



SURFACE CHARACTERIZATION OF JOVIAN MOONS VIA RADIATIVE TRANSFER-COHERENT BACKSCATTERING MODELING

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OUTLINE OF THE TALK

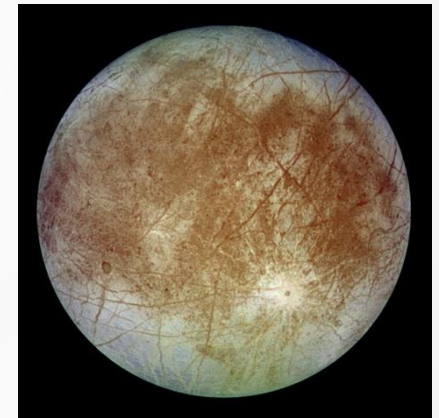
- Why we're modelling Jupiter's moons' surfaces
- Physical phenomena of coherent backscattering
- Overview of the RT-CB method
- Particle shape modelling and our input construction
- Current results and future plans

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MOTIVATION

- Jupiter's moons' surface layers still poorly understood.
- Increasing availability of polarimetric / photometric data
- JUICE and Europa Clipper - more data in the 2030s
 - Need for models that can support interpretation of these missions
 - RT-CB modelling helps link data to physical surface properties

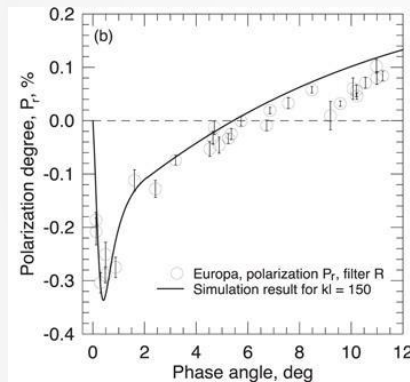


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COHERENT BACKSCATTERING EFFECTS



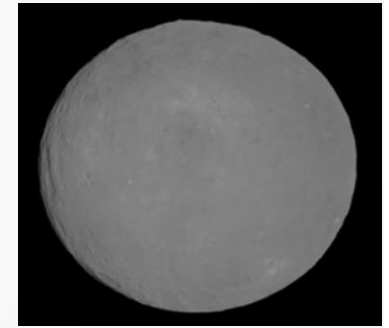
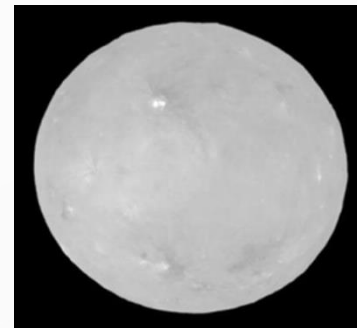
- Phase angles less than 20 degrees
- Sensitive to many surface properties: particle size, species, packing density



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- Negative linear polarisation

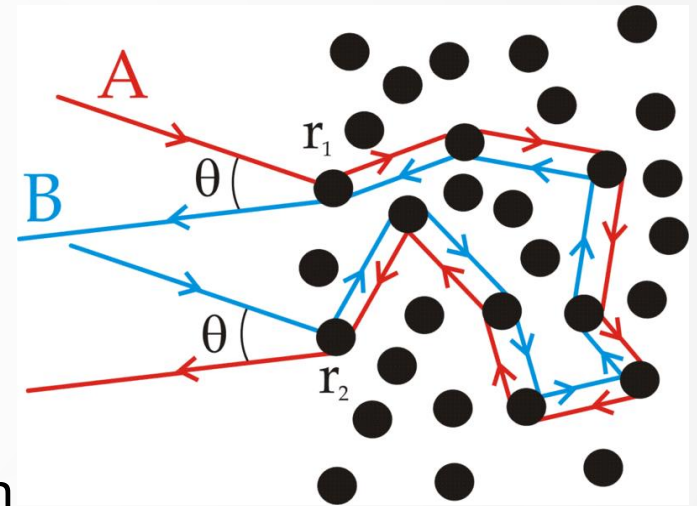
- Non-linear brightening near backscattering direction





COHERENT BACKSCATTERING

- Two light rays traveling same path
- Reciprocal directions
- Interference near backscattering direction

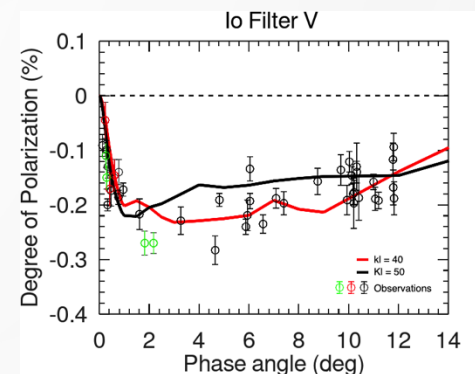
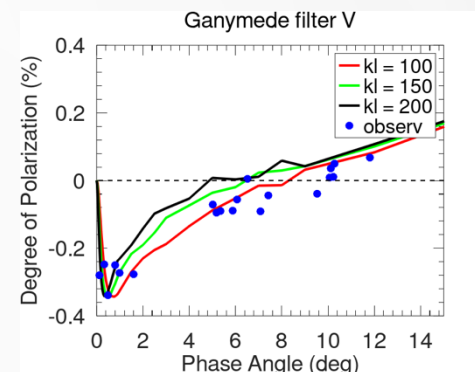




