

# The Legacies of Galileo

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## 1. Introduction

The scientific community is celebrating in 2009 the International Year of Astronomy. The timing coincides with the 400th anniversary of the first astronomical use of a telescope, when Galileo's observations demonstrated that the Earth is not alone in the Universe. One can hardly think of a more important event in the history of mankind.

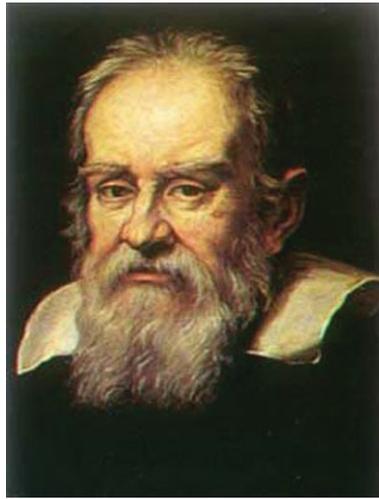


Figure 1. The poster announcing the open-house of the Arcetri Observatory in 2007 for children

In 2009 we also celebrate the 40th anniversary of the first human landing on the Moon and the 400th anniversary of Kepler's laws. For the occasion, I was asked, several months ago, by the IAU General Secretary to give a Discourse about Galileo during our Assembly in Rio. I am honoured by the request but I am also very concerned, since I am not an historian of Science. The only justification for my talk could be that I have had the fortune of working for about 30 years at the Arcetri Observatory, just outside Florence. This Observatory was erected in 1872 as a memorial to Galileo, in a location where the natural beauty combines with the importance of the historical heritage.

## 2. The Astronomical Discoveries of Galileo

It is generally agreed that Galileo did not invent the telescope. Similar instruments had existed for some time. Some of them had been used for astronomical viewing but the quality of the lenses was poor and did not lead to significant results. Galileo set for



**Figure 2.** Galileo Galilei



**Figure 3.** A view of Arcetri Observatory

himself the goal of constructing better lenses and using them for building an instrument at the cutting edge of technology.

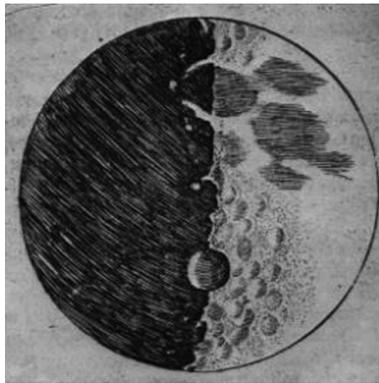
Indeed, one of the most important legacies of Galileo is the connection of technological progress with the advancement in pure knowledge. Scientific progress in astronomy and in other areas of science has always been dependent on this connection. Over the centuries, the big steps in science (astronomy in particular) have generally been associated with innovative instrumentation. Perhaps the efforts made by Galileo to obtain a sharp view of the lunar surface can be considered the equivalent of modern advances in interferometry and adaptive optics.

When Galileo turned his telescope towards the sky, he realized that the moon is another world, with mountains, craters, plains. The similitude between lunar and terrestrial features suggests that the Earth and the Moon are made of similar materials. However, it took a long time (centuries) for astronomers to establish the identity of cosmic matter and physical laws across the whole Universe. This has been one of the main achievements of modern astrophysics.

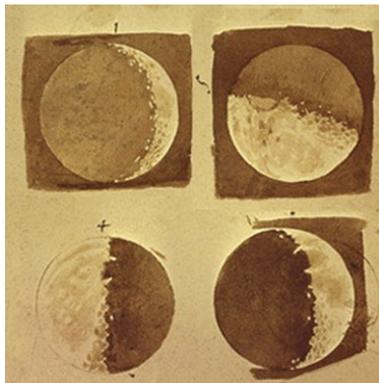
Following the observations of the Moon (Winter 1609), Galileo made a series of additional discoveries which can be listed as follows: In both cases the observations provided support for the Copernican view of the Planetary System.



**Figure 4.** Galileo's telescope



**Figure 5.** Half Moon as observed by Galileo



**Figure 6.** Phases of the Moon as observed by Galileo

Observations showed that Saturn had an elongated shape, indicating the presence of external material, the famous rings.

He saw that the number of stars visible with a telescope exceeds by far those visible with the naked eye. In addition, the Milky Way can be resolved into a very large number of stars, too many and too distant for seeing them individually with the naked eye.

