Experiments in Acoustically-Induced Freezing

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Frozen drops do not adhere when colliding with surfaces as do supercooled water drops. Therefore, methods to freeze supercooled droplets before colliding with surfaces may significantly reduce atmospheric ice accretion. Reports by investigators regarding problems with unintended freezing of supercooled droplets in acoustic levitators prompted us to investigate deliberate freezing of droplets using acoustics. We investigated acoustic freezing of supercooled drops, including how the mechanisms and requirements for inducing freezing change with temperature, drop size, acoustic power, and acoustic frequency. Our work was experimental and was conducted in an acoustic levitator incorporating a waveguide resonator tuned to provide maximum sound pressure on the levitated supercooled drops. Previous unsuccessful experiments by others in an icing wind tunnel concluded that sound pressures of 150 dB or higher may be necessary to cause drops to freeze. The waveguide resonator was designed to subject nominally 1000 µm diameter supercooled drops to 150 dB at 2.8 kHz.

Developing a robust experimental procedure was challenging because of the need to levitate and supercool drops without inducing freezing by stray ice nuclei, the need to control drop size, and the need to impart high acoustic pressures on levitated drops without causing them to exit the levitator. These experimental challenges prevented fully systematic, repeatable measurements as desired. However, we believe that freezing was produced by acoustic stimulation of the supercooled drops on multiple occasions. We describe the experimental procedure, show how freezing was inducted in a controlled manner and the sound pressures inducing freezing, and describe work that should be done to more formally demonstrate the process and understand the acoustic freezing of supercooled drops. We will also describe the potential utility of the acoustic freezing as an ice protection technology.