Thermo-Acoustic Radiation of Free-standing Nano-thin Film in Viscous Fluid

Prof. C.W. Lim
City University of Hong Kong

Abstract:

Thermo-acoustic (TA) effect did not attract very much attention in the past. Morse and Ingard [1] derived the coupled thermo-acoustic governing equations in 1968. In 2008, Xiao et al. [2] conducted thermo-acoustic experiment for carbon nanotube projectors in air and further in 2010, Aliev et al. [3] extended the work of Xiao [2] underwater. Hu et al. [4] put forward a theoretical explanation on thermo-acoustic emission of different kinds of sound source without taking the influence of heat capacity into consideration. Lim et al. [5] derived and presented thermo-acoustic wave generation for free-standing CNT thin film ignoring the viscosity of fluid.

In this talk, further works on thermo-acoustic wave emission and propagation in viscous media are discussed. The fully coupled thermo-acoustic field is obtained for a free-standing nano-thin film in viscous fluid, which has been usually ignored in the previous works on thermo-acoustic interaction. The influence of heat loss, heat capacity and heat exchange is considered in this investigation. When a sinusoidal alternating current acts on the thin film, the double frequency effect can be determined easily. Subsequently, the thermal wave propagation is decoupled from the acoustic effect by improving the order of differential equations. Then, with appropriate simplification an analytical prediction is derived in which the attenuation coefficient and the classic expression are identical. In addition, the theoretical results agree well with experiment. Compared with Lim et al. [5], an analytical solution of higher-order accuracy is obtained. This work may be helpful to the design of the thermo-acoustic projectors that have shown great potentials for new underwater sonars compared with the electro-acoustic ones traditionally induced by membrane vibration.