National Aeronautics and Space Administration

FY24 Strategic University Research Partnership (SURP)

Electrical Properties of Ocean World Solutions

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Objectives: Provide missing information about the electrical conductivity of ocean world solutions. These data—including electrical conductivity and phase stability of single- and multi-component salt solutions at high pressures and temperatures above the liquidus—are critically needed for analyzing the magnetic responses of planetary oceans to infer their salinity.

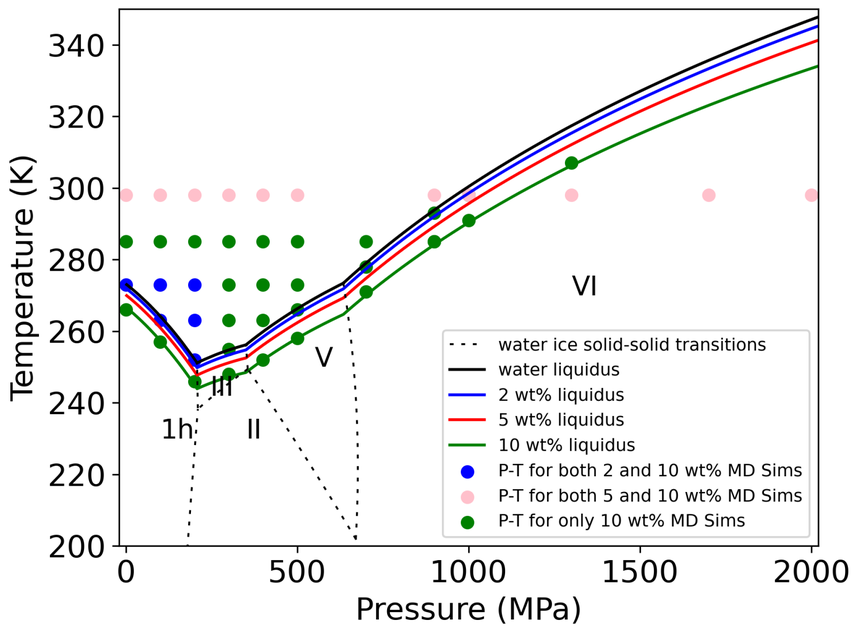
Strategic goal: Develop a long-term partnership with Co-I Kavner at UCLA, an expert in experimental mineral physics relevant to planetary interiors. Train students in planetary science with an eye toward joint inversion of magnetic induction and gravity data on Europa Clipper, JUICE, and future ocean worlds missions.

Background: Laboratory data sparse for electrical conductivity σ under ocean world conditions of temperature, concentration, and pressure.

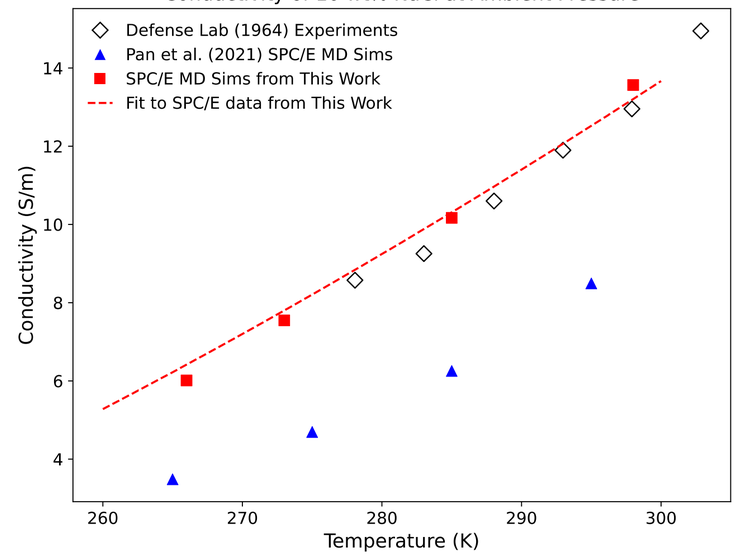
Approach and Results: Concurrently developing electrical impedance spectrometry measurements for relevant solutions at JPL and UCLA.

With SURP support we developed new electrical impedance spectroscopy measurements two graduate students at UCLA, in close collaboration with the the nascent electrical properties lab group in 183-319D. At JPL, we addressed failure of a key component of our high-pressure system through design and machining efforts. In the meantime, we rebuilt most of the apparatus for the measurements in question, which positions us favorably to undertake further measurements now supported by NASA's Precursor Science Investigations for Europa and Solar System Workings programs. This year we published our analysis of molecular dynamics (MD) simulations undertaken to predict the dependences of electrical conductivity on temperature, concentration, and pressure [A].

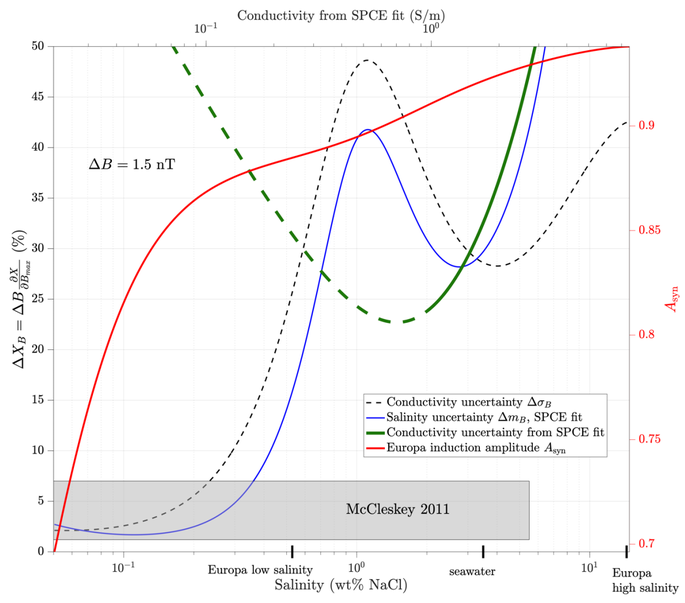
Significance/Benefits to JPL and NASA: The targeted electrical conductivity data are essential for meeting the Europa Clipper goal to determine the ocean's salinity to within ±50%.



Phase diagram for water and aqueous NaCl showing P-T coordinates for molecular dynamics simulations that we conducted to investigate electrical conductivity over the range of interior pertaining to ocean worlds. From [A]



Simulations better match to previously published data than to the recent measurements by Pan et al. (2021) that were undertaken to address electrical conductivity under ocean world conditions. From [A]



We published our analysis of the sensitivity of Europa's induction response to conductivity. Determining the salinity of Europa's ocean (ie the concentration and composition) requires precise and comprehensive laboratory data. The available data from McCleskey et al. 2011 are adequate for likely Europa conditions shown on the x axis, but cover a limited range of temperature, concentration, and pressure. From [A]

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Publications:

[A] C. Psarakis, T. Fidelis, K. Chin, B. Journaux, A. Kavner, P. Sarker, M. Styczinski, S. D. Vance, and T. Wei. Electrical conductivity of subsurface ocean analog solutions from molecular dynamics simulations. ACS Earth and Space Chemistry, 2024. https://doi.org/10.1021/acsearthspacechem.3c00345

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