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Multiscale Homogenization for Sea Ice

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Polar sea ice exhibits complex composite structure on length scales ranging from millimeters to kilometers. I will address fundamental questions in sea ice homogenization, where behavior and structure on small scales is incorporated into representations of effective behavior on larger scales, and the inverse problem of estimating parameters controlling small scale processes from large scale observations. In particular, we find that powerful Stieltjes integral representations obtained originally for the effective complex permittivity of sea ice treated as a composite of pure ice with brine inclusions can be developed in a number of other settings in sea ice physics. The integral representation involves a spectral measure which incorporates statistical information on the geometry of the brine phase. Through parallels in the resolvent structure of the field equations, the Stieltjes framework is extended to polycrystalline composites, advection enhanced diffusion, and wave propagation through the sea ice pack, treated as a composite of ice floes in an oceanic host. We obtain rigorous bounds on the transport properties of polycrystals, the complex viscoelasticity for long waves in the ice pack, and the effective thermal conductivity of sea ice with brine convection.