

TeachSpin SL100B Apparatus
Operating Instructions
By Jonathan Hillel

The observation of Sonoluminescence requires a specific set of experimental conditions, which can be established by following the procedure outlined herein. An additional requirement is luck, which you will have to find on your own. These instructions are meant to be used in conjunction with the TeachSpin SL100B Manual (in the red binder); the manual describes how the apparatus works and these instructions relate the proper procedure for using it.

Sonoluminescence is a phenomenon whereby a gas bubble in a liquid collapses under pressure and emits visible light. The SL100B apparatus provides two cells to contain water and an ultrasonic horn for driving sound waves in the water. When a stable standing wave is established, a bubble inserted in the water will be trapped at the antinodes of the wave. If the amplitude of the wave is large enough, the bubble will collapse and sonoluminesce.

When ordinary water in a cell is subjected to sound waves, bubbles seed spontaneously and disrupt the stability of the standing wave. To prevent this, the water is degassed prior to usage by pumping on it with a vacuum pump. To degas the water:

- Ensure the oil level in the vacuum pump is sufficient.
- Fill the glass flask with about 1L of water and insert the black rubber stopper.
- Close the main valve coming from the stopper (turn clockwise), and tighten the pinch-valve on the T-Junction to close it.
- Turn on the vacuum pump and then open the valve coming from the stopper.
- Let the pump operate for 20-30minutes. The tube coming from the stopper should not be kinked while the pump is operating – the pinch-valve can be hooked onto the handle of the main valve to prevent kinking.
- ***Before turning off the vacuum pump***, close the main valve. (Otherwise, negative pressure from the flask will suck oil out of the pump.)
- Slowly open the pinch-valve from the T-Junction.
- Slowly open the main valve, and remove the rubber stopper. The water is now ready to be used.

The SL100B Apparatus includes two cells, one small rectangular-prism and one larger cylinder. The larger, cylindrical cell is attached to a Peltier cooling module, which cools the water and allows investigation of temperature effects. The smaller cell is easier to use, and is recommended for first trials.

Fill the cell up to 10cm with degassed water. (The 10cm mark is marked with pen on the rectangular-prism cell and with tape on the cylindrical cell.) Firmly screw in the 18" aluminum pole to its mount on the cell base with the Allen key, and mount the horn such that its tip is submerged about 1cm below the surface. Figure 1, below, illustrates the setup:



Figure 1 - SL100B Apparatus Setup¹

The ultrasonic frequency for driving the horn is generated by the Ramsey Audio Generator and amplified in the control box. If the volume level on the Ramsey Generator is too high, it will damage the control box circuitry. To set the volume level, connect the output of the Ramsey Generator to the Cell Transducer input and raise the volume level until the Cell Amplitude meter reads 4V. (Note: this should be done at an ultrasonic frequency.) Then, make the following connections:

- Audio Generator output to Function Generator input on control box (BNC).
- Cell Transducer output from cell to input on control box (BNC).
- Cell Transducer output and High Frequency output on control box to oscilloscope channels (two BNCs).
- Horn Power output on control box to black 3mH inductor box (TNC), black inductor box to horn (TNC). (Directionality on the inductor box does not matter.)
- Neutrik multi-pin cable from the control box to the cell.

Drive the horn at maximum power while varying the frequency in order to find the standing wave resonances. For either cell, there should be a resonance around 27kHz; however, this frequency causes the horn to rattle and is unusable for trapping bubbles. In the rectangular-prism cell, frequencies of around 28kHz and 47kHz tend to work. In the cylindrical cell, frequencies around 45kHz tend to work. The procedure in the TeachSpin manual for establishing resonance in the cell should be followed to set up a stable standing wave of high amplitude (more than 5V) at maximum drive power.

¹ Figure from TeachSpin website: <http://www.teachspin.com/products/sonoluminescence/index.html>

With resonance established, lower the drive to about 4V. Bubbles are inserted into the cell using one of the elongated eyedroppers. (The burner filament described in the TeachSpin manual draws excessive current from the control box, and should not be used.) The eyedropper with the looped tip tends to work the best for creating small bubbles. Also, it has a tiny air hole in the squeezing part to allow air to re-enter – this hole should be covered when inserting bubbles. Once bubbles are trapped (ie, stationary in the water), remove the eyedropper from the cell.

Sonoluminescence can now be observed. Turn off the lights in the room, and also turn off the oscilloscope and any other sources of ambient light. Increase the driving amplitude and closely observe the cell. After a short time, tiny, instantaneous blue flashes should be visible from within the cell. One may also observe a flickering light from particular places in the cell.

In addition to being a very “cool” phenomenon, sonoluminescence has several interesting properties. Possible investigations may focus on:

- Temperature dependence of the intensity of the light (using either the Peltier cooler or an ice bath/hot plate).
- Frequency and amplitude dependence
- Emission time (using the photomultiplier tube – consult your supervisor beforehand)
- Node structure in the cells (using the Hydrophone), and the physics behind trapping bubbles

For more information, consult the TeachSpin Manual, as well as the research paper included at the back of the binder. The TeachSpin website: <http://www.teachspin.com/products/sonoluminescence/index.html> is also helpful.