Author’s Response

Ref. 1 comments:

1. What is the importance of the Reynolds numbers ranging from 1.4E-3 to 2.1E-3 in the context of this study focused on creeping flow? Has the author verified the presence of backward flow and implemented measures to compensate for it in the simulation?

Due to computational limitations, It’s not possible to certainly make predictions about the exact range of Reynolds number in which the cell is completely restrained. However, It’s observed the cell is attracted strongly to Al and Si particles in all these Reynolds numbers 1.4E-3, 2.1E-3, and 3.0E-3.

2. What criteria did the author use to select the dimensions of the channel? The author employs relatively small channel dimensions, such as 250 μm *110 μm *375μm. Are these dimensions sufficient to observe particle trajectories effectively?

The length of the microchannel (250 μm) is chosen in a way that captures the whole trajectory of the particle while not increasing the computational cost, and the height (375 μm) is used to capture $\lambda/4 \approx 370.25\, \mu m$ for a wave with 2 MHz frequency. The width (110 μm) is chosen so that it captures particles of various sizes.

3. In which scenarios would the situation described by the author, where one particle remains stationary while another flows with the flow, typically occur? Additionally, what are the advantages and potential applications of conducting such a study.

By allowing the particles settle for a considerable period of time in a microchannel that is primed with deionized water (DI), due to the absence of detergents particles will stick to the channel bottom or wall (Saeidi et al. 2019). The study has been done to highlight the cell trapping which could be the first step of designing a cell trapping microfluidic device.

4. What time-step does the author employ in the simulation, and how is it determined?

numerical experiments were performed with different time step sizes to identify the optimal balance between computational cost and accuracy which is determined to be $\Delta t = 0.01\ s$. the results have been compared with analytical results.

5. In line 21, the author utilizes two particles with diameters of 4.8 and 25 μm. Could author clarify the rationale behind selecting these specific diameters? Do they correspond to the dimensions of any particular blood cells or other relevant biological entities?

two-particle system of 4.8 μm and 25 μm diameters was used by saeidi et al. in order to demonstrate pronounced particle-particle acoustic interaction effect.

6. In Figure 2, the author focuses on two forces, drag and acoustic. However, the influence of gravity force is not explicitly mentioned. Is gravity force taken into account in the simulation, and if so, what impact does it have on particle motion? This aspect is significant, especially given the low stated Reynolds number, which might prolong particle response time and facilitate settling.

The effect of gravity was thought to be non-significant but further investigation after receiving the comment revealed it's significance and it's included in the manuscript.

7. On line 23, author uses the values as, f = 1.95 MHz, p0 = 75 kPa. What is the criteria to choose these values?

These values are used in the experimental study of Saeidi et al [28] based on the channel cross-section and number of pressure nodes. These values and the whole setup is arranged to enhance particle-particle acoustic interaction.

8. In line 37, the author mentions that "The scattered field generated by Al and Si is stronger than that of PS and PMMA due to their higher sound speed and density." However, the reference supporting this assertion is missing. Can the author provide a clearer explanation of how sound speed and density are related to acoustic impedance mismatch?

The scattered field generated by Al and Si is stronger than that of PS and PMMA due to their higher sound speed and density since higher acoustic impedance $Z = \rho c$ leads to a higher reflection coefficient (according to "Fundamentals of Acoustics" by Lawrence E. Kinsler).

9. Similarly, on line 42, author uses 30 μm diameter particles as fixed particles and the size of WBC cells is not described?

There was a mistake in the manuscript, the diameter of the fixed particle is 60 μm, this size is the maximum size that does not block the microchannel. The size does affect the interparticle force magnitude. The diameter of the WBC is determined to be 14 μm and WBC is selected due to their spherical shape.

10. In lines 53-55 of the text, the author mentions that "The wall correction coefficient parallels the walls more accurately, while in the vertical direction, it accounts for a particle's motion away from or toward the wall within an infinite domain." Can the author provide a clearer explanation for why this phenomenon occurs?

The wall correction factor for the motion parallel to walls is more accurate due to the arisen flow being relatively stable and two-dimensional, However, in the vertical motion, the flow around the particle becomes more complex and three-dimensional creating intricate velocity and pressure gradients which makes it harder to accurately capture the resulting drag.

11. For Figures 8-10, author needs to increase the font size and reorganize the figure legends for better clarity?

The figures have been modified according to the requested changes in font size and legend reorganization of figures.

12. The claims made in the manuscript have not been thoroughly validated experimentally.

Although the present study has not been investigated experimentally due to budget limitations, it can be the preliminary step in designing cell entrapment microfluidic devices, since it followed the behavior of an experimental system with some errors which can be reduced by taking into account viscous losses.

Ref. 2 comments:

1. The literature review can be improved significantly. Prior work has been discussed but it was not clear how these work is relevant to this manuscript and how this manuscripts helps improve the knowledge gap.

the literature review improved significantly to show how the present study intends to helps improve the knowledge gap.

2. On Page 2 between line 10 to 50, seems AIF and ARF are both used and it was not clear the relation between the two terms.

The AIF arises from the interactions between particles in an acoustic field, while the ARF is the direct force exerted by the acoustic wave on a single particle.

3. Page 14 line 1: It is said that the acoustic pressure equations are solved in frequency domain. Is this a new concept?

The concept of solving the acoustic equations is not new, solving the acoustic equation in frequency domain at each time-step instead of time domain significantly decreases the computational cost.

4. Please elaborate how viscous loss can be included in the model and has it been done before?

to take into account viscous and boundary layer effects, second-order equations need to be solved in addition to first-order viscous equations which has been investigated thoroughly by Sepehrirahnama et al.

Ref. 3 comments:

1. The novelty of the present manuscript is not very clear. There is extensive study in the literature regarding cell separation, and entrapment using standing surface acoustic waves. Please highlight the novelty of the present work.

The novelty of this work has been highlighted in the introduction.

2. What is the motivation of the present study?

The motivation behind this study is to demonstrate the possibility of cell trapping which is the first step in designing a microfluidic device that uses solid particles rather than bubbles for such purposes.

3. For the present study, authors considered single particle/cell, how their model will react in the suspension of particles or let’s take blood (where various constituents are available)?

The suspension of other particles leads to particles get focused on the surface of the fixed particle. However, the computational cost of considering several particles is extremely high thus powerful computational resources are required.

4. How the morphological properties of WBCs were considered during the present study? please report them.

White blood cells have been selected due to their spherical shapes.

5. What is the computation cost and time for the present study?

The computational cost for each time step is about 40 minutes.

6. It is not clear from the present manuscript if the hydrodynamic collision of particles is considered or not? Please clarify

Since the fluid flow equations are solved coupled with solid mechanics, the hydraulic collision is considered in the study. The hydrodynamic effects appear as wall effect as they increase the drag force in proximity of walls.

List of changes made:

- Response to Q2 of Ref.2 on page 2
- Novelty of the research on page 2
- Motivation on page 3
- The gravitational effect included on page 3
- Hydrodynamic collision clarification on page 4
- The reasoning behind channel dimension on page 5
- Time-step explanation on page on page 5