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Spin states of Europa and Ganymede

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Radar speckle tracking observations of Europa and Ganymede with the Goldstone Solar System Radar and the Green Bank Telescope in 2011-2023 yield estimates of their spin axis orientations to ~0.01 degrees. These measurements conform to the expected 30-year precessional cycle and provide insights into the moons' Cassini States. I will describe the latest results and discuss new scientific prospects associated with these observations. First, the spin state can reveal the presence of a subsurface ocean: a decoupling between the icy shell and the interior results in a different obliquity than that of a solid body. Second, an angular deviation from the strict Cassini state enables estimates of energy dissipation. Third, a measurement of librations, if detectable, would enable a measurement of the shell's moment of inertia and provide bounds on the rheology and thickness of the shell. Fourth, the obliquity may explain remarkable surface features, such as the distribution and orientation of cycloids, strike-slip faults, and lineaments on Europa. Fifth, knowledge of the obliquity is required to enable tidal heating calculations. Finally, these measurements are expected to facilitate Clipper and JUICE operations and prevent initial, large mapping errors in spacecraft data products.