SUPPORTING INFORMATION

The general experimental setup for single bubble sonoluminescence (SBSL) studies consists of a resonator cell coupled to a spectral acquisition system as shown in Figure S1.

In the following paragraphs an overview of the resonator cells with different geometries and main requirements is given. Based on this the development of the resonator cell used in our studies is described. In total we developed four different resonator cells that differ in their geometry. These were used to identify the main parameters for a high intensity of the standing wave. The final cylindrical cell operates at a resonance frequency of 27 kHz. Temperature, gas nature, and acoustic pressure of the sample can be controlled.

Overview of resonator cells and main requirements

Studies on SBSL require a stable acoustic standing wave that traps a single gas bubble at its antinode. There the gas bubble oscillates in phase with the driving frequency. This effect underlies the operation of a resonator cell driven at one of its resonance frequencies. The cell (acoustic trap) varies in geometry and size depending on its application. In table S1 the general geometries used for SBSL are presented such as spherical,[19] cylindrical,[3] and cubical,[30] cells with one or two piezoelectric driving elements glued to the bottom or to the sides, with working frequencies between 20 and 30 kHz. Their theoretical resonance frequencies can be estimated using equations S1, S2 and S3.[31]

$$f_r = \frac{c}{2}\sqrt{2\left(\frac{1}{l_x}\right)^2 + \left(\frac{1}{h}\right)^2}$$

Equation S1. Resonance frequency of a rectangular resonator.

$$f_r = \frac{c}{2\pi}\sqrt{\left(\frac{2.4048}{R}\right)^2 + \left(\frac{n\pi}{h}\right)^2}$$

Equation S2. Resonance frequency of a cylindrical resonator.

$$f_r = \frac{cn}{2R}$$

Equation S3. Resonance frequency of a spherical resonator.

Where the speed of sound *c* in m/s, the resonating mode *n* (in our case equal to one), the dimensions of the rectangular resonator $l_{x,y}$ and the water height *h* or the radius *R* of a cylinder in m, determine the resonance frequency f_r in kHz.

With the help of these equations the dimensions of the cell to obtain a given driving frequency can be calculated. This frequency also determines the properties of the electrical LCR circuit which includes the capacitor-like piezoelectric transducer. The circuit consisting of an inductor L (coil with inserted metal rod) and a resistance R is used to swap the alternating current signal for one with a large alternating potential difference to drive the PZT with the maximal potential difference. In our case a resistance of 1 Ω was chosen and the inductance of the inductor L was determined with equation S4[31] giving a range of 5.1-52.4 mH.

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

Equation S4. resonance frequency f_r of an electrical circuit consisting of an inductor L, Further requirements for ideal conditions of high SL intensity is first temperature control, since SL is highest at low temperatures and second tightness of the reactor cell since SBSL is very sensitive to the nature and amount of the gas dissolved in the sample. Also the cell has to be transparent in the UV range.

Thus we could choose between three different geometries that fulfil the requirements listed above. Most suitable appeared the geometry of a cylindrical cell, since it has less difficulties with optical imaging compared to a spherical trap[32] and is easer to tighten and cool as a cubic cell. A cubic cell which is known from literature[31] to produce stable SBSL is used as a reference for the acoustic field required for stable SBSL.

Development of the resonator cell

The reference cell, a manufactured cubic shaped glass cell (cell 1 in Tab. S2) obtained from Hellma, is used to determine the limits of stable SBSL: 1.1-1.5 +/- 0.2 bar. The other four cells have a cylindrical geometry and are summarised in table S2. To seal the cylindrical cells a steel cap (Fig. S2 C) holding the hydrophone, thermometer, manometer, septum inlet for bubble introduction, and gas in- and outlet tubes is used. The resonator cells 2 and 3 consist of three parts: first the resonator cell itself which is out of glass with or without a quartz window (diameter 2 mm), the second part is a steel foot with a glass membrane glued to it with the PZT transducer on its bottom (Fig. S2 A/B). The same foot is used for reactor 4. To the bottom of the foot a cylindrical shaped piezo ceramic transducer (PIC155, diameter 20 mm, thickness cm, f = 1 MHz) obtained from PI ceramic was glued using a two component glue (UHU plus endfest 300). During the preparation of the glue it is important to keep the amount of gas bubbles inside the glue as low as possible to reduce wave attenuation. The drying time at room temperature takes at least 24 hours. This glue layer and the transmission property of the glass bottom cause the difference between the theoretical and experimental resonance frequencies (Tab. S2). Also it should be noted that changes in the ambient temperature and water evaporation can cause a drift of the resonance frequency. A needle hydrophone is used to find the resonance frequency of the vessel.

