Atmospheric Sciences 510, ESS 531
Physics of Ice
Spring Quarter 2014

Instructor
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This class provides an overview of the physical properties of ice and how they are related through the structure of the water molecules and their arrangement in ice. The purpose is to establish a background in the fundamental properties of ice for students with interest in ice in nature. The class emphasizes a conceptual understanding of the underlying solid-state physics.

Outline and reading assignments
(F = Fletcher; H = Hobbs; EK = Eisenberg & Kauzmann; PW = Petrenko & Whitworth)

Topic	***Assigned reading***	***Optional reading***
The water molecule	F1	EK1
The hydrogen bond	F1	EK1
Crystal structure of ordinary ice	F2	PW2, H1
Equilibrium thermodynamics, phase diagrams	F2	PW2, H1, EK3
Other phases of ice (high pressure, low temperature)	F3, PW11	H1
Optical properties of ice in ultraviolet, visible, infrared	PW9, handouts	H3
Elastic and thermal properties, lattice vibrations	F6, PW3	H5
Protonic and molecular defects; dislocations	F7	PW8, H4
Mechanical properties of single crystals	F8, PW8	H4
Electrical properties	F9	PW4,5
Ice surfaces and interfaces, quasi-liquid layer	PW10, handouts	
Grain boundaries, veins, nodes	handouts	
Crystal nucleation and growth from the vapor and from the liquid.	F4, handouts	
Evolution of crystal shapes	F5, handouts	
Clathrates; clathrate-bubble transition	PW11.10, handouts	

Reference Books *(in order of publication date)*

Eisenberg, D., and W. Kauzmann, 1969: *The Structure and Properties of Water.* Oxford University Press, 296 pp.

Fletcher, N.H., 1970: *The Chemical Physics of Ice.* Cambridge University Press, 271 pp.

Hobbs, P.V., 1974: *Ice Physics.* Oxford University Press, 837 pp.

Franks, F., 1982: *Water; A Comprehensive Treatise*. Volume 7: "Water and Aqueous Solutions at Subzero Temperatures." Plenum Press.

Petrenko, V.F., and R.W. Whitworth, 1999: *Physics of Ice.* Oxford University Press, 373 pp.

These books are on reserve in the Engineering Library. Copies of the Petrenko-Whitworth and Eisenberg-Kauzmann books, and photocopies of Fletcher and Eisenberg-Kauzmann are in a box on the reserve shelf in the Atmospheric Sciences Library, room ATG 623B.

Organization

The course will be a combination of lectures and discussion. The beginning of each class will be devoted to a short review of the principal conclusions and questions of the previous class presented by one of the student participants. Reading will be assigned from the above books. There will be some homework assignments, and a take-home final exam. The exam will be handed out during the last week of class, and will be due on Monday June 9.

Each student will complete a project, presented as a written summary with bibliography. The subject of the project can be related to an area of special interest to the student. The project can be in the form of a proposal. It should be tied to the physics of ice as a material. Students will give oral reports on their projects during the last class period (June 5) or during the designated final-exam time (10:30-12:20 June 9).

Grading

Homework	1/3
Final exam	1/3
Project	1/3