Thermophones Produce Sound Without An Increase In Thin Film Temperature

Century old claims based on classical heat transfer that thermophones produce sound by temperature changes in thin films under electrical heating are refuted by quantum mechanics

Aug. 26, 2009 - *PRLog* -- Background
In 1914, Lord Rayleigh communicated the description of the thermophone by de Lange to the Royal Society. But as early as 1880, Preece produced sound by passing current through micron sized platinum wires affixed to a diaphragm. Around 1800, the Russian engineer Gwozda produced sound by heating a straight wire without a diaphragm. Historically, the theory of thermophones is based on the production of sound from a thin platinum film published by Arnold and Crandall in 1917.

Recently, Xiao et al. showed sound was produced by passing an alternating current through thin carbon nanotube (CNT) films. The high sound level at low electrical power for the CNT films were thought more efficient than platinum that required more power for the same sound level. However, the experimental frequency response did not agree with the long standing thermophone theory of Arnold and Crandall. Modifications were made to the theory including the conductive heat loss from the film to the air based on classical heat transfer methodology. See “Thermophones,” at link “Nano Letters Paper”, of www.nanoqed.org, 2009. Xiao et al. claim agreement of the modified theory and experimental data. However, the claimed agreement could not be confirmed by this author because of the experimental fitting necessary to determine the conductive heat loss.

Problems with Classical Heat Transfer Theory
Classical heat transfer theory predicts that sound levels in thermophones are produced by changes in thin film temperature caused by Joule heat produced from passing electrical current though the films. However, this cannot be correct. Classically, temperatures should increase in CNT thin films in proportion to the electrical power, but the CNT films produced high sound levels at lower power than in platinum films at high power levels.

What this means is that temperature changes in thin films have nothing to do with the sound produced in thermophones. Alternatively, classical heat transfer theory that predicts sound is produced by temperature changes in thin films is not applicable to thermophones.

Heat Transfer under Quantum Mechanics Restrictions
Quantum mechanics (QM) methodology differs from classical heat transfer in that the specific heat of the atom is required to vanish under electromagnetic (EM) confinement. Ibid, “Thermophones,” at link “Paper”. In heat transfer restricted by QM, Joule heat absorbed in the thin film cannot be conserved by an increase in temperature. Classical theory differs in that specific heat of materials in macroscopic structures is assumed to remain the same at the nanoscale.

Regardless, EM energy is still required to be conserved at nanoscale. Lacking specific heat, thin films conserve Joule heat by the theory of QED induced EM radiation. QED stands for quantum electrodynamics. By this theory, the low frequency Joule heat is conserved by frequency up-conversion to the EM confinement frequency of the film. Like creating photons of wavelength L by supplying EM energy to a QM box having sides separated by L/2, the Joule heat in thin films creates photons having wavelength L = 2nd, where d is the thickness and n is the refractive index of the film. There is no increase in temperature of the thin film.

The QED photons are only confined briefly because the EM confinement is quasi-bound, and therefore the thin film promptly leaks EM radiation at the confinement wavelength. Typical CNT thin films in thermophones have thickness d > 0.125 microns, and therefore the EM confinement produce radiation in the ultraviolet (UV) and visible (VIS). Unlike thermal radiation in classical heat transfer theory that requires high temperatures, the QED induced emission is non-thermal and occurs at ambient film temperatures.

Sound from Thermophones by QM

Sound from thermophones requires pressure changes in the surrounding air. The QED induced UV-VIS emission is therefore required to be absorbed by air to increase its temperature and produce the pressure changes necessary for sound propagation. But nitrogen in air is transparent in the UV-VIS and cannot produce sound. Only oxygen has an absorption cross-section close to that necessary to produce sound. The Joule heating necessary to produce sound by oxygen absorption is found to be a very small fraction - around 10^-6 of the 1-4.5 watts supplied.

Almost all of the supplied Joule heat is lost to the solid walls of the thermophone enclosure. To improve thermophone efficiency, the gas volume between the thermophone and microphone should be sealed and filled with a UV-VIS absorptive gas.

Conclusions

1. Classical heat transfer that includes finite specific heat in thin films is not applicable to thermophones. The Joule heat cannot be conserved by temperature changes of the thin film.

2. Heat transfer by QED induced radiation as based on zero specific heat as required by QM should be used for the analysis of thermophone performance. The emission of UV-VIS radiation that conserves the Joule heat is required to be absorbed by the air surroundings to produce sound. But the absorption of UV-VIS in air is very low. Indeed, almost all of the Joule heat does not produce sound because of absorption by the walls of the enclosure. To improve sound levels, the space between the thermophone and microphone should be sealed and filled with a UV-VIS absorptive gas.

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About QED induced Radiation: Classically, thermal EM radiation conserves heat by an increase in temperature. But at the nanoscale, temperature increases are forbidden by quantum mechanics. QED radiation explains how heat is conserved by the emission of nonthermal EM radiation.

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