Vatican Observatory
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The Best Way to Travel

By Guy Consolmagno, S.J.

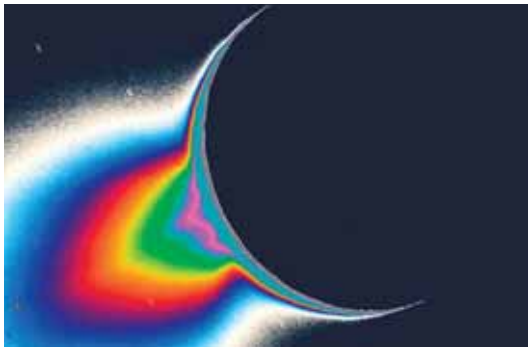
Coming out of a dark and dreary season, spring break is a time to take off to new and exotic climes; or at least, to daydream about such trips. My own voyage recently was a visit to my old hometown, snow-dusted Detroit, to attend a science fiction convention.

A panel discussion at that meeting, Travel Destinations of the Solar System, challenged us to imagine really exotic localities. Where among the planets would we love to go? And what it would be like to be standing there, in person?

In our minds we explored the caverns inside an asteroid. We saw how Pluto and its moon Charon spin and orbit such that each keeps the same face to the other, and imagined a cable car slung between them. We watched rainbows play along the hundred-kilometer high fountains of water spurting from the south pole of Saturn's moon Enceladus.

Astronomy provides us the bare facts of the solar system: the sizes and locations of bodies, their compositions, the rate they spin. Science fiction turns those facts into places where we can have adventures. It's an game that I learned reading Isaac Asimov.

And it's a style of prayer that St. Ignatius features prominently in his Spiritual Exercises. Using a series of carefully chosen settings, he has us insert ourselves into the Gospel stories, picturing what it would have been like to be present when Jesus cured the blind man or calmed the Sea of Galilee.



One of the fountains of Enceladus.

By imagining these events as vividly as we can, we bring alive a history that is not imaginary at all, but real, just as our planetary dreaming makes tangible this solar system.

We call it science fiction. But the craggy asteroids, the fountains of Enceladus, the dancing moons of Pluto are all as real as the man who walked the shores of Galilee two thousand years ago.

(Adapted from "The Best Way to Travel", published in The Tablet, January 26, 2007) ■

Upgrades and Repairs Done on VATT

The Vatican Advanced Technology Telescope underwent major maintenance and repair operations in 2006. The telescope was the first to use the advanced technologies of a spin cast mirror and innovative polishing techniques. It is in its 14th year of operation. Now is a critical time for the instrument. Major maintenance and repairs were done in 2006 to help insure that images and data are the best possible for research. Last summer, the primary mirror needed to be re-aluminized, i.e., cleaned and re-coated. This can only be done in Tucson at the Mirror Facility. A large crane was transported up the mountain from the base camp to lift the 1300 lb mirror. The crane broke before this operation started. The alumnization had to be rescheduled for this summer of 2007.

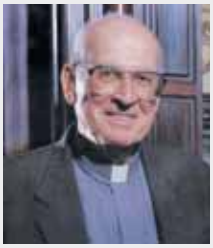
Additional challenges facing the VATT engineers this year included the damage to the Mount Graham power system by lightening, and one of the edge-supports holding the mirror became detached. Because of the age of the telescope, parts are becoming harder to find and the hardware/software that are running the system is outdated. Winter weather also poses a major factor in the operations. It reduces the "window of opportunity" that engineers have to work on the VATT and reduces the time available for completing a task. Special recognition goes to Dan McKenna, chief VATT engineer. He is responsible for the operations at the telescope and has worked hard to fix the problems and keep the maintenance schedule on track.

Dan McKenna working on the VATT

Dan and his team made several improvements during the year. A larger and more sensitive camera was integrated into the VATT system. Counterweights to balance the telescope were repaired, improved and installed. Safety concerns are being addressed and corrected. Image shifts, an annoying problem for astronomers, are being caused by shortcomings in the primary mirror support. This issue is being understood and so can now be addressed.

What does the future hold for the VATT? With an increase in funding, the VATT has the ability to be one of the finest telescopes in the world to provide remote observations. This will allow astronomers to do their research at their offices or research facilities. It is an exciting possibility. ■

The Vatican Observatory Foundation appreciates the generous support of its donors and friends. Gifts to the foundation support the research and operations of the Vatican Advanced Technology Telescope (VATT). Thank You!



