Radar Observations of Europa from 2011-2024 Reveal New Insights into Its Icy Surface

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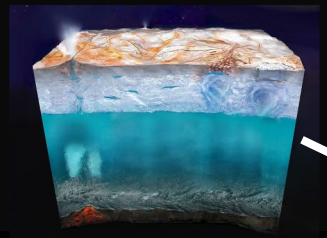
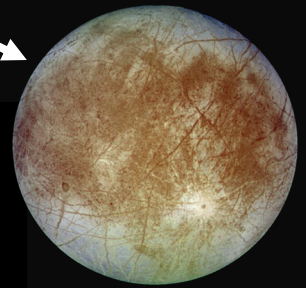
Icy Galilean Satellites are Possible Hosts of Subsurface Oceans

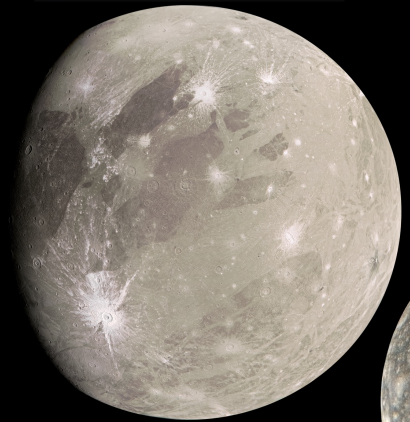
- Jupiter's icy moons: Europa, Ganymede, Callisto

Europa Clipper

JUICE







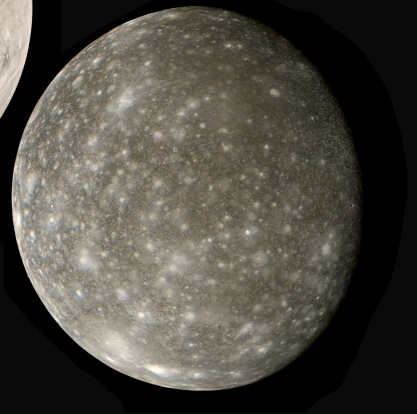
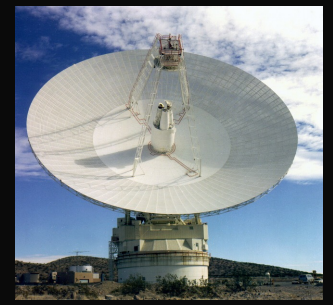
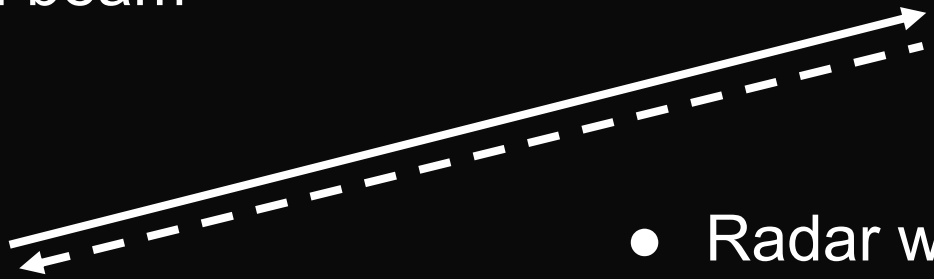


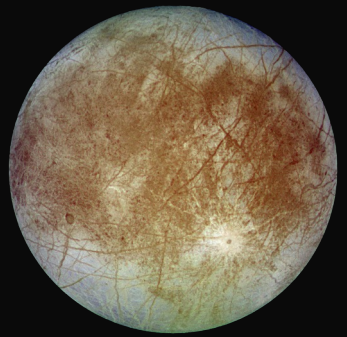
Image Credit: JPL/NASA/ESA

Europa Has Unusual Radar Properties

- Europa's radar albedo >> rocky planets'
- Europa's return signal is dominated by the same circular polarization as the transmitted beam





