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Ganymede and Jupiter System Exploration

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Abstract

The largest moon in the solar system, Ganymede is the linchpin of a coupled system. Io, Europa, and Ganymede are locked in tidal resonance in which Ganymede is by far the most massive member of the set. LaPlace [1] found the fundamental resonance of Io: Europa: Ganymede to be: 4:2:1. If one of them slows down the resonance acts to restore the geometry. Yoder [2] showed that it is tides that maintain the equilibrium in the system.

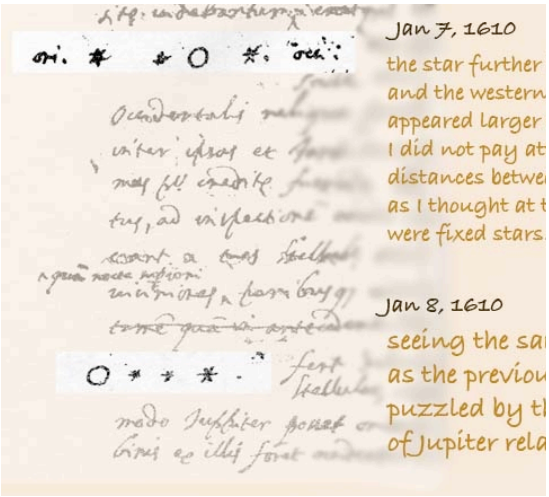

Figure 1: A representation of Galileo's original notes from his observations of the inner moons of Jupiter on the nights of Jan 7 and 8, 1610. Trans. by Consolmagno [pers. communication].

Ganymede's internally generated magnetic field is an intriguing geophysical phenomenon in its own right. When considered in the light of Ganymede's pivotal role in the resonance of the coupled system, intriguing questions arise about the role of tides in perpetuating and maintaining the physics that lead to the magnetic field. Ganymede is geologically interesting, in which ancient terrain covers 35% of the surface, resurfaced terrain covers the balance of the 65% of the surface. Ganymede sits in a relatively benign radiation environment (compared to that of Europa or Io) in which energy deposition to the surface may be of biotic consequence. Energy deposition contributes in an important way abiotically to two regions of the moon - evolution of the composition and state of surface layers, and to the physics of a surface-bounded exosphere. Ganymede is warmer than Callisto, with a thinner crust, and greater tectonic activity leading to the intriguing inference of a probable global ocean. Interesting questions include the potential for contact between ocean waters and the surface.

A mission to Ganymede provides for measurements of the height and phase of its tides, measurements that will fundamentally help characterize the physics of this interaction. Such a mission would also have the opportunity to characterize the higher order terms of its unique magnetic field. Characterization of the geology and exosphere would round out the physical questions of interest about Ganymede. A spacecraft stationed at Ganymede is also well positioned for monitoring the Jupiter system as a whole. The relatively low radiation environment allows for a long-term, low-cost mission that can among other things, observe Io and its effects on Jupiter's magnetosphere.

GEM is an independent mission study group assessing the highest priority science and mission scenarios to Ganymede as follow up to NASA's Jupiter Icy Moon Orbiter (JIMO) and Jupiter System Observer (JSO) studies. The group is focused on Ganymede, believing that more than a single mission to this compelling environment will be required to fully engage the science.

References

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[1] Laplace (1805, 1966) Mechanique Celeste 4, Courcier, Paris. Trans by N. Bowditch, New York.

[2] Yoder C.F. (1979), How tidal heating in Io drives the Galilean orbital resonance locks, *Nature*, *279*, 767-770.

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