The Microfluidic Jukebox
Supplementary Information

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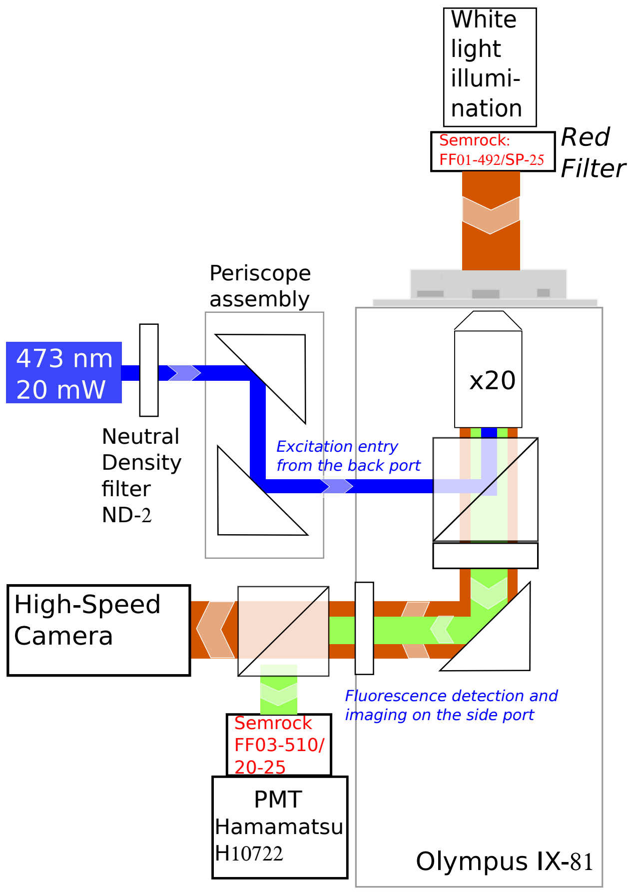
SUPPLEMENTARY INFORMATION: OPTICAL SETUP

The setup is similar to previously described systems [1]. The chips are mounted on a Olympus IX81 Microscope equiped with a MBL 473 nm laser at 20 mW output power. The laser is reflected by a dichroic miror and focused throught the microscope objective into the channel. A droplet containing fluorescein emits a fluorescence light when flowing through the laser. The fluorescence signal is transmitted by the dichroic which also reflects the backscattered laser light. A notch filter absorbs the remaining scattered light in order to keep only the fluorescence signal. This filtered signal is then reflected on a second dichroic towards a photomultiplier (PMT), powered at ± 15 V (ALR 3003 ELC). The PMT gain is controlled by a 0.1-0.4 V voltage (AL841B ELC), or alternatively by a Labview input/output card and home-made routine. A typical PMT signal is shown in Figure 1. The PMT output is connected to the computer through the audio card which digitalize the signal (AD converter; 44.1 kHz sampling rate and 16 bits depth).



SUPPLEMENTARY FIGURE 1. Laser induced fluorescence set up for droplet measurement. The PMT is further connected to the audio card of a computer.

SUPPLEMENTARY INFORMATION: SCORES

We demonstrate the capabilities of our instrument with two classical scores, ‘Ode to Joy’ (Beethoven) and ‘Flight of the Bumblebee’ (Korsakov).

(a)

(b)

SUPPLEMENTARY FIGURE 2. Scores of the songs played in the Supplementary Audio files (a) ‘Ode to Joy’; (b) ‘Flight of the Bumblebee’.

