In his later years, he wrote extensively on various historical questions regarding the 1582 Gregorian reform of the calendar, and on the study of ancient astronomy. In addition, from 1995 to 2007 he served as the librarian at the VO.

In his 33 years of service to the Holy See at the VO, Fr. CASANOVAS



Fr. Juan CASANOVAS S.J.

left a remarkable legacy of scientific and historical accomplishments, and his memory remains indelible in all who worked with him.

We have received many condolences messages from his colleagues and friends that show how much he was appreciated for his human, academic, and spiritual qualities.

Staff presentations, Academic Activities and Conference Participation

BOYLE presented a poster paper at the 221st meeting of the American Astronomical Society, Long Beach, CA, January 6-10 • together with JANUSZ, helped organize and participated in a workshop “Interstellar Extinction in Selected Dust Clouds and Star Forming Regions”, held at Moletai Observatory, Vilnius, Lithuania September 4-6. They presented VATT observations, processing and analysis on the Cygnus OB2 area; four graduate students of Vilnius University presented work based on VATT observations; and Dr. Cernis highlighted search and discovery of asteroids from VATT observations by BOYLE.

BROWN made a poster presentation at the 221st Meeting of the American Astronomical Society in Long Beach, CA, January 6-10 • made a poster presentation the 6th Meeting on Hot Subdwarf Stars and Related Objects Tucson, AZ, May 19-24 • gave a lecture on “Vatican Astronomy” at the University of Dallas Rome Campus, January 28 • gave a lecture on “Faith and Reason” at University of Walsh Rome campus, May 15 • gave a lecture on “Compatibility of Science and Religion” at the University of Dallas Rome Campus, September 2.

CARUANA moved from Heythrop College, University of London, to the Faculty of Philosophy of the

Gregorian University, Rome, where he was appointed professor on 17 September • continues to lecture and engage in research on topics related to the scientific mentality and its relation to religious belief and unbelief • presented a paper on July 14, 2013 entitled “From Water to the Stars: A Reinterpretation of Galileo’s Style” at an international conference for scientists, on unanswered questions in water research to mark 400 years since Galileo engaged in his famous debates on water and buoyancy, organized by the Università degli Studi di Firenze, Florence July 15-19.

CHINNICI gave an invited talk on “Astronomy in Sicily from the past to nowadays” at the 33rd Meeting of Italian Society of History of Physics and Astronomy (SISFA) in Acireale-Catania, September 4 • gave an invited paper on Fr. Secchi’s life and scientific activity at the 99th Meeting of the Italian Society of Physics (SIF) in Trieste, September 27.

CONSOLMAGNO was named a member of the International Space Science Institute (ISSI) team headed by Turrini (INAF), “Vesta: Key to the Origins of the Solar System”. This team held two week-long meetings at ISSI headquarters in Bern, in January and November • presented a paper at Division for Planetary Sciences of the American Astronomical Society, annual meeting, Denver Colorado, October 6 -11 • presented a paper at the European Planetary Sciences Congress, London, England, September 8 – 13 • presented a paper at the Meteoritical Society Annual Meeting, Edmonton, Alberta, July 28 - August 2.

CORBALLY was first author of one poster paper and co-author of a further two papers at the American Astronomical Society meeting #221,

Long Beach, CA, January 6-10 • served on the SOC of the workshop, “Cygnus OB2 and Cygnus X: the workings of a massive star complex”, at the VO, Castel Gandolfo, where he also chaired a session, May 15-17 • gave a presentation of skits and a dialogue with Margaret Boone Rappaport at The Eighth International Conference on “The Inspiration of Astronomical Phenomena (INSAP VIII)”, New York City, NY, held July 7-12 • was invited with Margaret Boone Rappaport to give the keynote address at the International Symposium “Interdisciplinary Studies: The Next 25 Years”, Pasadena, CA, August 1-4 • presented a paper on behalf of himself and Margaret Boone Rappaport at the International