RT-CB METHOD: A MATURE MODELLING TOOL

(RADIATIVE TRANSFER – COHERENT BACKSCATTERING)

- Combines radiative transfer and coherent backscattering.
- Validated and applied in recent peer-reviewed studies
- Accurately models opposition effect and polarization.
- Computationally efficient: allows large parameter sweeps.
- Ensemble averaged scattering matrix as an input.

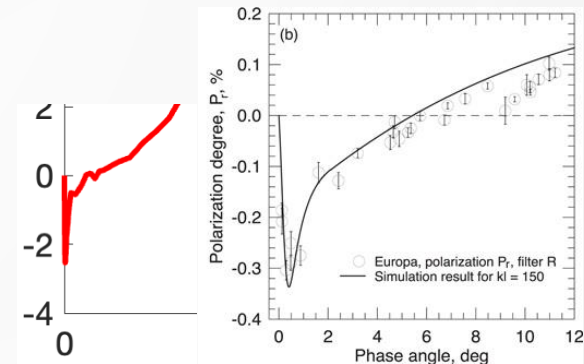
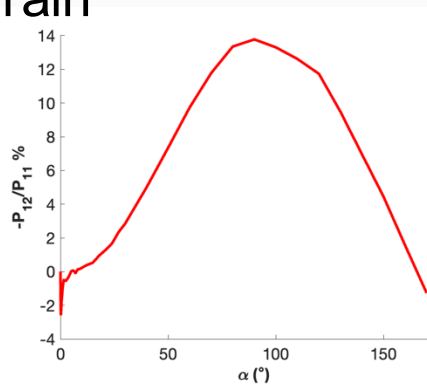
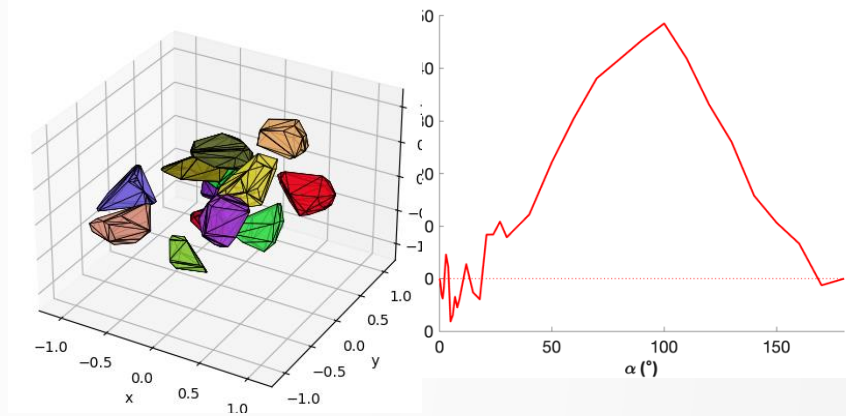


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PARTICLE MODELLING AND CHALLENGES - EUROPA

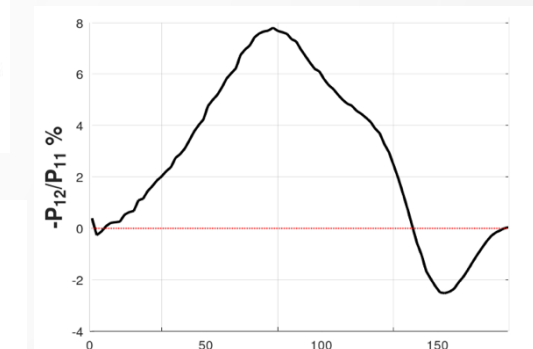
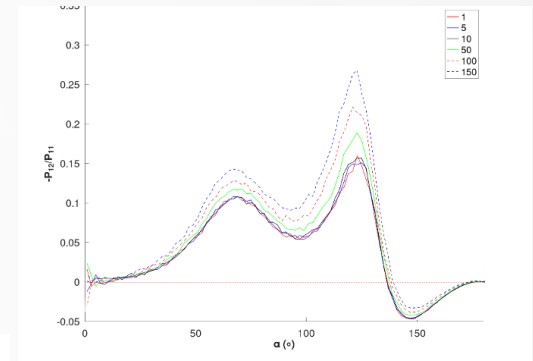
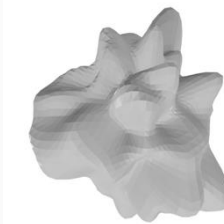
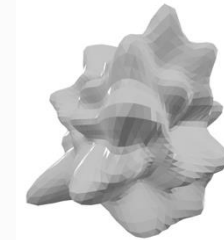
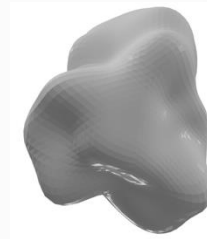
- Input concerning small particle - (ADDA) with size distribution up to 0.5 microns.
- Small particles alone overshoot observed polarization (too high)
- Cannot use pure small-grain populations alone
- Indicates dominant role of larger scatterers





