

THE TIMING OF TROUVELOT'S OBSERVATIONS OF JUPITER



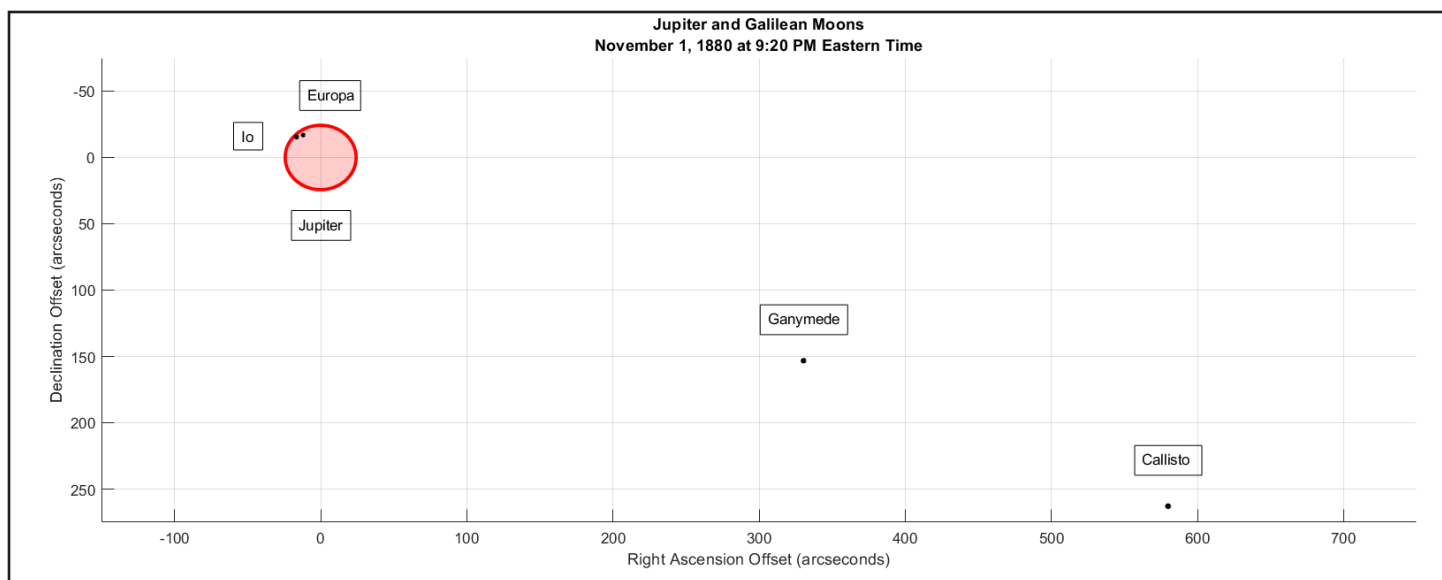
The Planet Jupiter: Observed November 1, 1880, at 9h. 30m. P.M. Credit: Étienne Léopold Trouvelot.

At Ladd Observatory we have a series of chromolithographs by the artist Étienne Léopold Trouvelot. A chromolithograph is a multi-colored print that was created from metal plates with an image of the original artwork engraved on them. The individual plates would then each have different colored inks applied. The inked plates were then pressed onto the same piece of paper, one after another. This forms a full color image.

The artist observed the planet Jupiter through a telescope at Harvard College Observatory, while sketching the details that he saw. He then returned to his studio to engrave his impression of the planet in metal plates. A printing company then reproduced them. Trouvelot's artwork was published by the Charles Scribner's Sons company of New York in 1881. The first detailed photographs of planets did not occur until about 5 years after Trouvelot's prints were published.

His Planet Jupiter print shows the planet with two moons in front of it. The disks of the moons, illuminated by the Sun, are depicted as white circles. The moons cast shadows onto the clouds of the planet. The shadows are the black circles to the right of each moon. The shadows are the locations on the clouds where a solar eclipse is occurring. One of the shadows is on an oval shaped storm called the Great Red Spot. To the human eye it appears salmon colored.