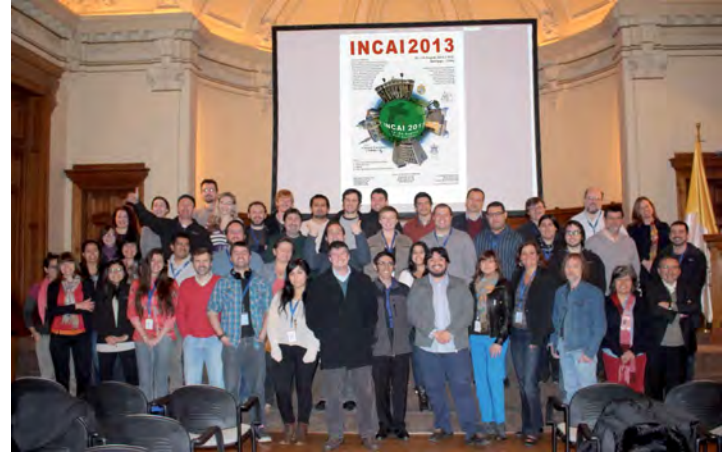
(Top) Richard Gray and CORBALLY stand by their joint posters at the AAS Meeting in Long Beach, January 2013.

(Bottom) BOYLE stands by his poster at the AAS Meeting in Long Beach, January 2013 and is joined by a colleague from NASA-Ames, Bent G. Andersson.

Symposium on Big History and Global Evolution, Moscow State University, Russia, held October 23-25 • spoke at the St. Thomas Institute of Philosophy, Theology and History, in Moscow, Russia, on the VO meeting its modern challenges, October 25 • attended the International Dark-Sky Association’s Annual General Meeting in Tucson, Arizona, November 15.

FUNES gave a keynote address at the 6th International Meeting of Astronomy and Astronautics in Campos, Brazil, 18-20 April • gave a seminar at the Instituto Tecnológico de Buenos Aires, Argentina • participated at III INCAI (International Network of Catholic Astronomy Institutions) Workshop Exploring the Nature of the Evolving Universe and gave a public lecture in Santiago, Chile, 19-24 August • gave a talk to the students of theology of the Pontificia Universidad Católica de Chile • gave a keynote address on the scientific work of the Society of Jesus at the Second Meeting on El humanismo y las humanidades en la tradición educativa de la Compañía de Jesús. at ITESO, Guadalajara, Mexico • gave several presentations at the Universidad Católica Andrés Bello Caracas, Venezuela • participated in a round table on Science and Faith in Europe at the World Conference Science for Peace organized by the Fondazione Umberto Veronesi, Milan, Italy.

GABOR presented two papers at a meeting on Requirements for UTC and Civil Timekeeping on Earth. A



MINNITI, FUNES and participants at the Third INCAI Workshop, Chile, August 2013.

Colloquium Addressing a Continuous Time Standard at the University of Virginia on May 29-31 • took part in the Plato 2.0 Science workshop held at ESTEC in Noordwijk, the Netherlands, July 29-31.

GIONTI attended and gave a talk at the annual ICRAnet Scientific Meeting on Relativistic Astrophysics on the occasion of the 50th anniversary of the Kerr Solution of the Einstein’s Equations, June 3-21 • attended the Strings 2013 International Conference in String Theory, Sogang University-Seoul, South Korea, June 24-29 • gave a talk on “The Gauge theory in Physics: How a symmetry principles allows to introduce interactions in particle physics”, at the School of History of Physics seminar on “The conservation principles and symmetries in history of physics”, Ferrara, February 18-22.

HELLER participated in an inter-department seminar on “Georges Lemaitre: from Primeval Atom to Quantum Cosmology”, Toruń, Institute of Physics, February 20 • attended and gave an invited paper “Physics at Its Limits” at symposium on “Neutron Spectroscopy and Related Phenomena. Tribute to Prof. Jerzy Janik”, Institute of Nuclear Physics,

Cracow, March 21 • gave an invited lecture “The Beginning of the Universe” at Spinal Surgery symposium Krynica, Poland, May 5 • attended “PhD seminar on the Philosophy of Cosmology”, Jagiellonian University, Institute of Physics, Cracow, May 18 • Courtyard of the Gentiles, panel discussion “Science and Religion”, Warsaw, October 11 • panel discussion “Cosmology and the Book of Genesis”, Museum of the History of Polish Jews, Warsaw, October 14 • Copernicus Center Lecture “Creation and the Beginning of the Universe” Copernicus Center, Cracow, October 24.