In The Beginning

By George Coyne S.J. President of the Vatican Observatory Foundation

Father Coyne is on sabbatical leave this year, serving as a parish priest at St. Raphael the Archangel Church in Raleigh North Carolina. He returns to his work at the observatory in September. This is a condensed article form Science-Spirit magazine.

Chance, necessity and opportunity shape our universe - a world of chemicals so fertile it made the mergence of life inevitable. The random encounters of atoms, the birth and death of stars, and the formation of galaxies establish the scientific underpinnings of our ultimate origins. Understanding this foundation, one that dates back billions of years, can yield new insights into the complexities of nature while enriching our faith in creation.

Each year, ninety-eight percent of the atoms in my body are replaced. Every time I breathe, I inhale billions and billions of atoms, recycled during the past few weeks by the rest of the world's breathing organisms, Living things are constantly exchanging the fundamental building blocks of life, giving to and taking from the total reservoir; all is refreshed, regenerated from the available energy and material in the universe. My skin is renewed each month, my liver every six weeks. All the elements needed to make everything from human hair to toenails come from the stars. Using infrared light, we can look at the center of constellations like Orion, seeing there the boiling dust and gas. If we look even closer, we see incandescent regions buried in the gas. And if we use the Hubble Space Telescope to look closer still, we see the fine separation of blue gas and red gas in the midst of a rather chaotic structure, Stars are being born in the gas, Where the hottest, most massive and therefore brightest stars have already been born, they are irradiating the gas, and the gas is giving off hydrogen alpha radiation. This region of star birth in Orion is just a little part of our Milky Way, a spiral galaxy that measures 100,000 light years across and contains about 100 billion stars. As any of these stars live, it converts lighter elements into heavier elements, hydrogen to helium, helium to carbon, carbon to nitrogen to oxygen to iron - and then, when the star dies, it regenerates its material out into the universe.

Around one star, which we call the sun. a group of planets came to be, among them the little grain of sand we call the Earth. An amazing thing happened on this grain of sand in the sixteenth and seventeenth centuries with the birth of modern science. We developed the capacity to put the universe in our heads using mathematics; physics, and to some extent, the laws of chemistry and biology.

We ask questions, and, as we discovered the answers, we learned things about the expanding universe as we age. The cosmic background radiation came to be. Galaxies an stars formed, and, after 10 billion years, the first microscope-life-forms emerged. In time, our new understanding led to mother much-discussed questions: Is our universe biofriendly? Was life destined to happen?

(The complete article "In the Beginning" can be found on vaticanobservatory.org. To order a copy of the article, please contact Nancy Knoche at nknoche@earthlink.net or 602-482-9147) ■

Extremely hot star (110,000° K) grasps its final breath to form the round planetary nebula.

Vatican Observatory in the News 2006!

The Vatican Observatory staff gave over 200 presentations and interviews to audiences throughout the world in 2006. The majority of these were done in Europe and South America. Those that were conducted in the USA include:

- *Why Does the Pope Have An Astronomer?* by Guy Consolmagno at the Milwaukee Public Art Museum
- *Hope in the Human World* - by Chris Corbally, in conjunction with Earth & Sky's 5,000th radio celebration. Chris is a regular contributor to the broadcast.
- *Dance of the Fertile Universe* by George Coyne, the inaugural lecture at Marquette University of the George V Coyne Lecture series.
- *Heavenly Science*, an article in the Chicago Tribune included interviews by Chris Corbally and Bill Stoeger, and highlighted the work done on the VATT.
- The Guardian ran a full-page profile of Guy Consolmagno in its May 9 Education supplement.
- *The Today Show* on NBC featured the Vatican Observatory and Guy Consolmagno in connection with the release of the movie "The DaVinci Code."
- *Is God A Scientis?*, an article by George Coyne featured in America Magazine
- *The Fertile Universe* by George Coyne in Company Magazine
- *God's Mechanics by Guy Consolmagno, Loyola Lecture at Fordham University. Currently, Guy is the holder of the Loyola Chair for visiting Jesuit Scholars at Fordham.*

The change of directors in August received extensive print coverage. It was also covered in several blogs with limited feedback.

The Vatican Observatory website received an average of 8,575 hits per day. This is an increase of over 10% from 2005. Spikes occurred when newsworthy events happened, such as the changeover of directors at the end of August. The website is accessed from over 90 countries worldwide each month.