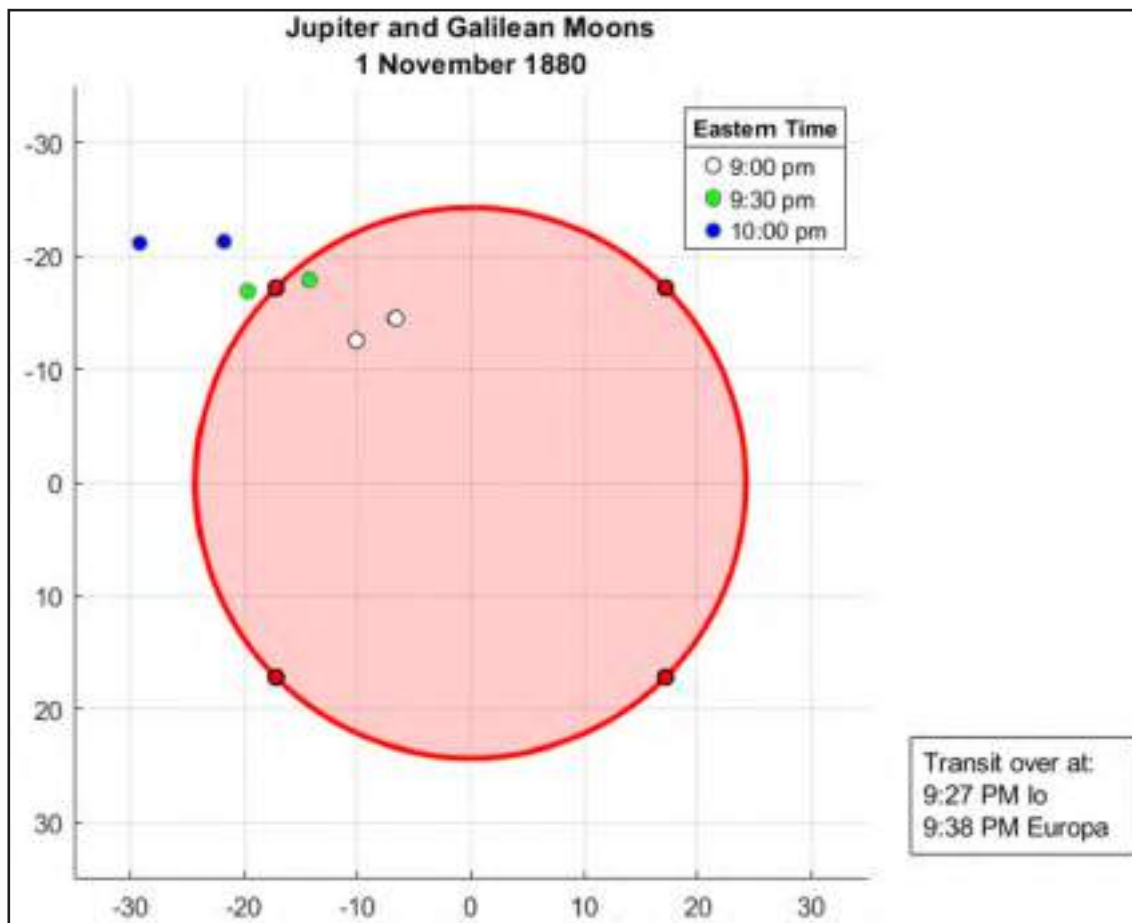
The moon at lower left is called Io. To the upper right is Europa. The other two moons, also discovered by Galileo, are named Ganymede and Callisto. The latter two moons are not shown in the print because they would have been far to the right of Jupiter, outside the field of view. The image in the print is rotated slightly compared to a modern diagram. The artist chose to render the planet with the moons at the left edge, instead of somewhat to the upper left. He depicted the equator of the planet as slightly tilted, down to the left.



The position of Jupiter's four largest moons at the time of the 1880 observations.