JANUSZ together with BOYLE participated in the meeting on “Interstellar Extinction in Selected Dust Clouds and Star Forming Regions”, held at Moletai Observatory, Vilnius, Lithuania September 4-6. They presented VATT observations, processing and analysis on the Cygnus OB2 area; four graduate students of Vilnius University presented work based on VATT observations.

KIKWAYA attended the Meteoroids 2013 symposium in Poznan, Poland, August, 25-30.



Fr. STOEGER

MINNITI Organizer and lecturer of the Third INCAI Workshop, held in Santiago, Chile, August <http://www.uc.cl/es/la-universidad/noticias/12156-uc-es-sede-del-tercer-congreso-de-la-red-internacional-de-instituciones-catolicas-en-astronomia->

MUELLER was appointed to the Editorial Advisory Board of “The Ignatianum Philosophical Yearbook” • gave the lecture “Science, Faith, and Progress” at the Hank Center for the Catholic Intellectual Heritage at Loyola University Chicago as part of the lecture series “Catholic Minds, Catholic Matters”, September 17 • gave the lecture “The Intersection of Art, Science, and Faith” at the Society of St. Vincent de Paul, Phoenix, on the occasion of the event “Eternal Beauty and the Pieta”, October 9.

STOEGER participated in the Templeton Foundation Cosmology Mini-series Conference “Is ‘God’ Explanatory?” delivering two invited papers: “Moving Beyond the Natural Sciences: The Cosmological Limit, Philosophy and ‘a Creator’” and “Big Bang Cosmology and Divine Creation – in Conflict or Complementary?” at St. Anne’s College, University of Oxford, U. K., January 9-11 • gave an invited talk at the Oakland (California) Cathedral to faculty of all the institutions of higher education in the Oakland Diocese, including the U. of California Berkeley, the Graduate Theological Union, St. Mary’s College and Holy Names University. It was entitled “Exploring Mystery: The Universe, Life, Ourselves, and God”, November 12.

Educational and Public Outreach

BROWN “The Heavens Proclaim” presentation to students at Jesuit High School, New Orleans, LA, December 20 • “The Vatican Observatory and Astronomy” presentation

talk given to students at Most Holy Trinity Parish School, Phoenix, AZ, January 11 • “The Heavens Proclaim”: talk given at St. Mary’s Norwalk Parish, Norwalk, CT, August 21.

CHINNICI gave a public conference on “Comets in 19th century” at Roccapalumba, Palermo, April 29 • gave a talk on literature, cinema and astronomy in “The Leopard” (1963), during the event “Le Vie dei Tesori”, Palermo, October 25 • together with Antonella Gasperini (INAF-Osservatorio Astrofisico di Arcetri) gave three public conferences on the scientific cooperation between Secchi and Tacchini, on the occasion of their book presentations in Reggio Emilia, October 10, in Catania, November 8 and in Florence, December 12.

CONSOLMAGNO presented the annual Ignatius of Loyola Lecture at Loyola University of Chicago, “The End of the World - Yet Again? Perspectives of Astronomy and Faith”, February 25 • presented the lecture “The Unfinished Cosmos: Creation, God, and Hawking’s Grand Design” at the University of Illinois Catholic Newman Center in Champaign, Illinois, March 7 • spoke on Astronomy and Belief at the Mount Street Jesuit Centre, London, March 18 • presented a “TEDx” talk “From MIT to the VO,” at the “TEDx Via Della Conciliazione on Religious Freedom” sponsored by Vatican Pontifical Council for Culture on April 19. The talk can be found online at http://www.youtube.com/watch?v=kmU2g-DbP_Tk&feature=share&list=PL-sRN0Ux8w3rMqx1LYBtxXHFc-6vfpl-19V • was the keynote speaker of the Stellafane Amateur Telescope Maker’s Convention in Springfield, Vermont; his topic was Comets Tales: Changing Views of Cosmic Vagabonds” on August 10.

