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Sonoluminescence was first observed in 1934 by German scientists H. Frenzel and H. Schultes. They regarded it as a purely electrical phenomena and it was ignored for a decade—until it was regularly observed in the cavitations of ship propellers during World War II. Sonoluminescence (the emission of light from bubbles produced in an acoustically excited liquid) has acquired a much greater scientific interest in the past two decades due in part to technological advancements and to a renewed curiosity about what causes sonoluminescence. In a 2002 issue of *Science*, Taleyarkhan et al. [1] at the Oak Ridge National Laboratory (ORNL) reported the detection of both tritium and <2.5 MeV neutrons during the acoustic cavitation of deuterated acetone (C_3D_6O). Both of these detections are consistent with the products of Deuterium-Deuterium (D-D) fusion. In this experiment, the organic liquid was subjected to both neutron irradiation and sound waves, which caused bubbles to form, grow, and then finally implode, at which point locally high temperatures and pressures were generated. Hydrodynamic shock code simulations indicate that the temperature within these collapsing bubbles can reach 10^6 to 10^7 K, which is sufficient for some D-D fusion reactions to occur.

Taleyarkhan's results have largely been refuted and he was ultimately found guilty of research misconduct while a faculty member at Purdue. With all the activity, predictions, and controversy involved, no one investigated the spectrum of the emitted light, where the ultimate proof or disproof could be quantified. This was because that experiment is difficult to do and a great deal of data is required before declaring knowledge of the temperature range involved. With the availability today of fiber optic spectrometers, that data is much easier to obtain.

There are two broad classes of sonoluminescence: multi-bubble (MBSL) and single bubble (SBSL). MBSL in non-aqueous fluids seems to be significantly more optically intense than MBSL in water; moreover, MBSL in degassed ethylene glycol is around 5 to 6 times brighter than in water. Of more interest in particular, SBSL generally shows the opposite effect- having a much greater brightness in water than in non-aqueous liquids, the exception being ethylene glycol. After conducting experiments with SBSL in degassed ethylene glycol, we determined that the emitted light is 3 to 4 times brighter than in water, which makes it an ideal test liquid for SBSL. A photograph of four bubbles is shown in Figure 1 below. [2]

The experiment can be conducted without any additional equipment costs or costs for the liquid being used. Usually a driver horn is set on top of the degassed liquid, producing a bubble on the order of 1 μm. This bubble has a defined orbit and can be held in a stable position for over an hour at a temperature of roughly 20 degrees Celsius. The light emitting bubble is easily observed using a microscope or CCD camera, making the characterization of the behavior of the bubbles a reasonably simple task. What remains unexplained is the emission of light itself, just at the moment of bubble collapse. The light emitted can go well into the ultraviolet range and a simple calculation implies that the total emitted light energy is greater than the energy put into the system. This is naturally an indication of some hidden physics taking place in the system. The duration of the light flashes is roughly 10 picoseconds making analysis difficult, but all the more interesting. Examination of the flashes indicates (again using a simple, perhaps too simple calculation) that the temperature inside the bubble at the moment of the emission is at minimum 10,000 degrees Celsius, and possibly over 1,000,000 degrees. Indeed, the short duration of the flashes and the limited understanding of the phenomenon make it considerably difficult to conclude how and why sonoluminescence occurs at all.

Research in sonoluminescence is not particularly complicated but it is tedious; close observations and rigorously controlled environments are required to get accurate data on the bubbles and flashes. Repetition is the only way to get enough statistical data to support any theory. The properties of the liquid itself do not seem to play a critical part in the SBSL effect. It has been observed in many types of liquids over the years and this fact is the impetus for much of the sonoluminescence work being done today.

The sonoluminescence research project at UAH was inactive until recently when a graduate student of mine, Srikamal Soundararajan, expressed an interest in the topic. The system is again up and working well thanks to him, and with a student's assistance, we should be able to capture reliable spectra using a fiber optic spectrometer. Initial data has already been collected, but it will take sustained work before any theory of why sonoluminescence occurs can be defended.

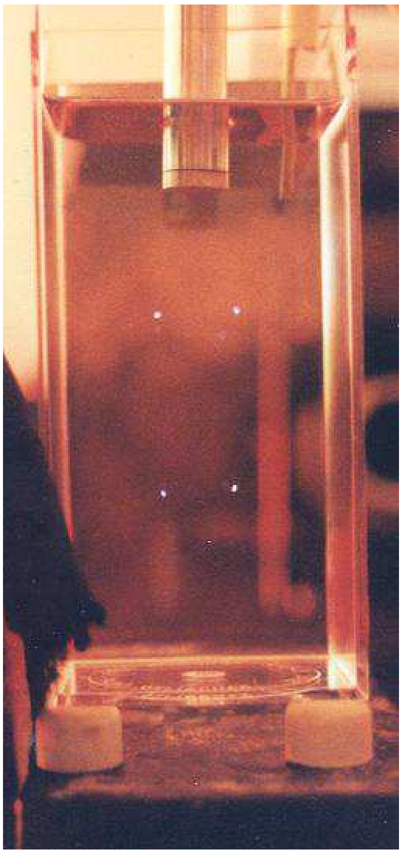

Fig. 1: SL Bubbles in Water

References

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2. "Temporally Stabilized Sonoluminescence in Ethylene Glycol", Fred B. Seeley, Don A. Gregory, Shane Thompson, and Jeremiah D. Brown, *Acous. Res. Lett.*, Vol. 6, No. 1, Jan, 2005, p.48

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