The caption on the print states that he observed Jupiter and the moons on November 1st, 1880 at 9:30 PM. I've been looking at this print for many years, but only recently decided to identify which moons are depicted in the print after a visitor to Ladd asked me the question. The available apps that show the positions of the moons only calculate where they were after 1900, before Trouvelot's observations. When I calculated the positions using a NASA website for the date and time in the caption, it didn't quite match the po-

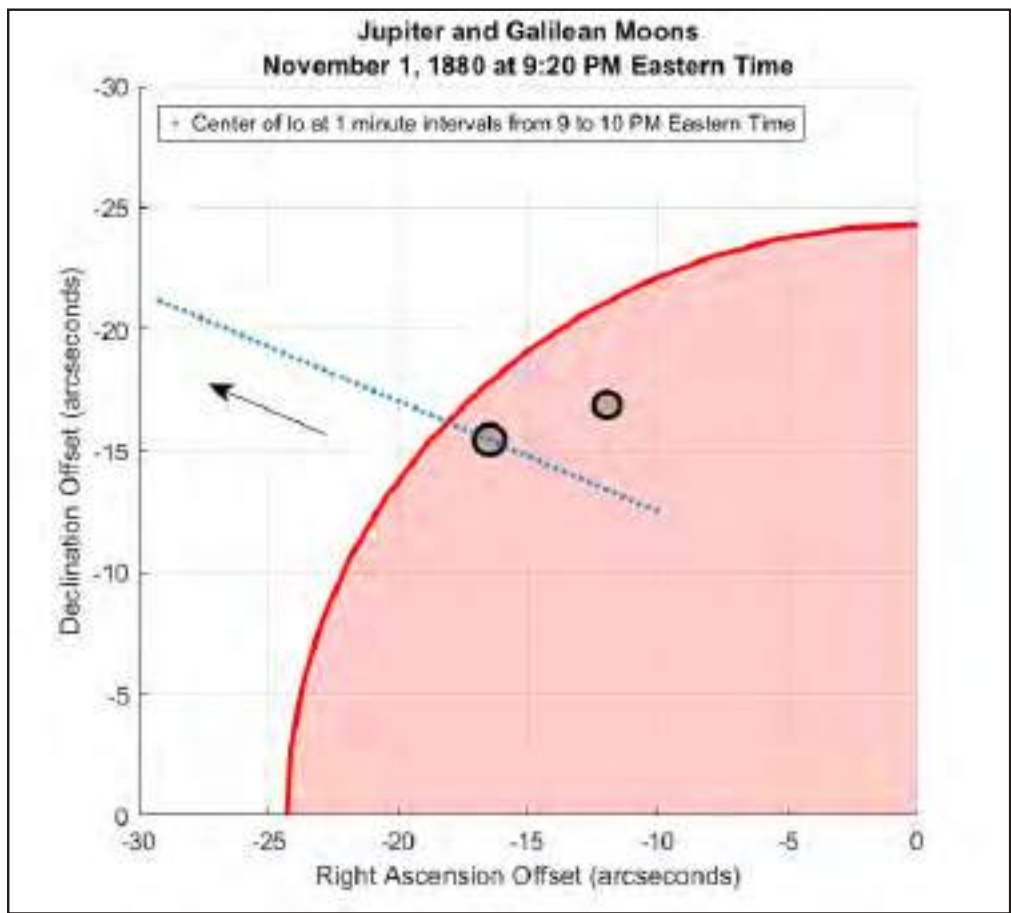
sitions shown in the print. The time that did match the positions in the print was 9:20 PM. Io would have moved off the disk of the planet at about 9:27 PM. (These are the times that the images of the moons arrive at Earth. It takes about a half hour for the reflected light to travel from the planet to an Earthly observer.)