CORBALLY was featured in The University of Charleston Dow Speaker Series at the two campuses of the UC-Beckley (a lecture) and UC-Charleston (a discussion moderated by UC President Dr. Edwin Welch) in an event titled “Star Wars: When Astronomy & Religion Meet”, on March 26 • gave the Annual St. Albert the Great Lecture on Faith, Reason, and Science in The Quinn Family Lecture Series at Providence College, RI, where he spoke on “Imagine That: Twenty Years of an Innovative Telescope for the Vatican” on November 21 • other talks included those on science and spirituality for the Priests Day of Recollection in the Reno Diocese, NV, on September 11 • spoke at St. Therese’s parish in downtown Reno, September 11 • gave a talk on the VO at nearby St. Gall’s parish, Gardnerville, NV, September 12 • presented the topic of “Upgrades in the VO” in the Third-Thursday Star Talks series at Prescott Public Library, Arizona • spoke on “Astronomy in China” at the East Valley Astronomy Club, Phoenix, Arizona, on November 15 • with GABOR he hosted a visit to the Mirror Laboratory on University of Arizona campus and to its Planetarium for 8th grade students from the Santa Cruz Catholic School, Tucson, AZ, on April 24 • hosted a small group of Dominican theology students from St. Albert’s Priory, Oakland CA, at VATT for an evening in January.

FUNES gave a keynote address to the assembly of the Jesuit Argentina-Uruguay Province on the Pastoral Challenges of the dialog between Science and Faith • gave presentations and public lectures on Astronomy, the VO, and Science-Faith Dialog at Civiltà Cattolica, Rome; Colegio del Salvador, Buenos Aires; Astronomical Observatory of Córdoba, Argentina; Fiera di Primiero, Viterbo; Saint Thomas Apostle Parish, Tucson.



Jeff Urban explains the LBT to Dominican theology students from St. Albert’s Priory, Oakland CA, during their visit to VATT and MGIO.

GABOR gave two talks to the students of the Dominican University of California and held a seminar for the faculty, Oct 21-22 • gave two talks to the Science and Religion classes and two talks to the Astronomy classes at the Saint Ignatius College Preparatory in San Francisco, California, Oct 23-24 • gave two talks in New Mexico: in Socorro on Nov 21, and in Albuquerque on Nov 22 • gave a talk at the Catholic University of Slovakia in Ruzomberok on Dec 17.

GIONTI gave a public talk on “A Brief history of Cosmology and some consideration about the Big Bang theory in science and religion” (in Italian), “The Observatory Club” in Rocca di Papa Rome, January 25 • gave a public talk on “A Brief history of Cosmology, the Big Bang theory and some questions arising from the concept of beginning” (in Italian) Ulrico Hoepli Municipal Planetary, Milan, May 8 • delivered a similar seminar at the Vocational

High School “Ugo Tognazzi”, Velletri, Rome, May 15 and in Padua, at the Jesuit School of Philosophy “Aloisianum” on May, 27 • gave a public talk on “A Brief History of Cosmology and Some Key questions Emerging from Quantum Gravity and the Early Stages of our Universe” (in Italian), in “The Beginning and the End of our Universe”- At the crossroad of Scientific, Philosophical and Theological reflections, Gregorian University, Rome, November 11 • gave guided tours to many groups visiting the VO, the gardens of the



GIONTI accompanies a group of visiting high school students on a tour of the telescopes and Papal Palace at VO headquarters in Castel Gandolfo.

Pontifical Villas and the telescopes on the Papal Palace in Castel Gandolfo. He has also, in several occasions, offered amateur astronomical observations through the VO telescopes.

HELLER gave a public lecture on “Incomprehensible Comprehensibility of the Universe” Cambridge University Scientific Society, Cambridge, UK, January 29 • gave a public lecture on “Man in the Copernican Universe”, Toruń, Museum, February 19 • gave a public lecture on “The Mathematical Universe”, Katowice, March 7 • gave a public lecture on “Limits of the Universe”, Cracow, Auditorium Maximum, April 26 • gave a public lecture “The Beginning of the Universe”, Wrocław Academic Center, Wrocław, May 31.