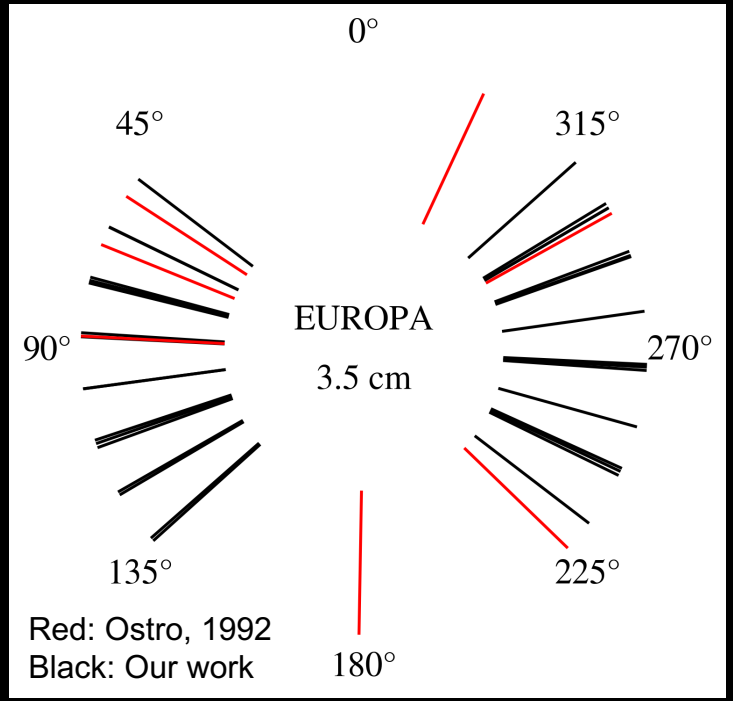


- Radar waves can penetrate into Europa's icy shell

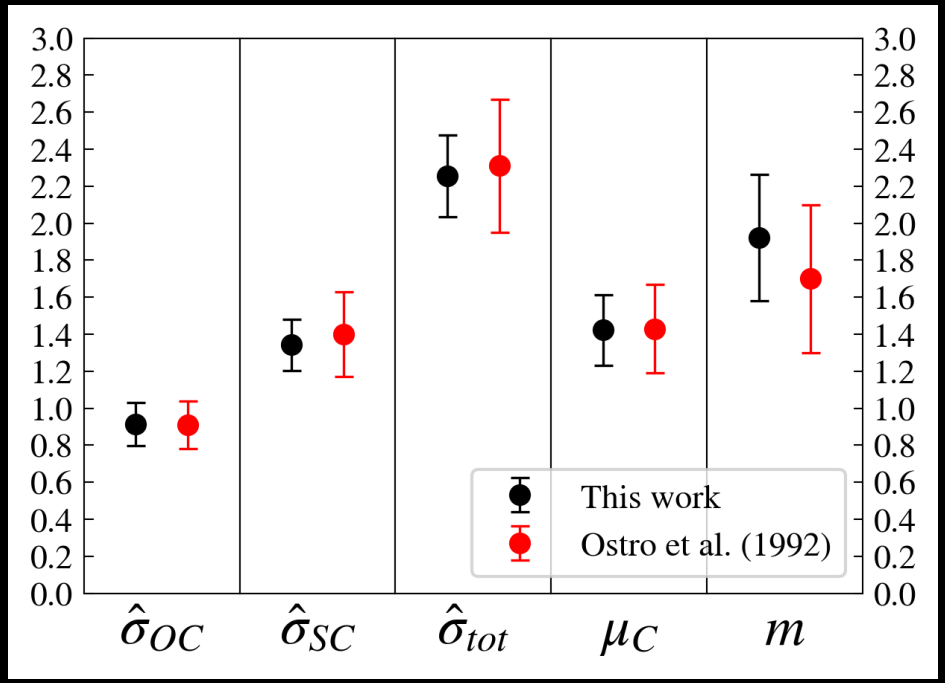
Image Credit: JPL/NASA

Our Observations Fill a Significant Gap

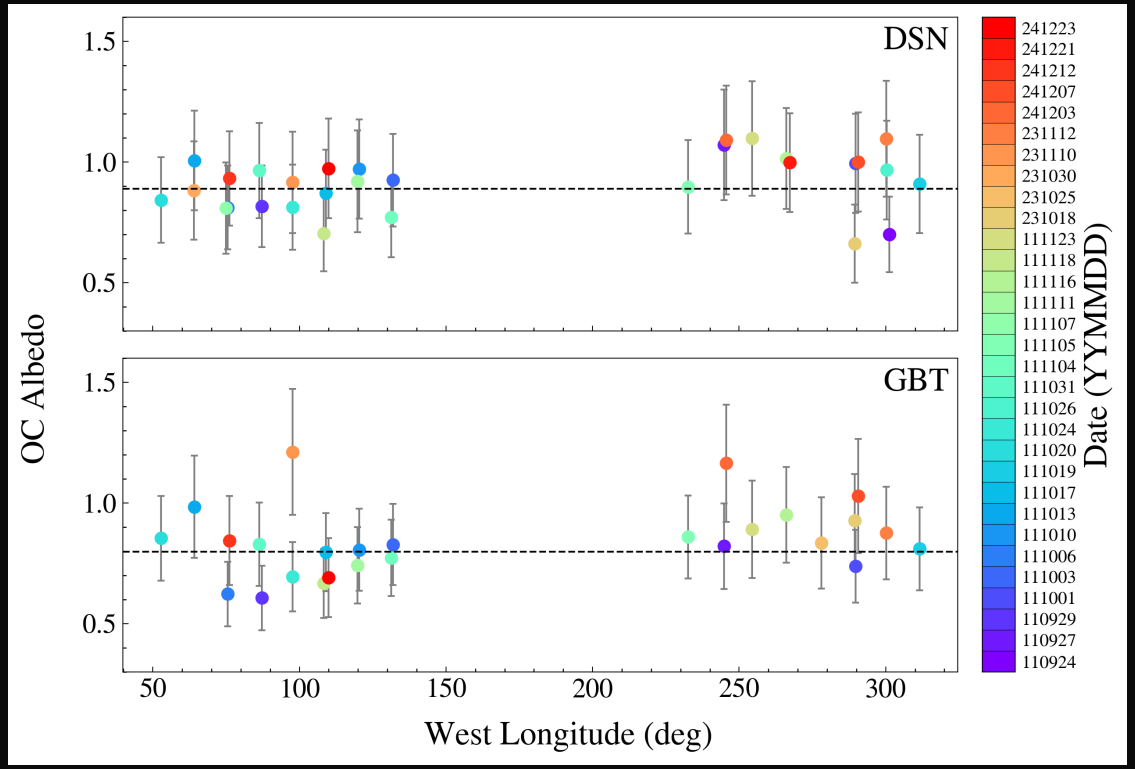
- Last major radar observations were in 1987-1990 (Ostro, 1992)
- We observed Europa from 2011-2024



Our Results Agree Well with Previous Results



Albedo vs. West Longitude



- Statistically consistent with a single value
- Possible hemispherical dichotomy –> penitente structures on the surface?