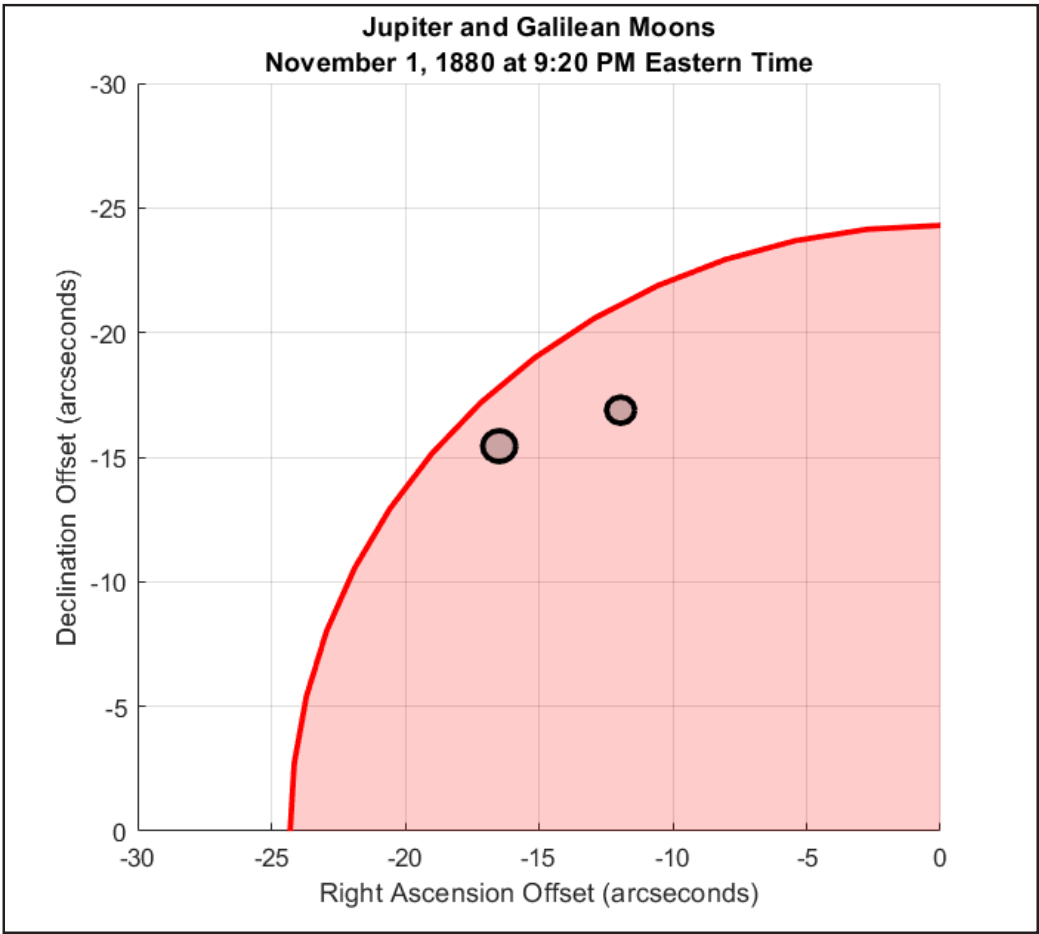
The position of the two moons at half-hour intervals. (The four solid red dots were used for alignment.)

The moons of Jupiter are orbiting the planet. They move significantly in a relatively short period of time. After Trouvelot's observations the two moons would have moved to the upper left. For example, first the moon Io would have appeared off the left of the edge of the planet. Its shadow would still have been on the disk of Jupiter. Later, the shadow would also have moved off the disk. The light from the Sun would have originated somewhat to the back left of the observer, causing the shadows to appear to the right of each moon. The exact position of the moons, relative to the planet, can be used as a "virtual clock" to verify the exact time the observations were made.

I found it curious that the time in the caption was ten minutes later than when Io was at the position shown. It should have been slightly off the edge of the disk of the planet at the time described. It is unlikely that the clock was set incorrectly at an observatory that provided a precision time keeping service. The timepieces at Harvard were among the most accurate in the world. The astronomers would have proof-read the caption to ensure that the time was close to their calibrated clocks.



