# Statistical Characteristics of Evaporating-Freezing Process of Water Droplet during Quick Depressurization

Wang-Fang DU, Jian-Fu ZHAO, Kai LI

Key Laboratory of Microgravity, Institute of Mechanics, Chinese Academy of Sciences. Beijing, 100190, China

E-mail address: jfzhao@imech.ac.cn

Flashing evaporation may occur when the system pressure is suddenly dropped to a value far below its saturation pressure corresponding to the system temperature, such as what happens in the case of liquid discharging into vacuum environment during space orbital flight. Generally, the liquid jet quickly breaks into small droplets, and the rapid evaporation leads to a quick decrease of the droplet temperature, which may eventually lead to freezing of the droplets and possible blockage of the discharge pipe, and then cause the failure of the discharging process. The objective of this study is to experimentally investigate the freezing point of water droplets during flashing evaporation process.

In the experiment, a droplet was hung in the test vessel with a thin thermocouple. Then the air inside the test vessel was evacuated quickly by opening the electro-magnetic valve connecting to the vacuum chamber. The liquid droplet temperature dropped quickly, which was caused not only by the expanding of air around it, but also by the quick evaporation on its surface. After the temperature exceeds some low limit, the droplet was frozen from the surface. The liquid transformed to the solid state, releasing the latent heat. Then the temperature rose to the freezing point, and maintained it until the whole droplet was frozen. Finally, its temperature dropped again due to the surface sublimation.

Generally, it's found that freezing temperature of liquid droplet is approximately constant after recalescence, which may be determined by the vapor partial pressure at the terminal state (Du et al, 2012). However, at the case of lower terminal pressure, more complex phenomena were observed. Fig. 1 shows a typical case during freezing of a water droplet at terminal pressure of 425 Pa. After recalescence, the temperature rose at first to a value above 0 °C. Then, it was observed that water flowed out to form a small protuberance at points a, or flowed out along down-lead of thermocouple at point b. The temperature dropped down subsequently, and a approximate constant freezing temperature was observed. These observations indicate that quick freezing leads to strong compression of water inside the ice shell due to volume increase across liquid-solid phase change, and that the freezing temperature may be affected by the actual pressure of water inside the ice shell.

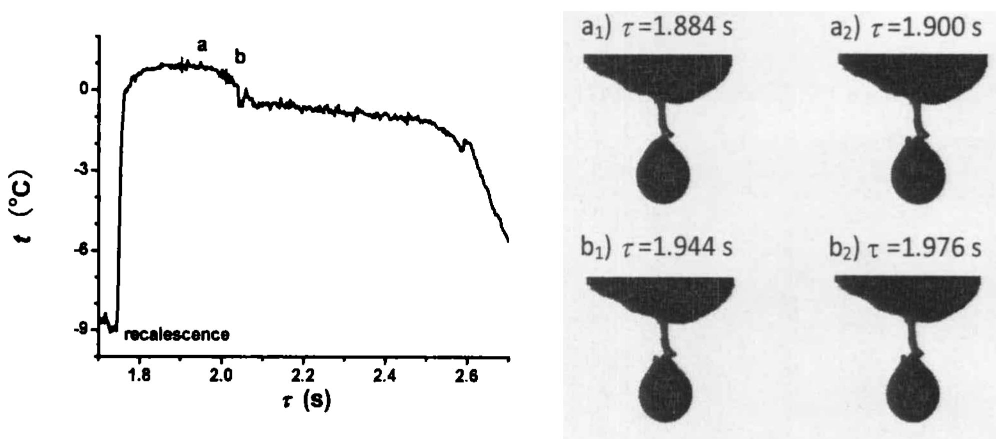


Figure 1: Processes of transient heating

## References

[1] Du W.F., Zhao J.F., Li K. (2012). Experimental study on thermal-dynamical behaviors of liquid droplets during quick depressurization. J. Eng. Thermophy., 33: in press.