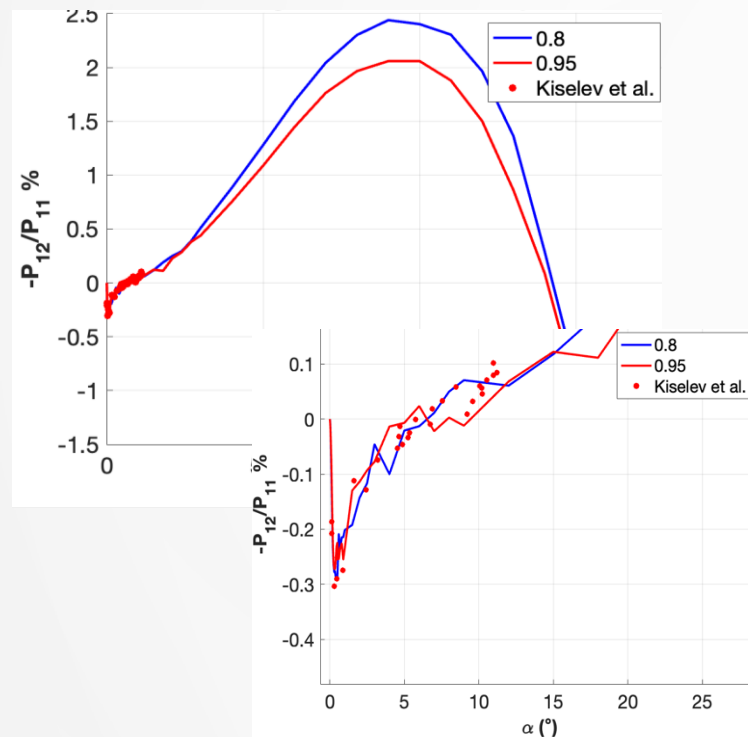
SIRIS4-GENERATED LARGE GAUSSIAN PARTICLES

- SIRIS4 used to generate Gaussian random particles
- Overestimated polarization — not consistent with observations
- High-surface-roughness Gaussian particles to suppress polarization
- Small grains still needed to shape the negative branch behaviour





CONSTRUCTING A COMPOSITE SCATTERING MATRIX

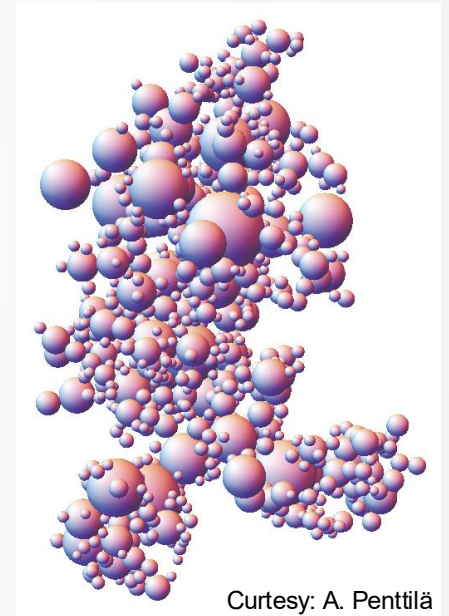


- Gaussian matrix parametrized to reduce noise
- Combined small + large particle populations
- Tested 80/20 and 95/5 weights on matrices contribution
- Shape of polarization curve improving

MATCHING THE SURFACE PHYSICS OF EUROPA



- Observed polarization wavelength-independent → large grains
- Surface temperature (80–120 K) supports sintering
- Small grains fuse → complex, rough larger grains
- Polarization maximum ~2%, at correct phase angle range
- Model and physics now align well



Courtesy: A. Penttilä



FUTURE WORK

- To match albedo from simulations with observed geometrical albedo of Europa (0.64), single scattering albedo (SSA) had to be set to be 0.985.
- Water ice has imaginary part for refractive index 10^{-8} , it would result SSA $\sim 0.9999X$
- Adding absorbing element will increase linear polarisation.
- Countered by mixture of crystalized and amorphous ice, (refractive indices 1.31 and 1.26) lower refractive index – more forward scattering – less polarisation due increased internal scattering.



SUMMARY

- RT-CB model performs well on Europa-like surfaces
- Polarization curves now closely match observations
- Model supports sintered ice grain interpretation
- Remaining step: fine-tune absorption and photometric contrast
- Aim: publishable regolith model for Europa and continue with rest of Jovian moons.