KIKWAYA gave a public talk on “From asteroids and comets to meteors”, to Sun City Oro Valley Astronomy Club, May 16 • gave an online talk to two Jesuit high schools in California: St Ignatius High School in San Francisco and Loyola High School in Los Angeles, October 4.

OMMIZZOLO gave a series of public conferences on astronomy and on the science and faith theme throughout Italy • gave a series of lessons on cosmology and stellar evolution in the Prison “Due Palazzi”, Padova.

STOEGER visited Alaska Pacific University, Anchorage, Alaska, February 10-14. While there he worked with several classes, met with faculty and science students, and delivered a public lecture, “God’s Creation and the Big Bang – How Do They Fit Together?” He also talked about astronomy, science and religion at two Catholic high schools and a Catholic elementary school in

Anchorage • visited some of the astrobiology labs at NASA Ames Research Center in Mountainview, California on August 16. While there he gave informal talks to graduate students and post-docs on cosmology, and on ethical issues in astrobiology, followed by profitable discussions • continued to serve as a Director and Secretary of the Vatican Observatory Foundation, as a Director and Chair on the Board of the Center for Theology and the Natural Sciences, Berkeley, California, and as a Trustee of the University San Francisco.

News and Media Coverage

CONSOLMAGNO hosted a film crew, including presenter Brian Cox, to film an episode of the BBC Science program The Human Universe in the VO’s historic Carte du Ciel telescope dome on July 5. The program is expected to air next year.

CORBALLY was interviewed by Drew Mariani, Relevant Radio, on February 19 about the 2013 Russian fireball and the 2012 DA₁₄ asteroid that passed near Earth on 15 February, and he was interviewed again on August 12 about a massive EMP that missed Earth by 2 weeks and the Sun’s magnetic field reversal.

FUNES participated in TV shows at RAI International and TV2000 and gave interviews to Vatican Radio, Radio Cope, Diario Perfil, Canal 12 and Crónica 10, El Mercurio, Vanity Fair, El Nacional.

Visits to scientific institutions and universities

GIONTI visited Dr. Franco Pezzella and Dr. Raffaele Marotta (INFN, Naples Section) several times at the Physics Department of the University of Naples Frederick II for research purposes • visited the ICRANET (International Center for Relativistic

Astrophysics Network) Center in Pescara on February 25, where he participated, on behalf of Fr. Funes, at the 2013 Icranet Steering Committee meeting • visited the University of Rome “La Sapienza” to participate, on behalf of Fr. Funes, in the Steering Committee meeting of ICRA (International Center for Astrophysics) on March 1 • visited the ICRANET Center in Pescara on June 15 to participate at the 2013 Icranet Scientific Committee meeting.

BOYLE along with Dr. Vyngandas Laugalys and Dr. Justas Zdanavicius of the University of Vilnius, after their two-week observing run at VATT, visited Dr. Leon Harding and Dr. Gregg Hallinan at CalTech, Pasadena, to confer over the successful VATT observation giving the occultation light curve in the Sloan r’ filter for the white dwarf / M dwarf object KOI-256.

JANUZ together with BOYLE visited the Moletai Observatory, Vilnius, Lithuania September 4-6.

PUBLICATIONS

Books

After a long preparation, the correspondence between Angelo Secchi SJ (1818-1878) and Pietro Tacchini (1838-1905), has been edited by Ileana CHINNICI and Antonella Gasperini (INAF-Osservatorio Astrofisico di Arcetri). The volume has been kindly revised by MAFFEO and contains forewords from FUNES and Fabrizio Bignami, President of INAF (National Institute for Astrophysics). It gives an important contribution in understanding the developing of early astrophysics



The book by CHINNICI and A. Gasperini, *Alle origini dell'astronomia italiana (At the Origins of Italian Astronomy)* published in July, 2013, features the correspondence between Fr. Angelo Secchi S.J. (top) and Pietro Tacchini (bottom).

in Italy and abroad. The volume has been presented in Reggio Emilia (Biblioteca Comunale "A. Panizzi"), Catania (Accademia Gioenia), and Florence (Soprintendenza Regionale per i Beni Archivistici) and is to be presented in Palermo and Rome.