SUPPLEMENTARY INFORMATION: SCALES, NOTES AND FREQUENCIES

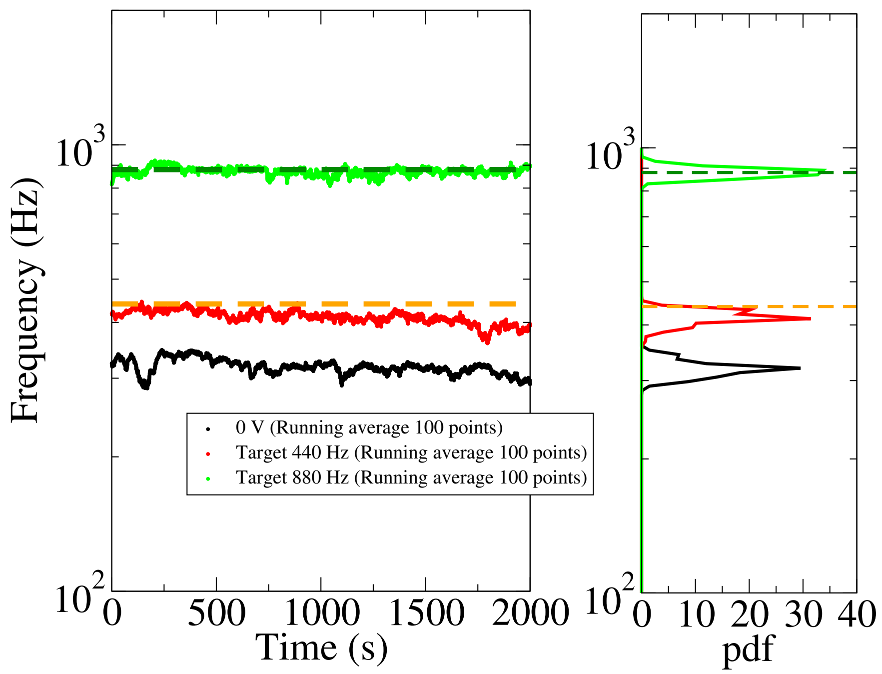
We converted the notes into frequency using the Equal Temperament scale, for an A at 440 Hz (Supplementary Table I) [2]. In this scale, the ratio between to successive half tones is $2^{1/12}$. The notes at higher and lower frequencies are obtained from this table by multiplying (higher octave) or dividing (lower octave) the frequencies by a factor of 2. The frequency shift between a note in the just intonation and in the equal temperament is at most 2%, which compares with the accuracy obtained for microfluidic droplet production.

Note	Note	Just intonation	Equal temperament
DO	C	264,00	261,63
DO ♯	C ♯	275,00	277,18
RE	D	297,00	293,66
MI ♭	E♭	316,80	311,13
MI	E	330,00	329,63
FA	F	352,00	349,23
FA ♯	F ♯	371,25	369,99
SOL	G	396,00	392,00
SOL ♯	G ♯	412,50	415,30
LA	A	440,00	440,00
SI ♭	B ♭	475,20	466,16
SI	B	495,00	493,88
DO	C	528,00	523,25

SUPPLEMENTARY TABLE I. Relationship between notes and frequency in two classical scales (Just intonation and Equal Temperament). We used the Equal Temperament scale where the frequency ratio between successive half-tones is $2^{1/12}$.

SUPPLEMENTARY INFORMATION: STABILITY

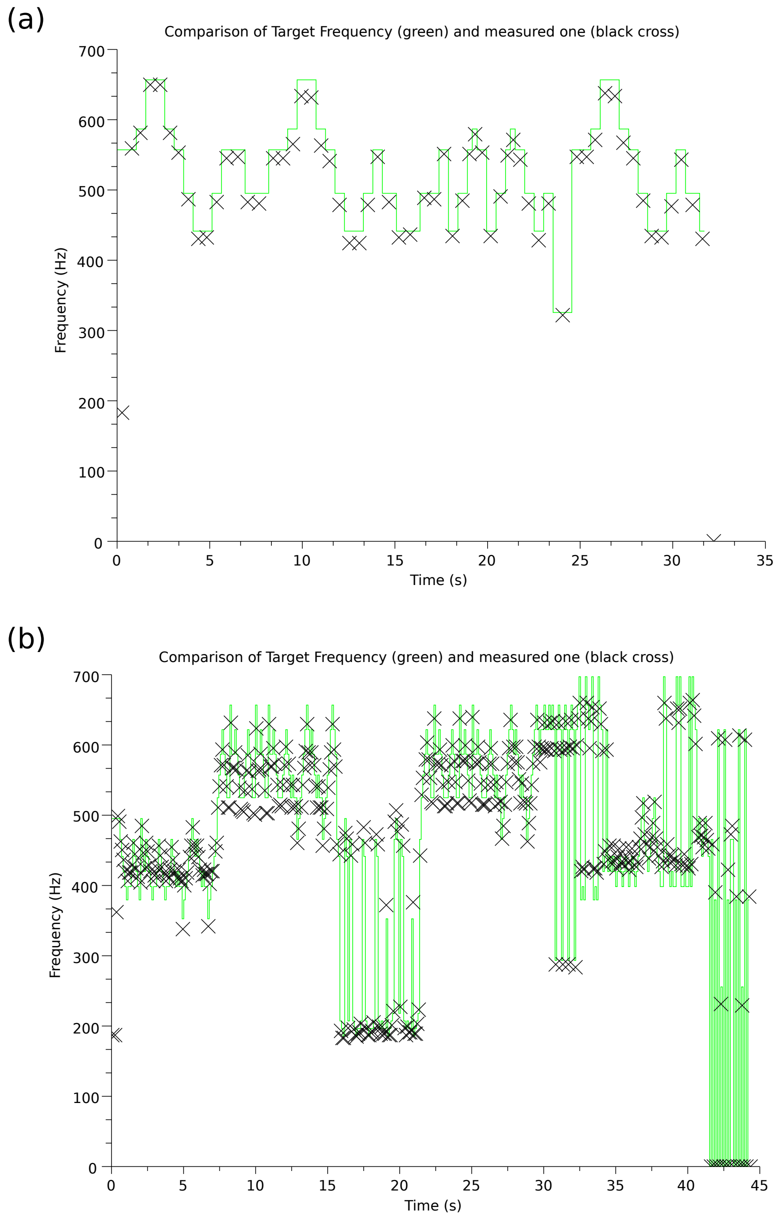
We measure the droplet frequencies as a function of time over periods of 2000 s for given sets of electrical and hydrodynamic conditions. We show here the results for three test cases: without field and with field targetting two different A at 440 Hz and 880 Hz. Without field, the variability in the frequency measured as the standard deviation divided by the mean is 3.8% and corresponds to standard droplet polydispersity reached in droplet based microfluidics. With field, we obtain 3.6 % and 2.5 % for the 440 Hz and 880 Hz cases respectively. The difference between the mean and the target frequency is 7.3 % and 1 % for the 440 Hz and 880 Hz respectively. This difference is mainly coming from the variability of the frequency between the time of the calibration and the time where the note is played. This can be seen at 440 Hz where the agreement between the note played and the target is smaller at short times (below 500 s).



