Caustic Grain Boundary Melting in Ice

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The equilibrium state of grain boundaries and the vein-node-trijunction system in polycrystalline materials is fundamental to a broad range of geophysical problems. Hence, a basic understanding of grain boundary melting touches a number of fields. The value of studying the phenomenon in ice is that experimental tests can be designed that exist in thermodynamic equilibrium. The effect of impurities on the grain boundary melting of ice is investigated using modified Derjaguin-Landau-Verwey-Overbeek theory. We calculate the full frequency dependent van der Waals contribution and Coulombic interactions within doped ice grain boundaries. Because the long range contributions are attractive (suppress melting) and the screened Coulomb interactions are repulsive a film forms at high temperature but as the temperature is lowered, depending on the dopant level and surface charge density, an abrupt jump to zero (or small but finite) grain boundary thickness is predicted.