Once again this year HELLER published a series of volumes including *Philosophy of Cosmology. Introduction*, Copernicus Center Press, Kraków 2013 (in Polish) and *God and Science.*

My Two Roads to the Same Goal, Interview by Giulio Brotti, translated from Italian by Ewa Nicewicz-Staszewska, Copernicus Center Press, Kraków 2013. He also co-authored the book *Creation and the Beginning of the Universe*, with Tadeusz Pabjan, Copernicus Center Press, Kraków 2013 (in Polish). Finally, Fr. Heller contributed to and edited *Between Philosophy and Science*, eds.: M. Heller, B. Brożek, Ł. Kurek, Copernicus Center Press, Kraków, 2013 and *The Causal Universe*, eds: G. F. R. Ellis, M. Heller, T. Pabian, Copernicus Center Press, Kraków 2013.

Academic Publications

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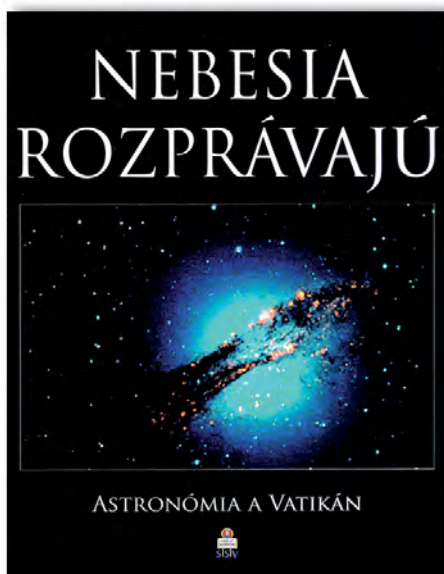
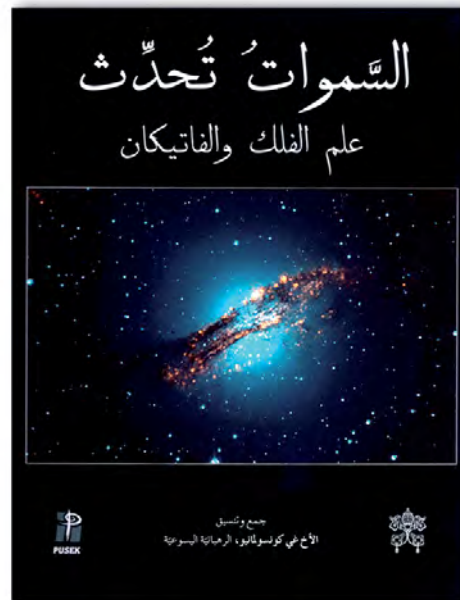
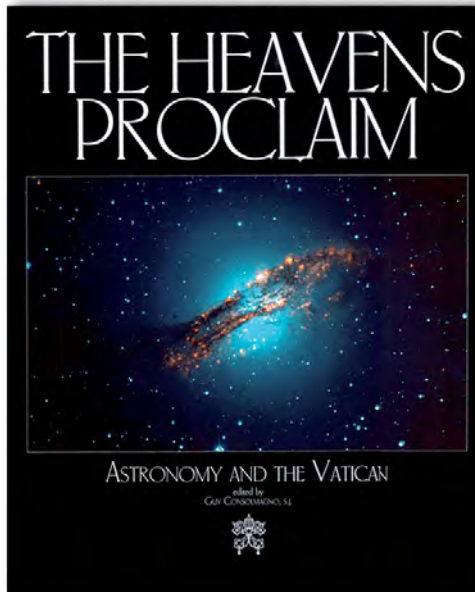
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*To honor the International Year of Astronomy in 2009, at the suggestion of Cardinal Giovanni Lajolo, Emeritus President of the Governatorate of Vatican City State, the Vatican Observatory prepared the coffee-table book *The Heavens Proclaim* describing our history and current research. Since that time, a number of translations have been published around the world, including versions in Italian, Spanish, and Arabic. The most recent to appear, in 2013, is a version in Slovak translated by Mária Hadjuková and VOSS 1997 alumnus Juraj Tóth.*