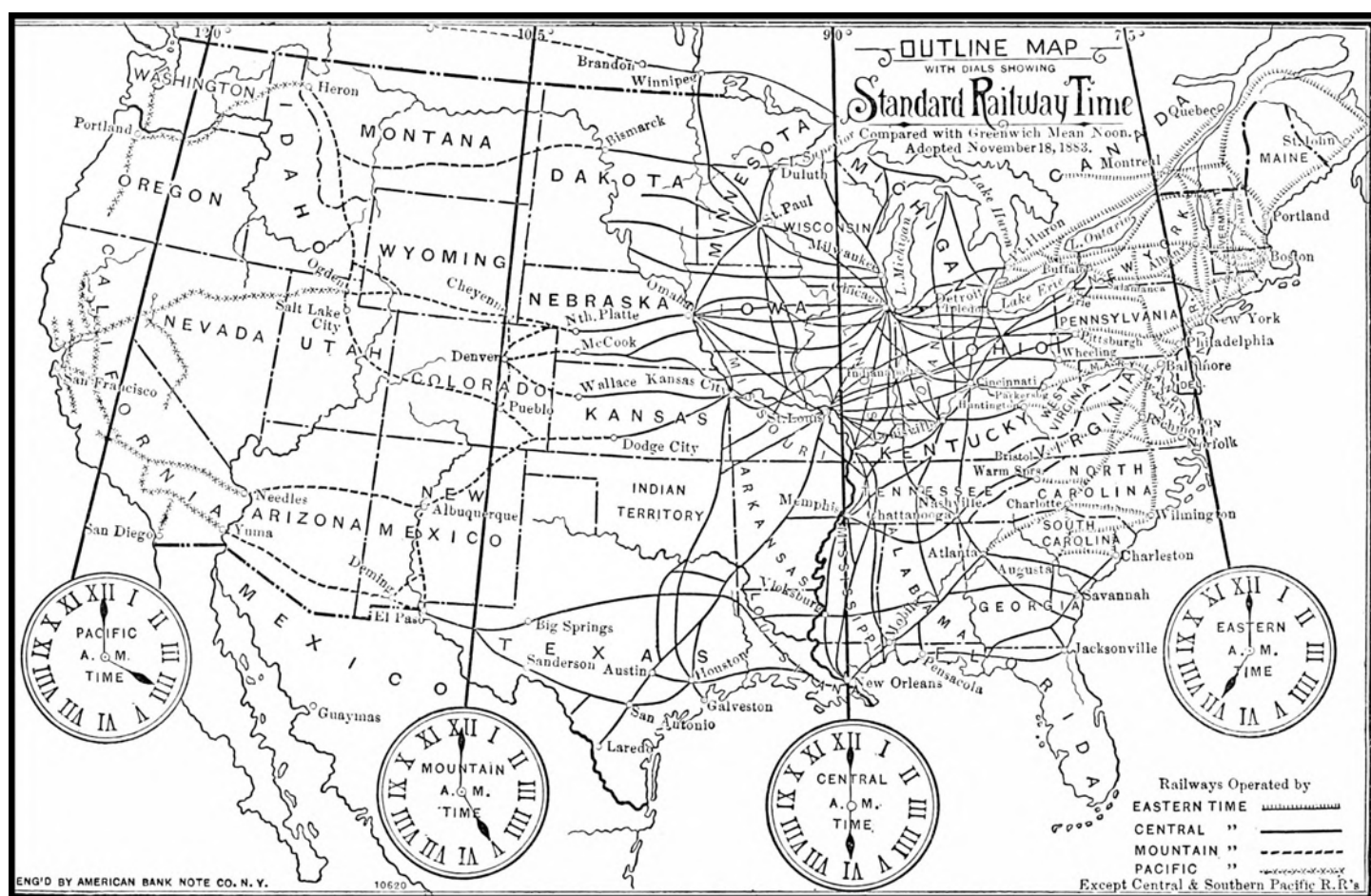
The motion of Io during one hour.



The position of the two moons, ten minutes before the time given in the caption.

It then occurred to me that the NASA calculations are based on our modern definition of time. The time zones that we are familiar with today were standardized in 1883. Before this date each city would have set their clocks to a slightly different time. This is because the Sun reaches noon in an eastern city like Boston first. About one minute later it is then noon in Providence, slightly to the west of Harvard. This is called local mean solar time. It is similar to what a sundial would show.

The differences in clock time caused confusion for travelers who took a train from one city to another. They would have to adjust their pocket watches to the time standard in the city they were visiting. It also caused great difficulties in safely operating the trains, sometimes leading to train crashes. The solution was to create standard time zones. All cities on the east coast were then set to the time that a place 75 degrees of longitude west of the Royal Observatory at Greenwich in England would have used. A place near Philadelphia, for example.



A railway map showing the adoption of time zones in 1883. Credit: Popular Science Monthly, 1884 - 1885.

Just three years after Trouvelot made these observations the clocks at the observatory would have been set to a time zone that was earlier than Harvard standard time. A time zone that is close to the one that we use today. — *Michael L. Umbricht*

(The diagrams in this article were created by the author. The data used to plot the positions of the moons is courtesy of the NASA Jet Propulsion Laboratory Solar System Dynamics group at the California Institute of Technology.)