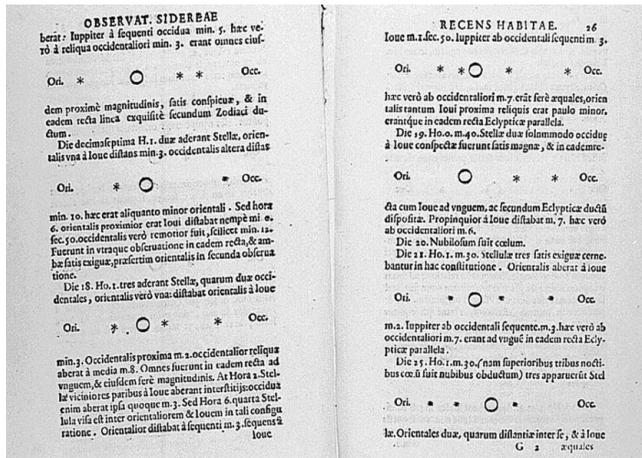


Figure 7. The 4 main satellites of Jupiter(January 1610)

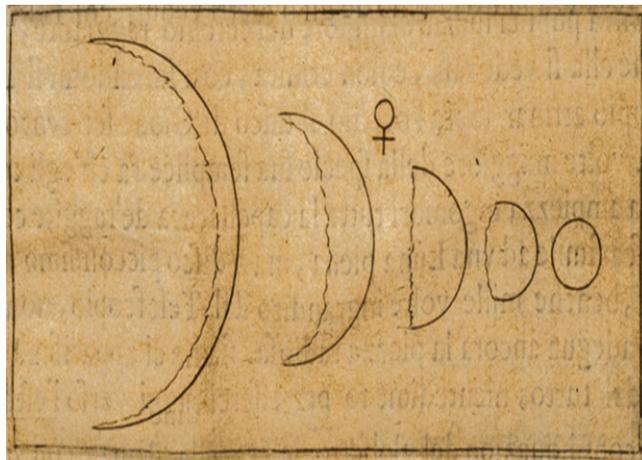


Figure 8. The phases of the planet Venus(October 1610)



Figure 9. Saturn with its rings (July 1610)

The first results of Galileo’s observations, made over a few months during the winter 1609-1610 were published in early 1610 in the Sidereus Nuncius. We can note that, at that time, the speed of publication was certainly much faster than at present!

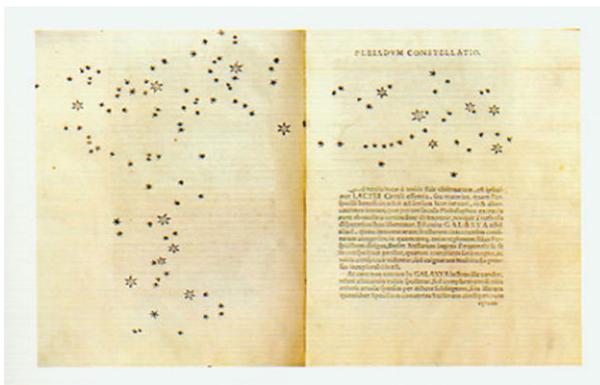


Figure 10. The Milky Way observed as individual stars

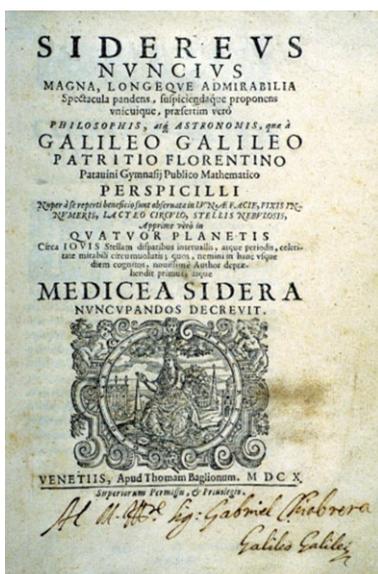


Figure 11. Sidereus Nuncius

### 3. Galileo in Arcetri

Galileo spent the last part of his life in Arcetri (1631 until 1642) in the Villa Gioiello. At that time he had already revolutionized astronomy, thanks to the observations carried out in Padova and Venice around 1610.

“Il Gioiello” was the typical residence of a land owner, overlooking a landscape rich of olive trees, vineyards, fruits. Roughly 400 years later, from the Observatory, we can admire a huge old oak tree and we can imagine Galileo resting under the shadow of this tree after a walk in the fields.

Galileo rented Il Gioiello in 1631, following a suggestion of his daughter Suor Maria Celeste who was a nun in a convent nearby. The signature of the rental contract took place in September 1631. The contract describes the details of the Villa which are nearly identical to those which one can presently find in the property.

