THE THREE GALILEOS:
THE MAN, THE SPACECRAFT, THE TELESCOPE

The Three Galileos

by Greg Mort

December 1996

Watercolor, image size: 39 cm x 48 cm

The painting is inspired by the discoveries Galileo made in Padova, which include the satellites of Jupiter, the craters and mountains on the Moon, the phases of Venus, the rings of Saturn, and the star composition of the Milky Way. These discoveries are represented in the painting along with the Copernican System, which he supported and verified through his findings. I choose to portray them as carvings in a stone wall reminiscent of the carving on the walls of the Palazzo del Bo at the University of Padova.

The pillars used to frame the image are crowned with the symbol of Galileo's family. One pillar stands for Science and the other for Knowledge, which open up our window to the Universe and the future.

I decided to show the figure of Galileo as a shadow against the stone-carved wall with the Galileo Spacecraft to his left and the Telescopio Nazionale Galileo to his right. I felt it important to realize that we all stand in this great man's shadow, as one of the true founders of the Scientific Method. The one blank panel behind Galileo represents the discoveries yet to come.

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THE THREE GALILEOS: THE MAN, THE SPACECRAFT, THE TELESCOPE

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held in Padova, Italy
on January 7–10, 1997

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INTRODUCTION

The idea of having a conference in Padova describing the results obtained by the Galileo spacecraft and the characteristics of the Telescopio Nazionale Galileo began in 1995, when a number of colleagues from both sides of the Atlantic began exchanging suggestions and ideas. Looking at the schedules of the two teams, it was clear that the beginning of January 1997 would be a good time to hold the conference; these dates also luckily coincided with the dates of the memorable discovery of the Medicean moons of Jupiter by Galileo Galilei in Padova in 1610. To emphasize these three elements, the name of the conference was then proposed and accepted by the involved parties: NASA and JPL in the United States, the German space agency DARA, the University of Padova, and the Astronomical Observatory in Padova.

I wish to recall a few key dates: In January 1610, Galileo--from his house in Padova--had the first hint of three and then four stars connected to Jupiter. In December 1995, the probe released from the spacecraft entered the atmosphere of Jupiter, and the spacecraft entered orbit about Jupiter. These extraordinary events were followed at JPL by a number of representatives of many institutions and space agencies. In June 1996, the Telescopio Nazionale Galileo was inaugurated by the King of Spain Juan Carlos I, in the presence of Prof. Luigi Berlinguer, Minister of University and Science. These ceremonies occurred as the spacecraft started touring the moon Europa. The conference was designed to describe these three aspects: the man, the spacecraft, and the telescope. The coordination between space and ground observations was also included. A number of interesting topics were also presented in poster form. Representatives of many of the world's space agencies participated in a round-table discussion about the scientific reasons and perspectives of the exploration of the Solar System. Regrettably, the diversity of these presentation materials did not lend themselves to a more formal presentation here.

During the preparation of the conference, several members of the scientific committee and several speakers expressed their desire to present the results of the conference to Pope John Paul II. Their desire was made known to the Holy Father by the Director of the Vatican Astronomical Observatory, Dr. George Coyne, a distinguished *laureato honoris causa* of our University in 1992. The members of the Honorary and Scientific committees, the speakers, and the organizers thus were invited to a private audience at the Vatican on January 11. Dr. Coyne also arranged a magnificent tour of the Vatican Observatory at Castel Gandolfo following the audience.

Several social events were held to help participants to enjoy Padova. It is my great pleasure to thank our speaker Dr. Les Deustch and the Rector of Saint Anthony's Cathedral, Father Olindo Baldassa, for the organ concert the evening of the 8th. The Chamber of Commerce made possible the Galileian dinner the night of the 9th. The Town of Padova helped organize the scientific exhibition "Voyage to the Cosmos" at the Palazzo della Ragione. Following a special preview for the participants on January 10, the exhibit enjoyed a successful run from January 25 - July 6. I gratefully acknowledge also the contributions by the Regione Veneto and by the Provincia di Padova, and by several other institutions and private organisations.

Two gifts were presented to the Rector of the University of Padova. The first is a copy of a letter by Galileo owned by the Special Collections Library of the University of Michigan (USA) in Ann Arbor. The importance of this letter has been recognized, for example, in a publication by the distinguished Galileian historian Stillman Drake. Thanks to the efforts of our speaker Prof. Sushil Atreya, the letter has been reproduced as faithfully as possible on a special paper for our University. The second is a watercolour, "The Three Galileos," painted by the great contemporary American painter Greg Mort. On the invitation of Prof. Francesco Bertola, Mr. Mort visited our University just before Christmas, and was inspired by the Galileian memories to paint the watercolour in a very short time.