VISITORS

Visitors to the VO Headquarters in Castel Gandolfo

To the edge of the universe: Pope Francis visits VO

“To the outskirts of the universe: the VO welcomes Pope Francis”: This is one of a series of messages tweeted just before Pope Francis arrived at the VO on Sunday, July 14, 2013, just four months after his election. He was accompanied by Cardinal Giuseppe Bertello, President of the Pontifical Commission for Vatican City State and President of the Governatorate of Vatican City State.

The very special visit of Pope Francis to one of the world’s oldest astronomical research institutions evoked excitement among VO staff, not least because they were welcoming a fellow Jesuit. Pope Francis stopped to have lunch with the Community and afterwards signed the same parchment that bears the signatures of all of his predecessors from Pope Pius XI to Pope emeritus Benedict XVI.

The Pontiff viewed some of the ancient texts that the Observatory holds in custody, the most precious among them being a copy of the book of Copernicus’ *De revolutionibus* and Isaac Newton’s *Principia*. Pope Francis was also shown a copy of the reform of the Gregorian calendar and Father Clavius’ *Tables* on the reform. The Pope also visited the meteorites laboratory, where the curator, Br. CONSOLMAGNO, had a surprise waiting for him beneath a microscope: a meteorite that fell in the Pope’s native city of Buenos Aires.

He also had a very clear message for the astronomers in their work at the VO, the same message he has insisted on since the beginning of his pontificate: the need to go out to the peripheries, not just geographical but



MAJ and FUNES give the Holy Father, Pope Francis, a guided tour of the VO headquarters. The Pope is accompanied by H.E. Cardinal G. Bertello.

also existential, of today's world.

VO director, Fr. FUNES, commented that their mission at the VO is precisely this, even if their idea of 'peripheries' are slightly further away and take in the entire universe. "In a sense we go back to the very start because we explore the beginning of the universe from the scientific point of view, but we also move forward, looking outwards, because we also study the most distant galaxies. This work places us in daily contact with the questions that both science and faith arouse. I think this is the Observatory's mission: to go out towards these distant peripheries, the peripheries of this universe, which is always a gift from God".

A tour of the Pontifical Gardens in Castel Gandolfo was given to The Prince and Grand Master of the Order of Malta, Fra' Matthew Festing, along with his retinue on April 17, 2013.

Dr. Elizabeth Green and Dr. Christopher Collins, astronomers at and from the University of Arizona, Tucson, visited the VO headquarters, Pontifical Gardens, and domes in the Papal Apostolic Summer Palace in Castel Gandolfo on October 7, 2013.

Scientific and Academic visits to the VO headquarters in Castel Gandolfo
Father Agustín Udías S.J., author of the book "Searching the Heavens and the Earth: the History of Jesuit Observatories", was working with the archive of the VO. He was investigating in the archive of the Observatory the correspondence between the first director Jesuit Father Johan G. Hagen and other directors of Jesuit Observatories.

Dr. Gumersindo Meiriño Fernández from Spain and Dr. María Benetti Meiriño from Argentina visited the

VO headquarters and domes in the Papal Apostolic Summer palace in Castel Gandolfo on behalf of the Centro de Observación Astronómico de Misiones, Argentina.