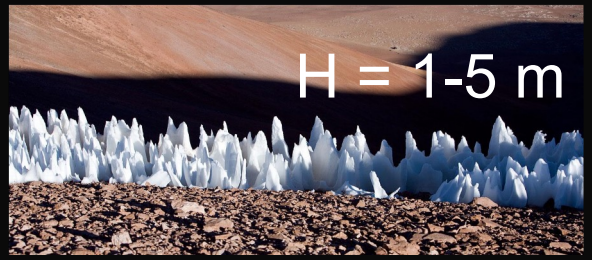
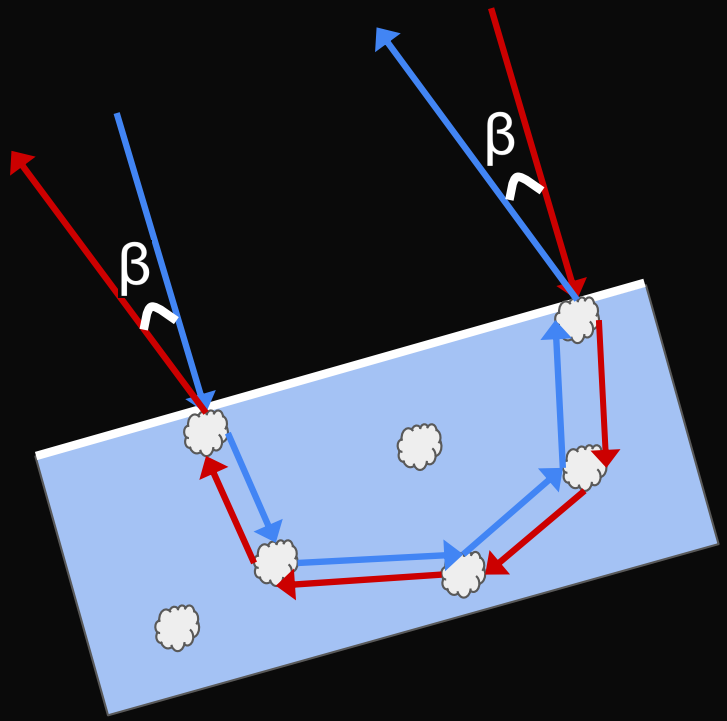


Image Credit: ESO

Coherent Backscatter Opposition Effect Can Explain Europa's Unusual Radar Properties



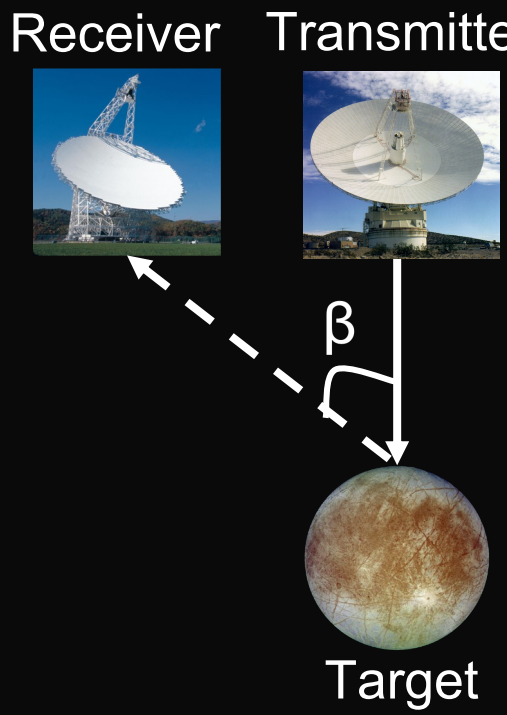
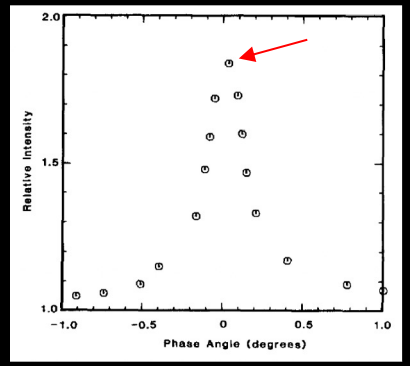
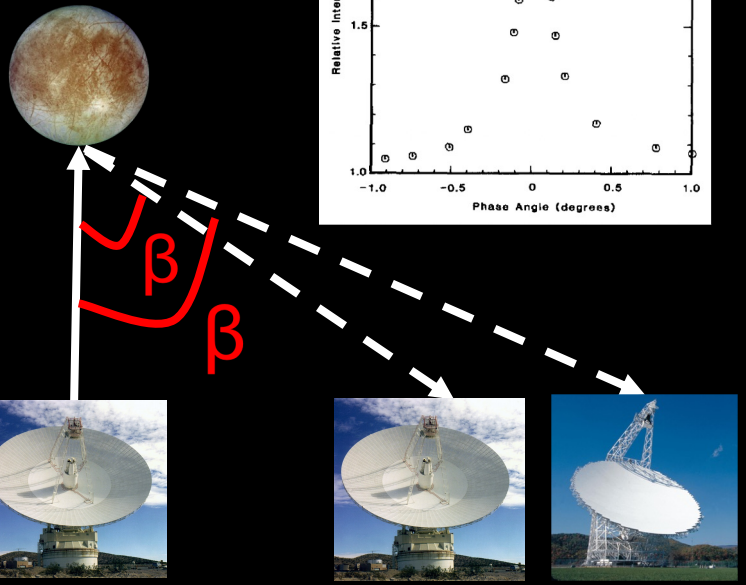