When moving inside the Villa it is hard to resist a strong emotional feeling. Unfortunately, Galileo was not able to enjoy for a long time the quiet of Arcetri and the pleasure of being very close to his daughter. Indeed, in 1633, he was tried by the Church because



**Figure 12.** “Il Gioiello”



**Figure 13.** The Entrance



**Figure 14.** The internal Courtyard – now

he had published one of his fundamental works “Dialogo dei massimi sistemi”. The Church did not accept Galileo’s arguments and ordered that his work be included in the list of forbidden books. From a general point of view it is not surprising that Galileo’s



**Figure 15.** The internal Courtyard – then



**Figure 16.** A view from the Observatory



**Figure 17.** Galileo's daughter, Suor Maria Celeste

discoveries led to conflicts with theology and philosophy: the Church could hardly tolerate such disagreements, roughly at the time of the Protestant Reformation.

However, because of his abjuration Galileo was spared the destiny of Giordano Bruno who, a few years earlier (January 1600), had been burned for heresy in a square of Rome



**Figure 18.** Galileo abjuration

(Campo dei Fiori). Bruno had supported the view that the Earth is not the center of the Universe and the existence of a multiplicity of worlds.

While in Arcetri, Galileo received important visitors such as the poet John Milton and his students Torricelli and Viviani. In 1638 he became blind and died in Arcetri on January 8, 1642.



**Figure 19.** Giordano Bruno in Campo dei Fiori in Rome

#### 4. Galileo and the Scientific Method

Though Galileo is famous especially for his astronomical discoveries, he is also generally recognized as one of the main founders of modern science. There are many examples which support this claim. The most important is probably his rejection of the principle of authority (“ipse dixit”) and the adoption of the experimental method. In many occasions Galileo stressed the importance of simplified experiments, evidencing the basic aspects of a physical phenomenon, clarifying the details. Some of his results involve what we call “conceptual experiments” (gedanken experiment). In addition to the famous discussion about the motion of a body falling inside a ship, another “conceptual experiment” was the attempt to measure the speed of light. Unfortunately light moves too fast and Galileo did not have the technology necessary to measure its speed.

On the occasion of the Year of Astronomy, the Arcetri Observatory, in collaboration with the Museum for the History of Science (both in Florence), reinvestigated the properties of Galileo's telescopes and evaluated their performance with modern techniques. Francesco Palla and his colleagues at the Arcetri Observatory have used the Sidereus Nuncius as a sort of guide for the observations. This has made it possible to compare modern observations with Galileo's drawings. The agreement is very good. It is impressive to look at a portion of the sky and to find the same stars which were catalogued by the great scientist. Furthermore, the image of Saturn clearly shows the elongated nature due to the presence of the rings.



**Figure 20.** The Historical Arcetri Telescope “Amici”



**Figure 21.** Saturn view with a Galileoscope

## 5. Conclusions

The life of Galileo was marked by many dramatic events, generally related to conflicts with the Church. There can be no doubt that the discoveries of Galileo are a milestone in the cultural history of mankind, one of the most important legacies, at the border between Science, Philosophy, Religion. In addition, Galileo was well aware of the importance of science in society.

He stated clearly that scientists should write in the common language of the people, rather than in Latin, because everybody should be informed and understand the new discoveries. This attitude is fundamental even in today's world, in a society dominated by Science and Technology. In many countries, especially in Italy, the Church was able to keep some control over the development of science. In other countries, Galileo's discoveries had a broader impact. One can perhaps argue that Galileo's discoveries also opened the way to science fiction and to more exchanges between art and science.

Several famous paintings (such as the one by Creti) were inspired by astronomy.



**Figure 22.** Jupiter in a painting by Creti

An alternative example is Paul Fontanelle who, in France, published an amusing dialogue narrating the speculations of a Philosopher with a young, pretty Lady, engaged in a variety of discussions about the possibility of extraterrestrial life.

Some years ago, the National Academy of Science of the United States stated that, at the present epoch, the number and the importance of astronomical discoveries nearly matches what happened at the time of Galileo.

The Year of Astronomy was conceived to give to the citizens of the world a special feeling for our science, following Seneca's statement *"If the stars were visible from just one place on Earth, people would never stop from travelling on that place in order to see them"*

Children are particularly fascinated by the sky. Unfortunately, in many parts of the world, stars are hidden by the light of the bombs falling from the sky. **Let's hope that the stars will soon be back.**



Figure 23. The poster announcing the open-house of the Arcetri Observatory in 2008 for children