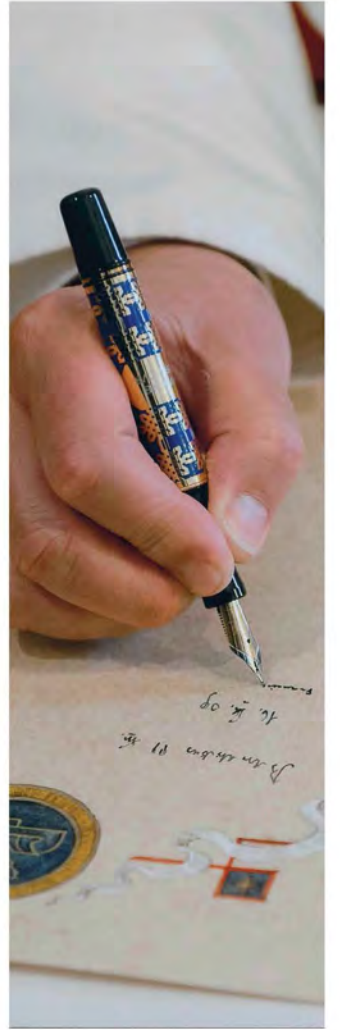
The following people also paid working visits to the VO headquarters: Ellen Howell and Michael Nolan, Arecibo National Radio Telescope; Joseph Harrington, University of Central Florida; Daniel Britt, University of Central Florida; Bradley Schaefer, Louisiana State University; William Higgins, Fermi National Accelerator Laboratory; Stephen Collins, Jet Propulsion Laboratory and Robert Zellem, University of Arizona.

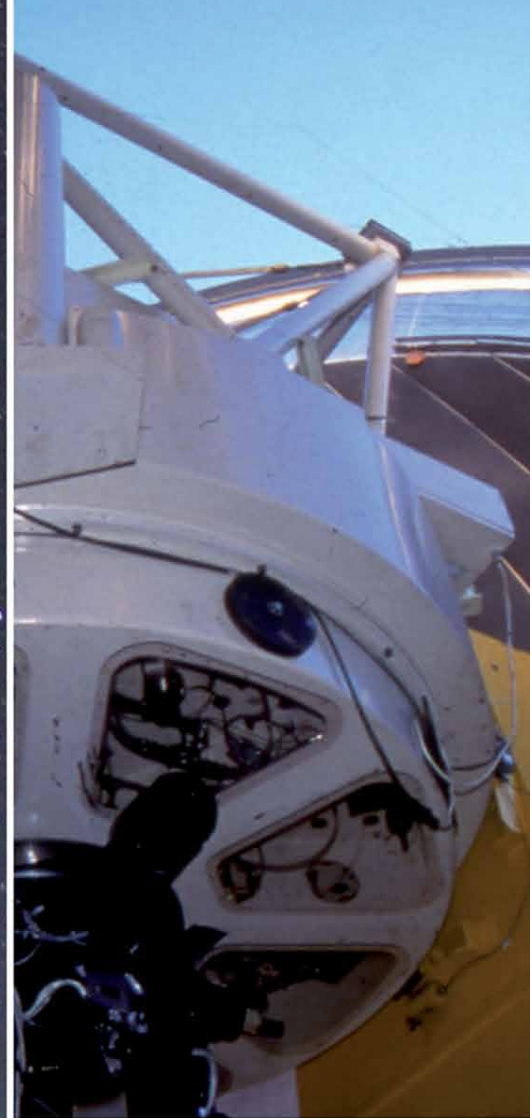
From August 12 to 17, Dr. Franco Pezzella, INFN-Section of Naples, visited for research collaboration. From July 29 to August 3, Dr. Matteo Galaverni, seminarian of the Reggio Emilia diocese, visited the VO to work, under the supervision of GIONTI, on some issues concerning the hypothesis of Multiverses in cosmology and its consequences for theology. On August 1, he gave a seminar on cosmic rays, which was the topic of his Ph.D. thesis.

Visitors to the Vatican Observatory Research Group and VATT Tucson

The following visited the Vatican Observatory Research Group and VATT in Tucson: C. Bayu Risanto, S.J., from Creighton University; Claudio Costa from Rome; Richard Gray from Appalachian State University, NC, and Jon Saken from Marshall University, WV.







The 20th Anniversary of VATT

September 18, 2013, marked the 20th anniversary of the dedication for the Vatican Advanced Technology Telescope (VATT) atop Mount Graham, Arizona, built and maintained through the generosity of the many donors to the Vatican Observatory Foundation, most notably Mr. Fred A. Lennon and Mr. Thomas J. Bannan.