Statistical physics and melting Arctic sea ice

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Abstract

Polar sea ice is a key player in the climate system and a critical indicator of climate change. For example, it reflects sunlight and helps mitigate solar heating of the Arctic Ocean. During late spring and summer, sea ice reflectance or albedo, a principal parameter in climate modeling, is largely determined by the evolution of surface melt ponds. As the ponds grow and coalesce, their fractal dimension undergoes a transition from 1 to about 2, around a critical length scale of 100 square meters in area. The ponds take on complex, self-similar shapes with boundaries resembling space-filling curves. I will discuss how methods from statistical physics, such as percolation, network and Ising models, are being used to quantitatively describe melt pond evolution and to address other multiscale problems in sea ice physics. Through our analysis of sea ice structures we have discovered an Anderson transition in disordered composite materials, where the eigenvalue statistics of a key random matrix governing classical transport transition toward universal Wigner-Dyson statistics as a percolation threshold is approached. Our work is helping to advance how sea ice is represented in climate models and to improve climate projections.

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