Acoustic tweezing of particles using decaying opposing travelling surface acoustic waves (DOTSAW)

JIA WEI NG, CITSABEHSAN DEVENDRAN and ADRIAN NEILD
Laboratory for Micro Systems (LMS), Department of Mechanical and Aerospace Engineering, Monash University, Clayton, Victoria 3800, Australia

*Corresponding author: Laboratory for Micro Systems, Department of Mechanical and Aerospace Engineering, Monash University, Clayton, Victoria 3800, Australia.; E-mail: adrian.neild@monash.edu

1. Time averaging

When time averaging a function, care needs to be taken in the selection of a suitable time window. In acoustofluidics, typically a single frequency sound wave is used, the period of which is several orders of magnitude shorter than the time scale of particle motion. The effect of increasing the time frame of the time integral of $\cos^2 \omega_1 t$ is shown Fig. S1 (red line), as can be seen, at a timescale of such smaller than that of particle motion (tenths of a second) the value of this time average has settled to 0.5. When two frequencies are used the time required to settle at a fixed value is longer, in the case of the two frequencies used in our experiments, 76.2 and 75.8MHz, a settled value is obtained over a time frame of milliseconds (blue line). However, it is worth noting that when two frequencies are very close together (differing by 20Hz in Fig. S1, green line) the time required for the time average to settle can be larger than that of particle motion, in this scenario constant motion of the particle will occur.

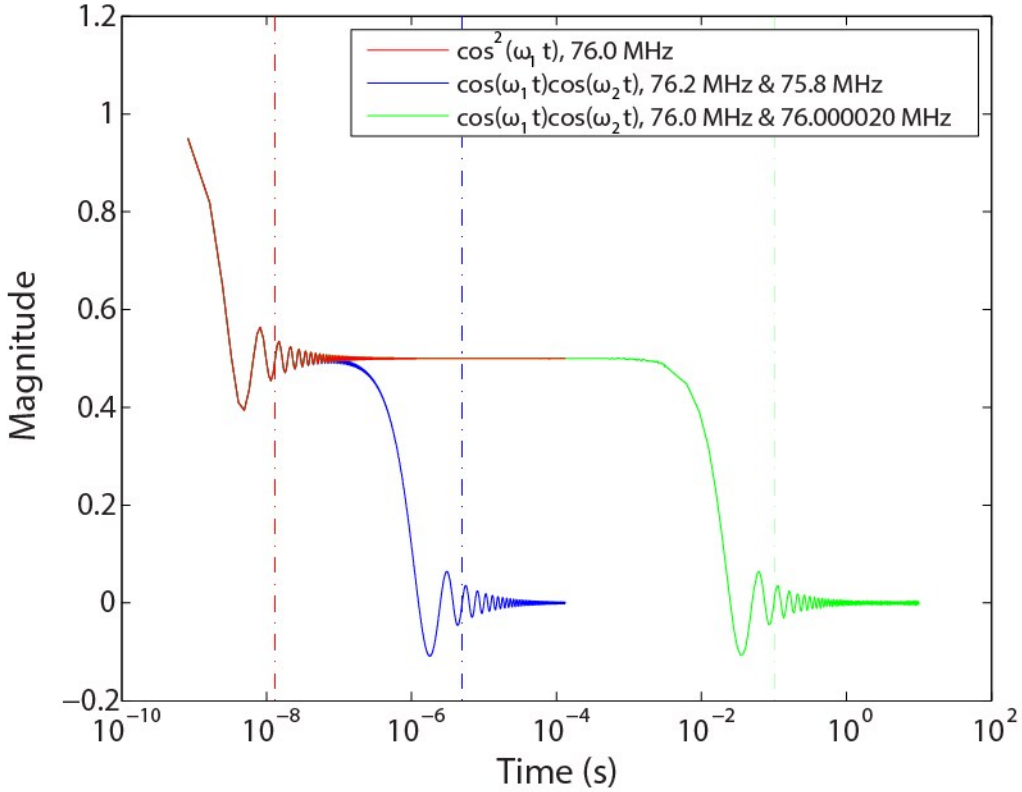

Fig. S1 This figure shows the value of the time averaged trigonometric functions $\cos^2 \omega_1 t$ and $\cos \omega_1 t \cos \omega_2 t$ with varying averaging period. For the term with same frequency $\cos^2 \omega_1 t$, the time averaged value with settles at 0.5, the vertical dotted line indicates the time period of the oscillation. As for the terms with different frequencies, $\cos \omega_1 t \cos \omega_2 t$, the time average values started with 0.5 but will eventually breakdown at a certain time averaging point depending on the difference in frequencies, and settles at zero. Here, the dotted lines show $T = \frac{2\pi}{\omega_1 - \omega_2}$. In our case (the one in blue), this time period T is small (~10^{-5} s) in comparison to the timescale of the net motion of the particles. We can safely assume that the trigonometric term will time average to zero. This assumption will breakdown when the two operational frequencies are very close together, as depicted by the green curve, where the time average value only settles at zero at around 1s.

*Corresponding author: Laboratory for Micro Systems, Department of Mechanical and Aerospace Engineering, Monash University, Clayton, Victoria 3800, Australia.; E-mail: adrian.neild@monash.edu

2. Parameters

Table S1 lists the parameters used in the simulations presented in this work.

Table S1 Parameters used in theoretical calculations

Water		
Density	ρ_0	997 kg m^{-3}
Speed of sound	c_0	1497 m s^{-1}
Compressibility	κ_0	448 TPa^{-1}
Lithium Niobate		
Speed of sound	ρ_{LN}	3994 m s^{-1}
Density	c_{LN}	4700 kg m^{-3}
Polystyrene		
Density	ρ_p	1050 kg m^{-3}
Speed of sound	c_p	2350 m s^{-1}
Poisson's ratio	σ_p	0.35
Compressibility	κ_p	249 TPa^{-1}
SAW actuation parameters		
SAW wavelength (at resonance)	λ_{SAW}	50 µm
Excitation frequency (top)	f_1	76.2 MHz
Excitation frequency (bottom)	f_2	75.8 MHz

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