From the perspective of humans, amphibians represent a storehouse of pharmaceutical discoveries as they carry valuable substances. Some of these compounds are already used as painkillers and in treatment of victims of traumas ranging from burns to heart attacks. Several amphibians have also been investigated for their antibacterial and antiviral properties. As amphibians disappear, potential cures for a number of maladies go with them. Save frogs and yourself as well!

ACKNOWLEDGEMENTS. I thank Gerald Durrell Memorial Fund of Jersey Wildlife Preservation Trust, United Kingdom for providing financial support and Coimbatore Zoological Park and Conservation Centre for academic cooperation.

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## RESEARCH NEWS

# Resolving single bubble sonoluminescence flash width

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Single bubble sonoluminescence (SBSL)[1], first studied and observed by Gaitan *et. al.*[2], is the phenomenon of light emission from a single gas bubble trapped at the pressure maximum of a resonant sound field in a liquid medium, generally water. One of the most striking aspects of SBSL was the estimated optical flash width being less than 50 picoseconds (ps)[3]; this upper estimate was based on the relative response of a SBSL flash in comparison to a 34 ps laser pulse using a microchannel plate-photomultiplier tube (MCP-PMT). Moran *et al.*[4] put the estimate to be less than 12 ps using a streak camera; however, there have been some questions raised on the accuracy of these measurements[5]. Most recently, two groups, Gompf *et al.*[6] and Hiller *et al.*[7] have resolved the optical flash width of SBSL using Time-Correlated Single Photon Counting (TC-SPC) technique which is well established[8] in fluorescence decay time measurements. We first summarize the results from these two contributions, then briefly describe the technique and finally consider the implications of this important new development.

Previous studies have shown that the SBSL intensity is sensitively dependent on the type and concentration of the dissolved gas in the liquid, the acoustic drive pressure amplitude and the temperature of the liquid medium. Gompf *et al.* have found the measured SBSL flash width (characterized by full width at half-maximum, FWHM of the optical pulse) at room temperature to increase from about 60 ps at low gas (air) concentrations and low driving pressures to more than 250 ps at high gas concentrations and driving pressures near the upper threshold of SBSL. Hiller *et al.* find the flash widths to range from 35 ps for a bubble formed in a 20 torr solution of air in water at room temperature to 380 ps for a 300 torr solution of 1 per cent xenon in oxygen cooled to 4°C. They also found that for the same flash intensity, helium and xenon bubbles have the same flash widths, whereas it is smaller by a factor of about 3 for air bubble. Another very important finding which is common to both the groups is the fact that the measured flash widths are independent of the wavelength of light over a range of 200 to 800 nm. This type of information is only possible by the use of TC-SPC method to characterize SBSL flashes.

As pointed out by Gompf *et al.*, to understand the principle behind the method, it is useful to consider a normal TC-SPC experiment as it is used to determine the fluorescence decay times. A short laser pulse, ideally much shorter than the decay time, excites the sample, and at the same time a fraction of this laser pulse acts as the start signal of a time-to-amplitude converter (TAC). The arrival of the first fluorescence photon is detected with a fast PMT which stops the TAC. Thus the time interval between the exciting laser pulse and the arrival of the first fluorescence photon is measured and stored in a multichannel analyser (MCA). Fluorescence is a random event and measuring the arrival time of the first emitted photon over a large number of events, typically $10^5$, and storing each time in the MCA then reconstructs the time-resolved decay. The main advantages of this method are (1) the good time resolution of about 10 ps, (2) the low intensity one needs for detection, (3) the high dynamic range and (4) the ability to discriminate different pulse shapes in different regions of a broadband optical spectrum. In contrast to fluorescence lifetime measurements, in the case of SBSL experiments, the TAC is started with a first photon from the SL pulse itself and it is stopped with the second photon from the same pulse. Since the start and stop pulses have the same statistical distribution, one then measures the autocorrelation of the pulse shape and the SBSL flash width can be obtained by deconvolution. The instrument width is determined with the help of a femtosecond laser pulse. Since TC-SPC is a sampling technique, an essential condition is that the pulse width be stable within measuring time. This to a large extent is satisfied in the case of SBSL; however, both Gompf *et al.* and Hiller *et al.* point out that the major source of error in their experiments are variations in bubble intensity, and a slow drift in the bubble contents if the experiments run over a long period. Both the groups have used electronic components with minimum jitter and MC-PMTs which have a small transit time spread; the claimed accuracy in the measured flash widths is of the order of ± 10% for short pulses and ± 5% for long pulses.