A complete listing of all the presentations can be found in the 2006 VOF Annual Report. ■

From the Director

By José Funes, S.J. Director of the Vatican Observatory

Times of Transition

A transition generates fear and hope. Fear for the unknown and hope for a better future. I am confident in the Providence that we always face a better future though we know that "all creation is groaning in labor pains".

One hundred years ago... The first Jesuit Director

The 1906 was a year of transition for the Vatican Observatory. That year, after a difficult period in the history of the Observatory, Father Johann Hagen, S.J. arrived to Rome, appointed by Pius X, new director of the Vatican Observatory. At that time he was a well known astronomer and the Director of the Jesuit Georgetown College Observatory in Washington, DC. Pius X put at the disposal of his Jesuit astronomers, his lovely little Villa constructed by Leo XIII in the Vatican walls.

Father Maffeo writes in his recent book J.G. Hagen, S.J., Astronomer and Priest: "Today when the Jesuits at the Vatican Observatory are asked by visitors and journalists about the relationship between science and faith, the quick and easy answer to that question is to say that the fact that we are religious men and scientists tells more than words that science and faith are completely compatible". Father Hagen was an exemplar witness of science and faith. We try to follow his steps…

A New Director

The year 2006 is another year of transition at the Vatican Observatory. On 19 August 2006 L'Osservatore Romano, the Vatican official newspaper, announced that Pope Benedict had appointed me as new director of the Vatican Observatory, succeeding Father George Coyne, S.J. in that office.

In May, after 28 years, Father Coyne asked our superiors if they didn't think it was time for the Vatican Observatory to select a new director and they agreed to accept his resignation as well as appoint a new director. He takes a well deserved sabbatical in Raleigh, N.C., before rejoining the Vatican Observatory in September 2007. He continues to direct the Vatican Observatory Foundation. All the staff is most grateful to Father Coyne for his years of inspired directorship. Personally, I am very happy that Father Coyne will continue as President of the Vatican Observatory Foundation and that after the sabbatical year he will be back with the Vatican Observatory.

Father Coyne's Legacy

At the time of Father Coyne's appointment as director of the Vatican Observatory, he was Director of the Catalina Observatory and Acting director of Steward Observatory, both institutes of the University of Arizona. This appointment and the need to establish another observing station contributed to the evolution of the Specola (as we call the Vatican Observatory in Italian). In 1980 an agreement was established between the Specola Vaticana and the University of Arizona. The Specola in Tucson became known as the Vatican Observatory Research Group (VORG). The clearest and most tangible sign of the fruitfulness of the collaboration between the Specola and the University of Arizona is the Vatican Advanced Technology Telescope (VATT) inaugurated in 1993. The existence and functioning of VATT is possible thanks to the generosity of our friends of the Vatican Observatory Foundation.

With Father Coyne's directorship a new period began at the Specola. The observing astronomers and those engaged in astrophysical research spend 10 months in Tucson, Castel Gandolfo continues to be the location where, in addition to hosting the work of the non-observing members of the staff and guest researchers, there are located the offices of the Director and the administration, the library, computers and where in the summer months the staff members all come together for some weeks both to discuss the observatory programs and to participate in scientific meetings and summers schools.

Another big achievement during Father Coyne's directorship is the Vatican Observatory Summer Schools (VOSS). We are very proud of the success of our schools in encouraging young scholars to establish professional friendship with faculty and students. We have now held ten VOSS, producing around 250 alumni plus faculty members, 85% of the alumni are still active in research and/or teaching astrophysics, many of them concentrated at major centers throughout the world. I, myself, am a "product" of VOSS 03. This success is due to the excellent contribution of faculty and students. For the next VOSS 07, two alumni are on the faculty. Father Coyne is "like a father" of the VOSS.

Under his leadership, the Specola has flourished, making its mark not only in astronomical research but in the interdisciplinary studies. In our service to the Holy See, the science - faith dialog is a natural consequence of our scientific activity. Our two-fold competency makes us especial interlocutors in the dialogue between the Church and the world of Sciences. Father Coyne gave a great impulse to this dialogue through the organization of many meetings and publications that followed them.

This transition had an unexpected (at least to me!) impact on the mass media. This fact puts in evidence that during Father Coyne's directorship, the Vatican Observatory has made a prominent impact on the popular culture. The Vatican Observatory is a very visible symbol of the Church's engagement with the contemporary world.

The Vatican Observatory I "receive" is in very good shape. The challenge of filling Father Coyne's big shoes is a "mission impossible" that with the help of our staff, friends and colleagues will be made "possible".

