Galilean Satellites

J.H. Lieske
California Institute of Technology
Jet Propulsion Laboratory
Pasadena, California USA

Jupiter's Galilean satellites have played an important role in science since their discovery in 1610. Ole Roemer (1644-1710) employed eclipse timings in 1676 to investigate whether the speed of light was finite or infinite. More recently, S.J. Peale predicted volcanism on Io in 1979, before the Voyager spacecraft encountered Jupiter and dramatically photographed volcanic activity on Io. The investigation by J.L. Lagrange (1736-1813) won the prize of the Royal Academy in 1766. P.S. Laplace (1749-1827) investigated the motion of the inner three satellites and discussed what we today call the Laplace libration, where the mean motions of the inner three satellites are locked together and follow the equation $n_1 - 3n_2 + 2n_3 = 0$. French scientists have played very significant roles in the study of Jupiter's Galilean satellites. One of the major efforts at international scientific cooperation in the 17th century involved the Galilean satellites and the attempt to determine terrestrial longitudes of observers by employing eclipses of the satellites. French Jesuits were active participants in these efforts, especially in the Orient, and some of the early maps of the world were drawn based upon Galilean satellite eclipse timings. J-B. J. Delambre (1749-1822) collected more than 6000 eclipse observations prior to 1800 and his collection was considered the best in the world. It disappeared about the time of founding of the Bureau des Longitudes and was thought to be lost forever. A-G. Pingre (1711-1796) had prepared a manuscript on 17th century science for publication at the end of the 18th century, but it disappeared at the time of the French Revolution. The manuscript contained a large collection of Galilean satellite eclipse observations because of the great interest in determining terrestial longitudes. C.G. Bigourdan (1851-1932) ultimately published Pingre's re-discovered manuscript in 1901. The extensive collection of observations of the Galilean satellites by J-N. Delisle (1688-1768) was re-discovered in 1980 and thus the lost Delambre collection has been recovered. While eclipse observations are of interest in their historical setting, they are equally relevant in today's science. The observations by Roemer are being employed in ephemerides which guide the spacecraft Galileo in its forthcoming encounter with the Jovian system later this year. Typical eclipse timing observations are accurate to about 800 km.

Other types of observations play important roles in the study of the satellite orbits also. The extensive photographic observations by D. Pascu at the U.S. Naval Observatory over the last quarter-century are accurate to 0.10 arcsec per exposure (or 0.05 arcsec per plate, equivalent to about 160 km). Optical Navigation frames made by the Voyager spacecraft in 1979 are good to about 45 km. Mutual event photometric observations 1973-1991 vary in their accuracy but appear to be about 100 km, with wide differences for the same event by different observers. Over the past several years CCD photometric observations have been made by the USNO Flagstaff and these data appear to be good to about 100 km per normal point. This research was sponsored by NASA and conducted at the Jet Propulsion Laboratory, California Institute of Technology.