The new experimental findings have confirmed the previous estimate of SBSL flash widths being in picoseconds regime; however, they have now been resolved and found to depend on experimental parameters. The most important observation is that, the flash widths and times of emission of SBSL are independent of wavelength of light. This fact rules out simple adiabatic heating as a mechanism for sonoluminescence since adiabatic compression followed by blackbody radiation would have resulted in flash width being much larger in red than ultraviolet. Further, since the SBSL spectra is broadband and devoid of any features which would suggest line or band emissions, the only possible mechanism for optical radiation is thought to be thermal bremsstrahlung. This, however, would require considerably higher temperatures than theoretical predictions of about 10,000 K on the basis of observed and also computed collapse of a typical sonoluminescing bubble from a maximum radius of about 40 μm to submicron size. Much higher temperatures are predicted if one includes the possibility of formation of a shock wave inside the bubble, during the bubble collapse phase. Then there is a mechanism for secondary energy focusing in the form of shock strengthening as it converges to the centre of the bubble and formation of high energy state in the form of 'cold' plasma for a very brief duration. Therefore, although the mechanism of emission in SBSL is still to be identified conclusively, the 'plasma' model of Moss *et al.*[9] which includes the above feature, seems to predict more aspects of SBSL than other models.


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# Drifting mantle plumes, mobile hot spots and island chains

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An examination of the global pattern of volcanisms shows that they are mostly connected with tectonic plate boundaries (divergent and convergent), while a few are located far away from such boundaries, as intra-plate or mid-plate volcanoes. The magma for most of the plate-boundary related volcanism arises from the asthenosphere, a seismically low velocity mushy or soft layer at the bottom of lithosphere; they may also be eruptions of refined fractions of basalt differentiating in a magma chamber or remelted continental rocks or oceanic crust sinking into the asthenosphere. The mid-plate volcanoes, on the other hand, appear as elevated domes, far from these plate boundaries and compositionally too, they do not seem to be related to plate margin volcanism. These intra-plate volcanoes, better known as hot spots, have their source direct from the mantle. Classic examples of intra-plate volcanoes are the many island chains dotting the Pacific plate, prominent among which is the Hawaiian group, stretching from Hawaii all the way up to the Aleutian trench (Figure 1 *a*). Most members of this chain appear above the sea-surface as extinct, aseismic volcanic islands, except for the island of Hawaii, where the volcanism is still active and associated with seismicity. A few in this chain, however, remain as undersea mountains and ridges of varying heights. Presently, more than 120 hot spots have been reported around the world, on both oceanic and continental plates (Figure 2).

With the advent of plate tectonic concept during 1960s, geologists began to recognize links between the plate motions and development of island chains. Tuzo Wilson, the Canadian geophysicist, explained that the intra-plate volcanic ridges or islands are actually upwellings of ascending plumes of magma, as the plate moved over a mantle hot spot (see inset, Figure 1 *a*), this volcanism ceasing as the plate moved away from the hot spot[1,2]. Developing these ideas in the 1970s, Dietz and Holden[3] demonstrated, how the trend of these ridges indicated the direction of plate motion, while Jason Morgan[4,5] introduced the notion of fixed hot spots and showed that the island chains of Hawaii–Emperor, Tuamota-Line and Austral-Gilbert-Marshall are volcanic products arising as the Pacific plate rotated around a pole-axis over three fixed hot spots. Such plate movements result in progression of age of the islands away from the hot spot, as seen very well in the Hawaiian and Emperor Seamount chains. Here, the oldest of the islands, dated 80 m.y., is farthest from the present day hot spot site and the youngest one, just 800,000 years old, is at the hot spot site, beneath the island of Hawaii. Likewise, the Kerguelen Plateau hot spot volcanism, in the far south Indian Ocean, is supposed to have given rise to the Kerguelen islands (oldest of which is about 115 m.y. and youngest 38–0 m.y.) and also the N–S trending Ninetyeast Ridge, stretching from Broken Ridge (30°S, 38 m.y.) northwards to the Andaman group (13°N, > 83 m.y.) in Bay of Bengal, the former associated with separation of India from Australia–