Our Mission

At the time of the appointment, I was participating in the IAU (International Astronomical Union) General Assembly in Prague. We were seven Jesuits and Dan McKenna (VATT manager), participating in the most important astronomical meeting that is held every three years. The Assembly covers all astronomical topics, from the near Earth objects through the very distant galaxies. During the meeting, we enjoyed, at the Jesuit community in Prague, a very lovely evening with VOSS faculty and alumni participating in the General Assembly.

The fact that I was participating in this very prestigious meeting is not a minor detail. It tells me about the mission of the Vatican Observatory which is to be the presence of the Church in the world of Sciences, in particular, Astronomy. We are called to serve the Holy Father and our colleagues, doing astronomical research and helping others to collaborate scientifically through the organization of schools and scientific meetings. Our challenge is to keep doing good science in all the fields in which the Vatican Observatory is involved, from the solar system to cosmology.

RESEARCH HIGHLIGHTS

Radio Emission From Brown Dwarfs

Brown dwarfs are substellar objects spanning the mass range between planets and stars. Unlike stars, they possess insufficient mass to sustain the nuclear fusion of hydrogen in their cores, but can burn deuterium for a short period at the start of their lives. After which they cool, contract and fade into obscurity. Therefore, although they may outnumber all the stars in our Galaxy, these dim objects are very difficult to detect and have garnered a reputation as failed stars, the veritable cinders of the Galaxy.

However, in recent years a number of these "failed stars" have been detected as extremely bright sources of radio emission, thousands of times brighter than expected. Observations at the VATT, coordinated by Richard Boyle, have played a crucial role in a recent large multiwavelength campaign

"Is Our Universe Just One of Billions?"

By Bill Stoeger, S. J.

There is much more to the universe than we see, or will ever be able to probe. But are there other observable universes or universe regions disconnected from ours? And are they similar to ours? Just as there are planets other than the Earth, trillions of stars other than the Sun, and hundreds of billions of galaxies other than the Milky Way, does that pattern continue with our universe itself? Are there billions or trillions of universes other than our Observable Universe? It seems that may be the case!

There are good reasons why we cannot dismiss this possibility. As just mentioned, there is strong evidence that our universe is much larger than the region we see, even with the most powerful instruments. Most of physical reality is inaccessible. Along with that is the realization that, in order to understand more about our universe, we must relate it to larger and more all-embracing systems. We simply cannot fully understand the universe, or ourselves, without situating ourselves relative to all that exists — God, the universe, and whatever the universe is part of. And so the quest for increased intelligibility continues!

Two recent scientific developments compel us to consider a large collection of universes, or universe domains, likely. First, from cosmological, physical and other basic scientific considerations, it appears that our universe has been "ne-tuned" for complexity and life. This has been often referred to as "the Anthropic Principle," though it is neither "anthropic" nor a "principle." If any one of a number of key parameters — e. g. the gravitational constant, which gives the strength of gravity — were just slightly different, then complex systems, and therefore life, would be impossible. There are lots of slightly altered conditions each of which might have prevented stars from forming. Without stars, there would be no elements heavier than lithium, and very little chemistry to work with! And no life!

With just slightly different physics, then, our universe could have been much different than it is. Other universes can be very different from one another — the vast majority of them completely sterile and boring — with just slightly different values of fundamental parameters. From a scientific point of view, then, we might best understand our fine-tuned universe as one of a large number of other related universes — a multiverse — which represent a range of possible universes. We would be in one of the few which allow for complexity and life — just as we are in orbit around one of the few of innumerable stars which are friendly to the emergence and flourishing of life. This does not fully explain fine-tuning. But it is an intermediate, partially satisfying scientific explanation!

The second surprise has been that we now have indirect, theoretical indications that "before the Big Bang" — before time and space emerged from the incredibly hot Planck era 13.7 billion years ago — any process which would have generated our universe, would have automatically generated lots of others. It's very difficult — if not impossible — to generate just one universe domain, just as it is difficult, if not impossible, to form just one planet, one star, one galaxy. So the pattern does seem to continue!