The cells were characterised by detecting the acoustic pressure evolution in the liquid at a constant water height of 4 cm and a constant PZT driving voltage (Fig. S3) with increasing distance of the hydrophone from the PZT. From these data we can localise the antinode, which corresponds to the maximum of the standing acoustic wave, at a height of 1.8 cm which also determines the position of the cavitation bubble.

In the next step the hydrophone placed at the antinode is used to detect the acoustic pressure in water at room temperature with increasing voltage at the PZT while the cell is driven at its fundamental resonance frequency. The response of the hydrophone to the voltage applied at the PZT is displayed for all cells in Figure S4. In the first cell SBSL was observed within the range of 1.1 – 1.5 (+/-0.2) bar and a PZT voltage of 80-105V. These ranges were defined as required for an ideal resonator cell. In cell 2 the minimal acoustic pressure for SBSL can only be reached with a voltage twice as high as in cell 1. In cell 3 this acoustic pressure is not reached even at higher voltages. The comparison between cells 2 and 3 leads to the conclusion that a lowered symmetry of the cell results in a much stronger energy dissipation lowering the US field intensity of the standing wave.

In the next step a quartz cylinder with a cooling jacket (cell 4 in Tab. S2) was tested. The comparison of the hydrophone signal in the presence and in the absence of a cooling liquid in the jacket (black and blue curves in Fig. S4) reveals a strong difference. Without cooling liquid the acoustic pressure is as high as in cell 1 while in the presence of the cooling water the acoustic pressure remains at a constant pressure of 1.4 bar even with increasing voltage at the PZT. Besides, formation of bubbles was observed in the cooling liquid, indicating that US was dissipated in the cooling jacket and degassing the cooling liquid.

Thus only in reactors 1, 2, and 4 without cooling water a sufficiently high acoustic field can be established to trap a single gas bubble. The main parameters that cause strong energy dissipation were identified to be first the symmetry of the bubble trap and second an adjacent cooling liquid.

Taking these results into account and the requirements of UV transparency cell 5 made out of quartz was prepared and used for all SBSL studies. The liquid cooling was achieved via a silicon tube wrapped around the cell.

