

In situ and remote observations of the ultraviolet footprint of the moon Callisto by the Juno spacecraft

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Abstract

Peculiar features of Jupiter’s auroral emissions, with no counterpart at Earth, are the auroral structures induced by the interaction of the Galilean moons Io, Europa, and Ganymede with Jupiter’s magnetosphere. These footprints are observed in the ultraviolet, infrared, and radio wavelengths as the result of the local sub-Alfvénic electromagnetic interaction between each moon and the magnetospheric plasma flow. Since July 2016, these interactions and the resulting auroral emissions have been characterized in detail by the Juno mission thanks to its highly-eccentric, polar orbit around Jupiter. The spacecraft enables both remote-sensing observations, including UV, IR, and radio measurements, and in situ observations, with plasma and wave measurements obtained along the magnetic flux tubes connecting the moons to their auroral footprints.

Among the four Galilean moons, Callisto has remained the missing piece. Detecting its faint footprint is particularly challenging due to its location, buried within Jupiter’s bright main auroral oval. Moreover, Callisto’s interaction with Jupiter’s magnetosphere also differs from that of the other three Galilean moons, as the moon encounters super-Alfvénic electromagnetic interactions when located at the center of the plasma sheet.

Here, we report the first in situ and remote observations of Callisto’s ultraviolet footprint using Juno observations. This detection was allowed by unusual magnetospheric conditions that led to a significant equatorward shift of Jupiter’s main auroral oval. Remote observations by the Juno spacecraft reveal a double-spot structure, characteristic of the footprints of the other three moons. Concurrent observations within Callisto’s flux tube reveal field-aligned electrons.

The observed similarities, both in the auroral structure and the in-situ electron properties, point towards a universal physical mechanism at work for moon-planet and planet-star magnetospheric interactions, relevant for other binary systems that are only accessible remotely, in the solar system and beyond.