Now, of course, none of this is in final or definitive form — no theory ever is! But it seems to provide a promising approach to explaining key features of our universe in its very early stages. But how would one ever validate the existence of a multiverse to which our observable universe belongs, if we shall never be able to detect other universes? Indirect evidence! If the best, most successful and most fruitful theory explaining and rendering our universe more intelligible has a large number of other universes as an essential element or an inevitable consequence, then we are scientifically justified in saying that those universes exist, even if shall never directly detect them. So, what makes such a theory successful and fruitful? If, over a long period of scientific development, it leads to key discoveries, unifies and deepens our understanding of nature, provides a foundation for other scientific advances, and is not falsified in any of it essential elements by observation and experiment, then it is both successful and fruitful. In that case we would have every reason to assert that our universe is just one of a multitude of universes having the qualities given by that theory. We could no longer say, perhaps, that we are unique, but certainly we would still be very special! ■

undertaken to investigate this anomalous radio emission. This campaign, which consisted of observations conducted simultaneously at the Vatican Observatory in Arizona, the Very Large Array (VLA) in New Mexico and the US Naval Observatory (USNO) in Flagstaff, Arizona, should shed light on the mechanism producing this radio emission and establish its association with the presence of magnetic spots on the surface of brown dwarfs."

Debris Disks in Main Sequence Binary Systems

For an investigation of debris disks in main sequence binary systems, using the Multiband Imaging Photometer for Spitzer onboard the Spitzer Space Telescope, Chris Corbally and colleagues have provided new MK spectral types and physical parameters for 62 systems. These data have been used to help model the dust disks around these systems. The calculated dust temperatures suggest that about half the excesses observed are derived from circumbinary planetesimal belts, while one third of the excesses clearly suggest circumstellar material. Three systems with excesses have dust in dynamically unstable regions. So these results strengthen the suggestion that asteroids (and by extension, rocky planets) should be present in binary star systems as well as singles.

Observations of Trans-Neptunian Objects:

The ongoing program of Guy Consolmagno and colleagues to observe KBO colors entered a new phase in 2006. They continue to use both the VATT and the Keck Telescope in Hawaii, the world's largest, to collect data on the BVI colors and rotation light curves for these objects; but in addition, time was acquired on the MMT, a 6.5 meter telescope south of Tucson, to take some of the first detailed visible spectra to determine the surface compositions of the largest of these objects: bodies which may qualify for the newly-defined category of "dwarf planet". At the MMT, the team obtained high signal precision optical reflectance spectra of the large KBOs (Kuiper Belt Objects) 2005 FY9 and 2003 EL61, and discovered that the spectrum of 2005 FY9 exhibits strong methane ice bands.

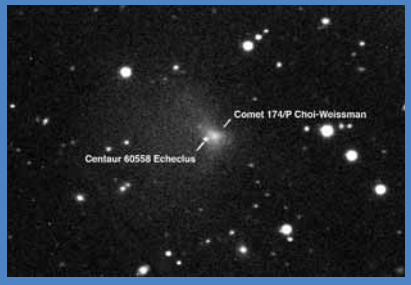
2007 UPCOMING VATICAN OBSERVATORY EVENTS

The Eleventh Vatican Observatory Summer School

The eleventh Vatican Observatory Summer School in Observational Astronomy and Astrophysics on Extrasolar Planets and Brown Dwarfs, will be held in Castel Gandolfo between 8th June and 6th July. Dante Minniti (Pontifcia Universidad Católica, Santiago, Chile) serves as Chair for the academic program.

Formation and Evolution of Galaxy Disks Conference

José Funes, S.J. with the help of his colleagues is organizing an international conference, sponsored by the Vatican Observatory, on the formation and evolution of galaxy disks in Rome on 1-5 October 2007. The topics of these conference are: properties of nearby galaxy disks; star formation laws, chemical evolution; outskirts and environment, disk edges; accretion onto disks, mergers; secular evolution of disks; evolution of disk structural properties; disk formation in a hierarchical Universe.



Centaur 60558 Echeclus looked like it was sporting a coma in this image taken at the VATT. Further investigation, however, fingered a comet that just happened to be nearby: a once-every-1600-years coincidence.

A comprehensive listing of Observatory events can be read in the 2006 Vatican Observatory Annual Report. ■

UP IN THE SKY... IT IS A METEOROID!

John-Baptiste Kikwaya S.J.

Introduction

If there has been late heavy bombardment in the past explaining the presence of craters on Moon and by inference on Earth, Mercury, Venus and Mars, the meteor events didn't stop there. They still occur, although certainly not at the same rate and with the same mass influx as at the hypothetical late heavy bombardment. They are of different sizes suggesting that they come from different areas of the solar system and they deliver onto the Earth different chemical and organic materials. In order to link them to their parent bodies and to their chemical history, it is important to know and study their density.