Jürgen Rahe, in memoriam, June 1997

Five months after the conference, we were stunned and saddened at the tragic loss of Dr. Jürgen Rahe, science program director for NASA's Office of Space Science. The space science community around the world will greatly miss his guidance as many of the projects started under his direction come to fruition and planning continues for future efforts. In tribute to his memory, we dedicate these proceedings to him.

Prof. Cesare Barbieri
*Dipartimento di Astronomia,
 Università di Padova, Italy
 June 1997*

PRESENTATION TO POPE JOHN PAUL II

Cesare Barbieri, Dipartimento di Astronomia, Università di Padova

Holy Father, in November 1986 a large group of scientists from many countries presented to you the beautiful results obtained by a series of spacecraft directed to comet Halley. I still remember in his address to you how Professor Roald Sagdeev compared those spacecraft to modern Magi following the path of the comet, in the same way depicted by Giotto in the Scrovegni chapel. We return to you today, a few days after the Epiphany, to propose to you some of the topics we have discussed during this past week at the University of Padova during the conference, "The Three Galileos: the Man, the Spacecraft, the Telescope."

The conference has been jointly organized by the University and Astronomical Observatory of Padova, by the American space agency NASA and JPL, and by the German space agency DARA. Three themes were discussed:

- the figure of Galileo Galilei both as a scientist and as an inhabitant of Padova in that remarkable period of history when from his home he first observed the Medicean moons of Jupiter in January 1610.
- the main characteristics of the Galileo spacecraft and the results obtained so far. The beautiful images of our own Earth and Moon, of the two asteroids that the spacecraft visited on its way to Jupiter, of the Medicean moons, would alone completely justify such an ambitious enterprise. But this space mission has achieved many other fundamental, and in some cases unexpected, results about the chemistry of Jupiter's atmosphere, the surface of its moons, the electric and magnetic fields, and the particles environment. With such missions as this one, the past one to comet Halley and the imminent Cassini spacecraft to Saturn, we have come to be directly present through our instruments in a large part of the solar system, with the novel capability of analyzing the matter in addition to the traditional observations using light and other electromagnetic waves. This new possibility fosters in turn a great change in the body of scientists interested in the extraterrestrial universe; astronomers are joined by an ever growing number of geologists, chemists, biologists, a richness of different competencies, attitudes, and methodologies that in my opinion will profoundly affect how and why the heavens will be studied in the forthcoming millennium. The entire solar system will truly become a

home for mankind, given for us to understand its mechanisms of formation and evolution, in the framework of the more general comprehension of the stars and interstellar medium and of the entire Universe.

- the Telescopio Nazionale Galileo, the first telescope built for the entire community of Italian astronomers, has been erected on the Roque de los Muchachos in the Canary Islands, one of the best sites for observing in the northern hemisphere. As with other modern telescopes it employs new technologies to exploit the advantages of observing from the Earth as compared to space. These include active control and ways to minimize the deleterious effects of the Earth's atmosphere. I wish to recall that the Vatican Observatory has already employed many of these techniques in the Vatican Advanced Technology Telescope in Arizona. We are just beginning with the new Italian telescope and we are looking forward to the first scientific results from it.

More than one hundred scientists and historians from Europe and the United States have gathered in Padova in a spirit of international coordination and cooperation between the humanities and science to discuss those three themes. In a round table discussion this unifying view was also extended to cover the search for extrasolar planets. Over the past few years, evidence continues to grow for the existence of planets around other stars. The new generation of telescopes on the ground and future space mission will not only contribute to this body of evidence, but will also seek to obtain images of these planets, so as to compare their characteristics with those of Jupiter, of Saturn, and of the Earth. In this way the perennial quest of humans to understand ourselves in the universe, a quest forever associated with the name of Galileo, will be pursued by direct investigations.

Holy Father, in conclusion, allow me to thank you for having constantly stimulated us scientists and historians to reevaluate our knowledge and to rethink our methods and perspectives in order to reach even further into our understanding of the universe.

AN AUDIENCE WITH POPE JOHN PAUL II
VATICAN CITY, ITALY
JANUARY 11, 1997
“THE THREE GALILEOS” CONFERENCE PARTICIPANTS

Ladies and Gentlemen,

1. I am pleased to welcome the distinguished participants in the International Conference on Space Research which has just concluded its meeting at the University of Padova on the theme “The Three Galileos: The Man, the Spacecraft, the Telescope”. You have concentrated your attention on recent scientific results from the spacecraft Galileo and on your expectations of future findings both from the Italian National Telescope, also named for Galileo and inaugurated just eight months ago at a site in the Canary Islands. I congratulate the scientists from the Jet Propulsion Laboratory and the National Aeronautics and Space Administration whose achievements have been solemnly recognized by the University of Padova, where the great physicist himself spent many fruitful years.