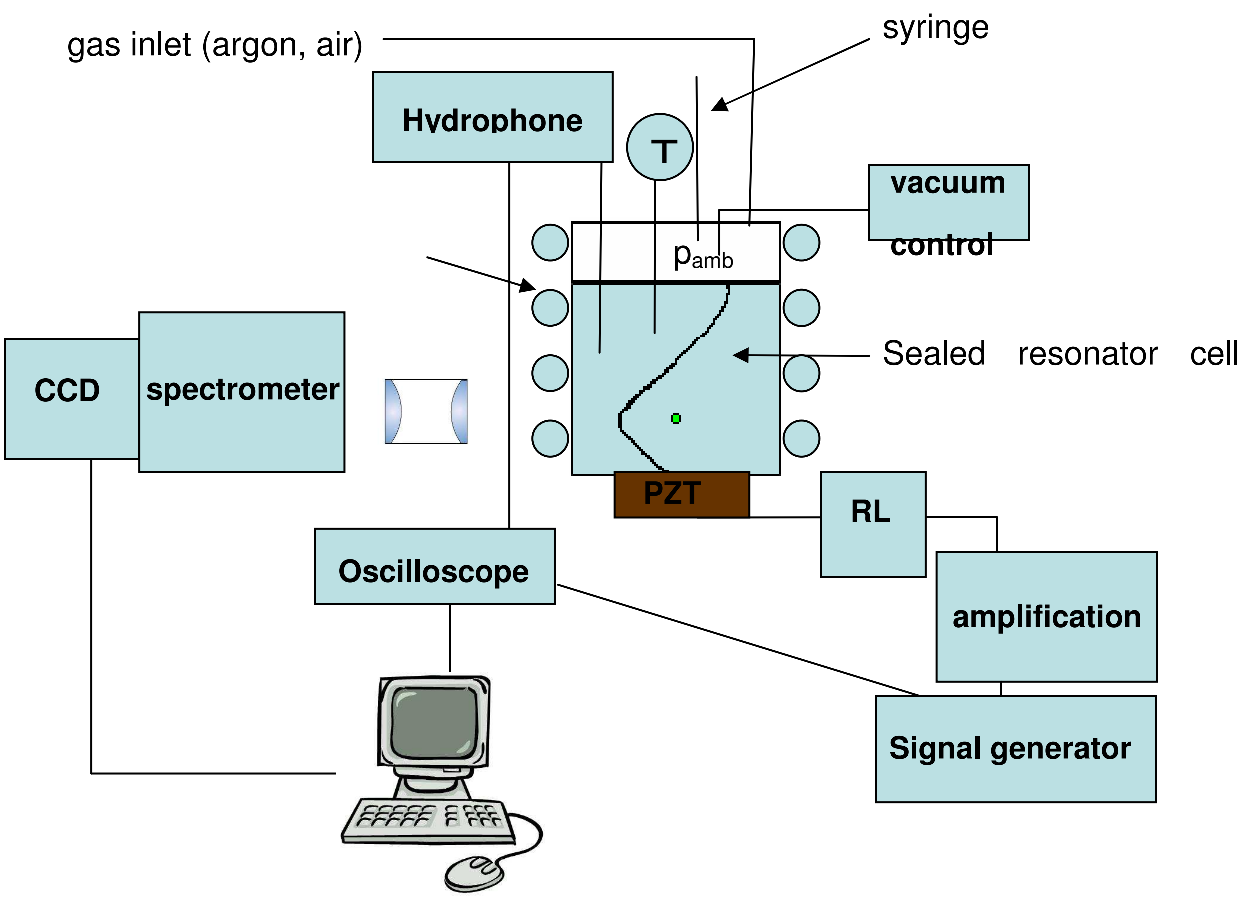

Figure S1. Experimental setup to detect single-bubble sonoluminescence; for details see manuscript text.

Cell shape	f_R	Dimensions/ volume
cubic	23.3 kHz	5 cm[31]
cylindrical	21-25 kHz	3.6 cm height 7.5 cm o.d.[3]
spherical	25 kHz	100 mL[24]

Table S1. Example for different geometries of typical acoustic resonators cells found in literature.

Cell number	(1)	(2)	(3)	(4)	(5)
Resonator cell					
height of reactor	5 cm	16.5 cm		16.5 cm	9 cm
inner diameter	-	5.2 cm		5.2 cm	5.2 cm
reactor volume	100 mL	139 mL	145 mL	126 mL	180 mL
specification	Open system	SF	SF Quartz window	CJ SF	Quartz
experimental f_R theoretical f_R for 4 cm height (h)	25.2 kHz 24.9 kHz	27.2 kHz 27.8 kHz	29.9 kHz 27.8 kHz	28.8 kHz 27.8 kHz	28.5 kHz 27.8 kHz

Table S2. Resonator cells tested (CJ: cooling jacket, SF: steel foot with a PZT).

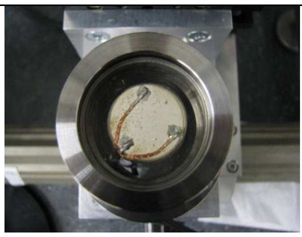		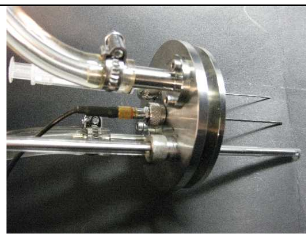	
A	B	C	D

Figure S2. A+B: steel foot with PZT for cells 2, 3 and 4 in Table S2; C: steel cap holding the syringe, hydrophone and thermocouple for cells 2 to 5 in Table S2; D: cooling jacket for cell 5 in Table S2.