Some Definitions

We start with meteoroid, which we define as a piece of stony or metallic debris that travels in outer space. A meteoroid revolves around the Sun just like any planet, asteroid or comet does. Meteoroids can enter the Earth's atmosphere, be heated by friction, and for a few seconds, streak across the sky as a meteor with a glowing trail. A brilliant meteor, called a fireball (bolide) is a meteor that may weigh many kilograms. Some bolides are large enough to survive (at least partially) their trip through the atmosphere and impact the ground as meteorites. Interplanetary Dust Particles (IDPs) are another category of meteors. Ranged between 10 and 35 micrometers, they don't ablate, but are nevertheless decelerated by the air molecules. They are collected from the Earth's stratosphere at an altitude of about 20 kilometers.

Meteor Events

On October 9th, 1992, a bolide entered the Earth's atmosphere and landed at Peekskill Park in New York. During its flight, it was observed at many places, particularly at Olmsted Falls in Ohio, in Fairfax in Virginia and in Maryland. In 1996, in Texas at El Paso on October 3rd, a bolide was recorded. Again on October 9th, 1997, another bolide occurred in the atmosphere above El Paso. We can also mention the 150-ton space rock that plunged into the Earth's atmosphere over Tagish Lake (Canada). When observing the images of the1se 4 bolides, we notice that they don't behave in the same way in the atmosphere. Some seem to have more wake than others, cover more sky than others. This suggests that they may have different compositions and therefore are coming from different parent bodies.

There are small meteoroids as well which are believed to be grain aggregates with low bulk density, high porosity and low cohesivity. A volatile matrix holds the grains together. In total, meteor events that strike into the Earth's atmosphere deliver about 30,000 tons of dust each year

Density of Optical Meteoroids

For determining the density of optical meteoroids, we use the single body theory against the quasi-fragmentation theory. Single body theory requires particularly the deceleration of the meteoroid and its photometric mass. The astrometric technique is used on the meteoroid image captured by two different cameras set at two different sites to determine the meteor's velocity and deceleration. And the photometry produces the light curve of the meteoroid, which can be used to determine its photometric mass.

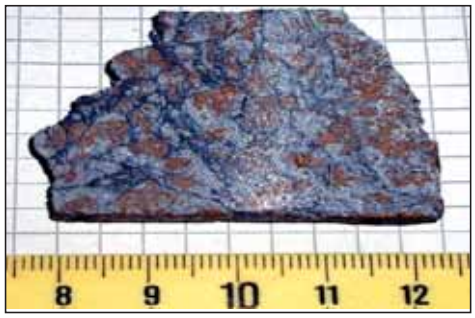
Conclusion

Meteor events, a part of our solar system history since the formation of the planets, continue to occur and they are of different sizes going from tens of micrometers (IDPs) to tens of meters (Bolides). About 30,000 tons/year of dust accretes onto to the Earth. Here are pictures of recent meteor events. ■

SCIENCE QUIZ: What is the difference between a meteoroid, meteor and meteorite?

A meteoroid is when it is flying around in space; meteor is when it is streaking through the sky and a meteorite is when it has hit the ground!

Peekskill bolide at Olmsted Falls, Ohio on October 9th, 1992

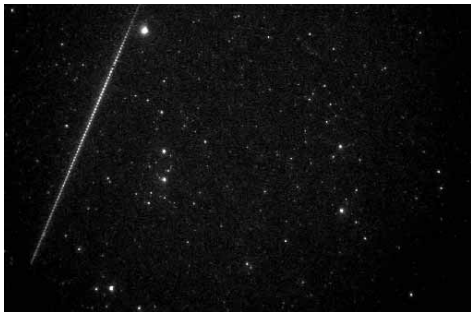


Peekskill Vatican meteorite produced by Peekskill bolide October 9th, 1992 (Picture from Guy Consolmagno)

Peekskill bolide in Maryland on October 9th, 1992

El Paso, Texas on October 3rd, 1996 at 8:00 p.m. (local time)

El Paso, Texas on October 9th, 1997 at 12:47 p.m. (local time)



Meteor captured with gated camera at Elfinfield London Ontario on April 9th, 2005 at 9:12:34 UT

Announcing the 2008 Vatican Observatory Calendar

Colorful wall calendar that makes an ideal gift for friends, family and business associates this year!

Featuring 14 four color images of planets, nebulas, galaxies and other celestial wonders.

Includes dates of significant astronomical observances and religious holidays.

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