2. The spacecraft Galileo and the Italian National Telescope are both making significant contributions to the formation of a more comprehensive vision of the universe. Building on well-established experimental results, you and others around the world are perfecting a model which traces the whole evolution of the universe from an infinitesimal instant after the starting point of time up to the present, and beyond, into the distant future. As never before man’s gaze is open to the wonders of the universe. And the marvel of it all is a constant call to ponder ever more seriously the greatness of man’s own destiny and his dependence upon the creator. Thus, while we stand in awe before the vastness of the cosmos and the dynamism which pervades it, our hearts echo with certain fascinating and fundamental questions which continue to challenge humanity at the dawn of the new millennium.

3. The participation of the Vatican Observatory in your work is a practical sign of the Church’s appreciation of the particular genius, objectivity, self-discipline and respect for truth which scientists bring to the exploration of the universe. Your dedication to scientific research constitutes a veritable vocation at the service of the human family, a vocation which the Church greatly honours and esteems. That vocation is all the more fruitful when it helps us to acknowledge the link between the beauty and order of the universe and the dignity of the human person—reflections of the creative majesty of God. The more men and women of science engage in rigorous research to penetrate the laws of the universe, the more insistent becomes the

question of meaning and purpose, the more pressing the demand for contemplative reflection which cannot help but lead to a profound appreciation of the sense of man's transcendence over the world, and of God over man. (cf. Address at UNESCO, 2 June 1980, n. 22)

Through you, who have kindly wished to share the deliberations of your Conference with me, I address an appeal to all your colleagues in the various fields of scientific investigation: Make every effort to respect the primacy of ethics in your work; always be concerned with the moral implications of your methods and your discoveries. It is my prayer that scientists will never forget that the cause of humanity is authentically served only if knowledge is joined to conscience.

4. Ladies and Gentlemen; in concluding these brief remarks I confide to you my hope that the research which brings you so close to the marvelous mysteries of the universe will enkindle in you an ever deeper appreciation of God's power and wisdom. May your discoveries contribute to the building of a society ever more respectful of all that is truly human. May the Lord of heaven and earth bless you all abundantly!

Pope John Paul II

THE THREE GALILEOS

Lex^{mo} Prince.

Galileo Galilei Humiliss.^o Servo della Ser.^a V.^a inuigilan.
do assiduamente, et da ogni spirito di potere non solam. satisfare
alcun che viene della Lettera di Mathematici nello stu-
dio di Padova,

Sto di Lavona,
 Scrivere d'auere determinato di presentare al Ser^{mo} Principe
 l'Ordinale et di prendere di giuramento inestirabile per ogni
 negozio et impresa marittima o terrestre stimo di tenere qual-
 che nuovo artificio nel maggior segreto et solap a disposizione
 di V. Ser^a. L'Ordinale cavato dalle più ricche speculazioni di
 prospettiva ha il vantaggio di scoprire Legni et Vele dell'inimico
 per due hore et più di tempo prima che egli sia sopra noi et distinguendo
 il numero et la qualità de i vasselli giudicare la sue forze
 pallesiarsi alla caccia al combattimento o alla fuga, o pure ancor
 nella campagna aperta vedere et particolarmente distinguere ogni suo
 moto et preparatione.

Adi 7. di Giovanni
Giorno si uolde uti
Adi 8 uti
Adi 12. si uolde in tale costituzione
Adi 13. si uolde in minima: e a Giorno 4 Stelle
Adi 14 è regulo
Adi 15 la prossi^a a 7^a era la min^a la 4^a era di
stante dalla 3^a il doppio l'altra
Lo spazio delle 3 occidentali no era
maggiore del diametro di 7^a et e z
vano in linea retta.

Translation of Galileo's letter to the Prince of Venice:

"Most serene prince, Galileo Galilei most humbly prostrates himself before your highness, watching carefully, and with all spirit of willingness, not only to satisfy what concerns the reading of mathematics in the study of Padova, but to write of having decided to present to your highness a telescope ("occhiale") that will be a great help in maritime and land enterprises. I assure you I shall keep this new invention a great secret and show it only to your highness. The telescope was made for the most accurate study of distances. This telescope has the advantage of discovering the ships of the enemy two hours before they can be seen with the natural vision and to distinguish the number and quality of the ships and to judge their strength and be ready to chase them, to fight them, or to flee from them; or, in the open country, to see all details and to distinguish every movement and preparation."

Beneath the letter are diagrams and notes explaining the position of Jupiter's moons on several nights.

On the 7th of January
Jupiter is seen thus

On the 8th thus

it was therefore direct and not retrograde

On the 12th day it is seen in this arrangement

The 13th are seen very close to Jupiter 4 stars

or better so

On the 14th it is cloudy

The 15th

the nearest to Jupiter was smallest the 4th was distant from the 3rd about double.

The spacing of the 3 to the west was no greater than the diameter of Jupiter and they were in a straight line.

J long. $71^{\circ}38'$ lat. $1^{\circ}13'$