Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)


MIS22-02 Room:106 Time:May 27 09:15-09:30

# Spontaneous rotation of a block ice melting on metal surface

TANAKA, Masashi[1] ; HOHOKABE, Hirotaka[1] ; YOSHIDA, Shigeo[2] ; NAKAJIMA, Kensuke[2*]

[1]Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, [2]Department of Earth and Planetary Sciences, Faculty of Sciences, Kyushu University

We have discovered that a block ice placed on a flat surface of a warm brass column rotates without any external driving torque. Air bubbles supplied to the ice-metal interface as ice melts are found to be essential to the spontaneous rotation. According to our observation, while the ice rotates, air bubbles almost remain stationary on the metal surface. Heat supplied at the bottom of the ice block is also essential. The ice block cannot rotate when the temperature of metal column is low enough.

We carried out the experiments to examine the dependences of the rotation rate on several parameters, which are the heat flux, the supply of air bubbles, the weight of ice, and the size of ice, under the setup with which the stability and the reproducibility are established.

It is found that the angular velocity of the rotation is proportional to the 0.51th power of the temperature gradient in the brass column and the minus 0.56th power of the size of the ice block. On the other hand, the air supply and the weight of the ice had little effect on the angular velocity.

We have developed a scaling theory for the angular velocity assuming that the rotation is driven by the excess pressure of the air bubbles in the water layer. Due to the difference between the thermal conductivities of water and air, the melting of ice just above air bubbles is retarded, resulting in the growth of inverted ridges of ice. The pressure in the air bubble is higher than it in the water layer because of the surface tension. The excess pressure pushes the ridges, and the ice block rotates. The scaling formula of the angular velocity, which is derived from the balance between the driving force and the viscous force on water ice interface can explain many of the experimental results quantitatively.

Keywords: phase change, surface tension, heat conduction, self-propelled motion, bubble