SUPPLEMENTARY FIGURE 3. Stability of the note as a function of time for three test cases: no field applied (black), 440 Hz taget and 880 Hz target. Frequencies as a function of time (left) and distribution of the frequency over the whole measurement window (right). The stability corresponds to values of droplet polydispersity as obtained in standard microfluidic flow focusing geometries.

SUPPLEMENTARY INFORMATION: ACCURACY

The accuracy in playing specific notes as a function of time is represented in Supplementary Figure 4.



SUPPLEMENTARY FIGURE 4. Accuracy in playing the target notes for (a) 'Ode to Joy'; (b) 'Flight of the Bumblebee'. The first note is missplayed as a result of device initialisation. The notes are mainly played within a ± 5 % accuracy (See Figure 4 of the main text).

SUPPLEMENTARY FILES

File	Type	Experiment	Flow rates
Movie01	.avi	Droplet production 0 V	$Q_d = 50\ \mu$L/hr
			$Q_c = 400\ \mu$L/hr
Movie02	.avi	Droplet production 600 V	$Q_d = 50\ \mu$L/hr
			$Q_c = 400\ \mu$L/hr
Movie03	.avi	Droplet production 1000 V	$Q_d = 50\ \mu$L/hr
			$Q_c = 400\ \mu$L/hr
Movie04	.avi	Switching 40 Hz	$Q_d = 75\ \mu$L/hr
			$Q_c = 500\ \mu$L/hr
Movie05	.avi	Switching 40 Hz	$Q_d = 200\ \mu$L/hr
			$Q_c = 1600\ \mu$L/hr
Movie06	.avi	Switching 400 Hz	$Q_d = 200\ \mu$L/hr
			$Q_c = 1600\ \mu$L/hr
Audio01	.wav	*'Ode to Joy'*; Beethoven	$Q_d = 100\ \mu$L/hr
			$Q_c = 300\ \mu$L/hr
Audio02	.wav	*'The Flight of the Bumblebee'*; Korsakov	$Q_d = 100\ \mu$L/hr
			$Q_c = 300\ \mu$L/hr
Calibration	.avi	Calibration / Tuning	$Q_d = 90\ \mu$L/hr
		Video and Sound	$Q_c = 275\ \mu$L/hr
OdeToJoy	.avi	*'Ode to Joy'*; Beethoven:	$Q_d = 90\ \mu$L/hr
		Video and Sound	$Q_c = 275\ \mu$L/hr

[1] Jean-Christophe Baret, Oliver J Miller, Valerie Taly, Michal Ryckelynck, Abdeslam El-Harrak, Lucas Frenz, Christian Rick, Michael L Samuels, J. Brian Hutchison, Jeremy J Agresti, Darren R Link, David A Weitz, and Andrew D Griffiths. Fluorescence-activated droplet sorting (fads): efficient microfluidic cell sorting based on enzymatic activity. *Lab Chip*, 9(13):1850–1858, 2009.

[2] Harry F. Olson. *Music, Physics and Engineering.* Dover Publications, 1967.