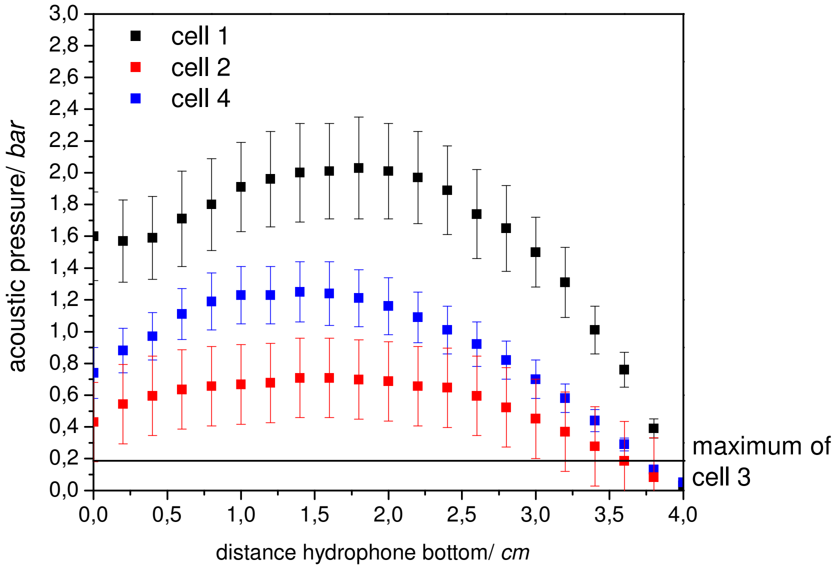

Figure S3. Propagation of the acoustic pressure from the bottom to the top of the resonator cell, for cells 1 to 4.

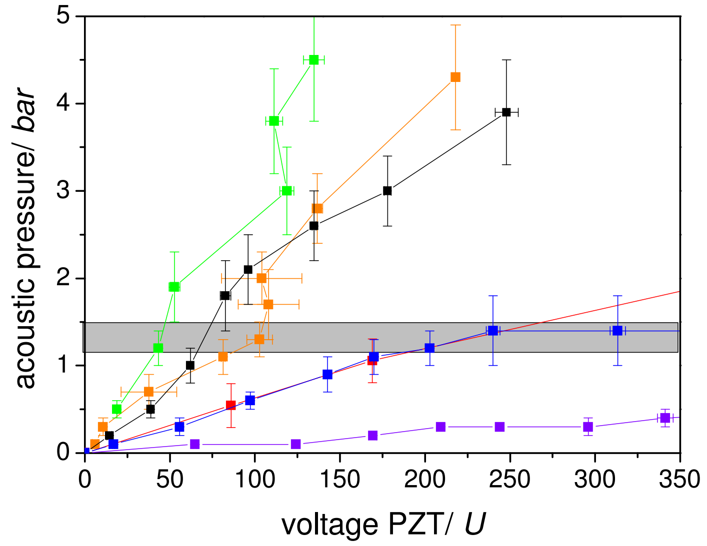

Figure S4. Voltage in V applied at the piezoceramic transducer (PZT) vs. acoustic pressure for cell 1 (orange), cell 2 (red), cell 3 (violet), cell 4 (black without cooling liquid, blue with cooling liquid), and cell 5 (green); grey zone is the threshold for stable SBSL.

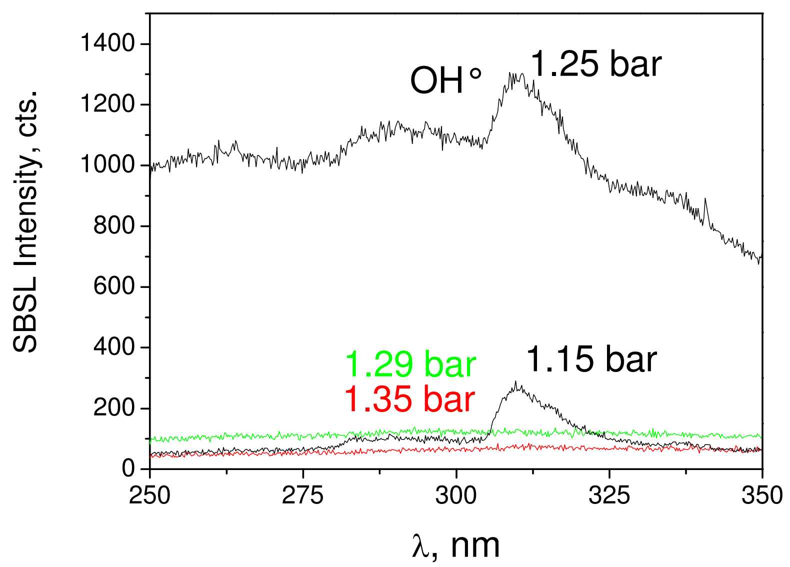

Figure S5. SBSL spectra of water with 70 mbar of argon at P_{ac} 1.15 and 1.25 bar (black); water containing 1mM of sodium dodecylsulfate with 70 mbar of argon at Pac 1.29 and 1.35 bar (green and red).