Image Credit: JPL/NASA/NRAO

New Bounds on CBOE

Hapke, B., Icarus, 88, 407 (1990)

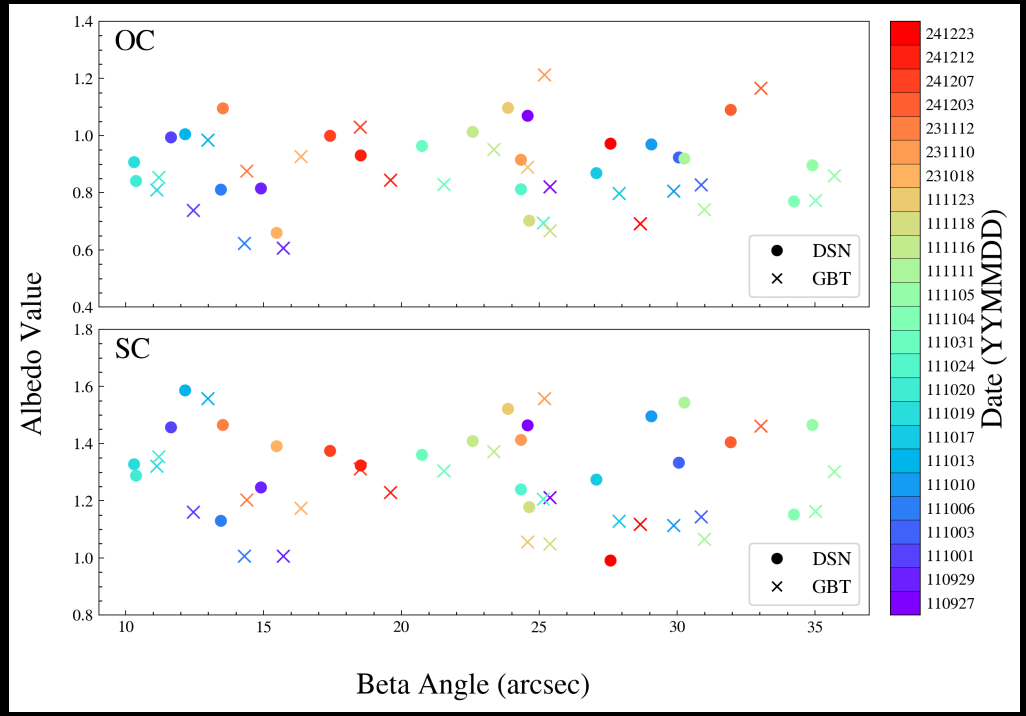




Goldstone

Goldstone

GBT



Mean photon penetrating depth < 32 m

Image Credit: JPL/NASA/NRAO

Summary

- We present the most comprehensive dataset of Europa's radar measurements to date.
- We measured Europa's disk-integrated radar properties, all of which are in agreement with previous works.
- Europa's disk-integrated radar albedo is statistically consistent with a constant value, although there are hints of an hemispherical dichotomy.
- We place an upper bound of 32 m (or ~1000 wavelengths) on the mean photon penetrating depth of X-band radar waves within the icy shell.

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