

# Which satellite did Galileo miss?

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## 1 Introduction

On a cold winter night on 7th January, 1610, in the city of Padua, (40 kilometres west of Venice) Galileo pointed his newly made telescope at the planet Jupiter and observed that

“... three little stars, small but very bright, were near the planet ...”.

He captured the image (see Figure 1) in his notes to the Prince of Venice and then more formally announced it to the world in the *Siderius Nuncius*. As he

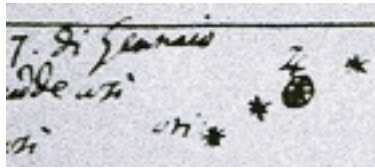


Figure 1: Galileo’s “three little stars”

continued his observations, it became apparent that Jupiter had four satellites and they were arguably the most important verification of the Copernican system by confirming that there were places in the universe, other than the earth, about which objects revolved.

The amusing fact always struck me that no-one seems to have asked an obvious question, namely

“Which of the Galilean satellites did Galileo not see on that first fateful night?”.

When I first considered this question (in about 1983) I had of course assumed that one of the satellites had either been eclipsed by Jupiter, was in transit, or was so close to that Galileo’s early instrument was unable to resolve it. Early calculations using Galileo’s own observations (to avoid the need to simulate the universe) suggested that Io was the missing one—however, this turned out not to be the case.

While the experts have long known the answer, the rest of us novices now have tools available to allow us to see a very good simulation of what Galileo

saw—and as a result answer the question for ourselves. One such tool is a spectacular piece of software called “Stellarium” which provides anyone with a planetarium with remarkably flexible control. (Another is “kstars” which runs under linux.) All one needs is the exact location in space-time of the observation. For Galileo’s observation a little research uncovers the data in Table 1. With

Location	Padua, Italy
longitude	11.8715 (east)
latitude	45.4003 (north)
altitude	12 metres
Date	7 January 1610
Time	First hour of the evening

Table 1: Galileo’s space-time coordinates

this data in hand one drives Stellarium backwards in time until the image shown in Figure 2 appears. In particular, it appears that Io and Europa were so close together that the resolving power of Galileo’s telescope was too weak to separate



Figure 2: Six pm, 7 January, 1610, Padua—Stellarium’s view

them. Thus, in fact all four satellites were visible. A remarkable side note, is that the planet Uranus (not discovered until 1781 by William Herschel) was actually in the vicinity and could have potentially been discovered by Galileo.

## 2 Confirmation

Could I really trust the answer that Stellarium was providing?

It was trivial to step through day by day and compare its view with the well documented subsequent observations that Galileo made on successive nights (see Figure 3).

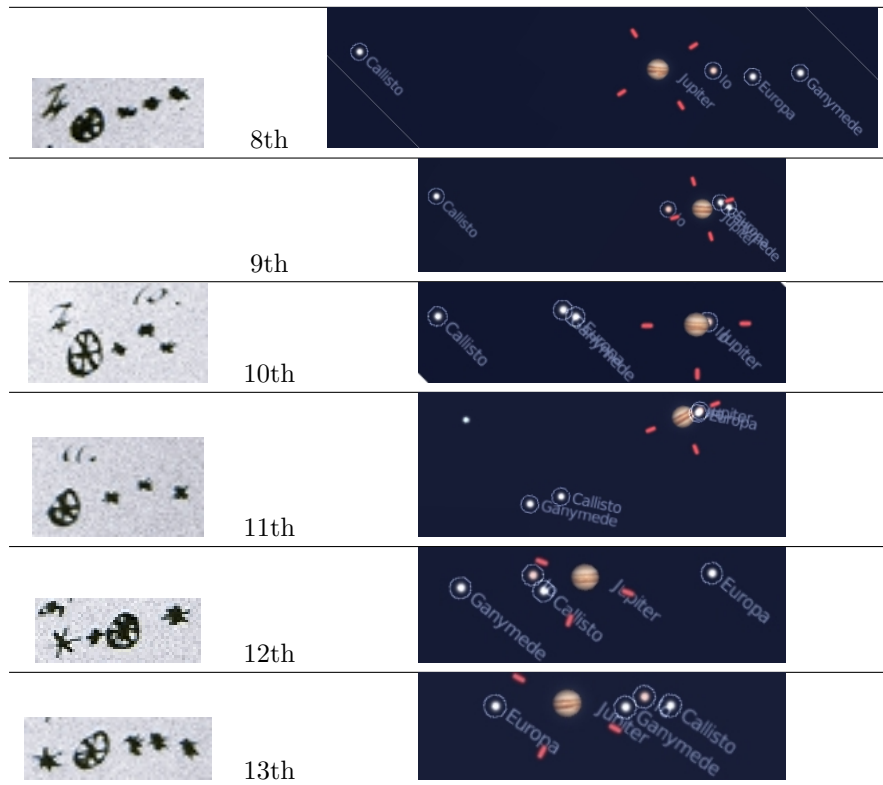


Figure 3: Subsequent nights

On the 8th Calisto was so far away from Jupiter that Galileo clearly did not associate the two objects—in fact he thought that the three little stars originally to the east<sup>1</sup> were the same ones as were now to the west.

On the 9th it was cloudy for Galileo—but of course we can see what he would have seen.

On the 10th and 11th it appears that Galileo swapped the roles of east and west and furthermore on the 11th that he mistook a star for one of the satellites. Then on the 12th and 13th one sees a very close correspondence—on the 13th of January, Galileo unambiguously sees all four of the Galileans.

<sup>1</sup>Note that east and west are opposite to what one might expect—the reversal is of course due to the lens.