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A volume-averaged model for acoustic streaming induced by focused ultrasound in soft porous media

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Ultrasound has been found to improve the delivery of therapeutic agents into tumors thereby improving the therapeutic response in cancer treatment [1]. Acoustic streaming which is the net movement of fluid generated by propagation of sound waves is one of the many proposed mechanisms for this improvement. However, it would be of great advantage to have an experimentally validated model in order to understand acoustic streaming, and to compare its effect relative to other possible mechanisms for improved delivery.

We have derived equations describing acoustic streaming in soft porous media driven by focused ultrasound. From these equations we created a model that predicts the time-averaged flow on the macroscopic scale as well as the advective transport of the trace components in the fluid. We used this model to perform simulations for different shapes of the focused ultrasound beam. The results from the simulations was also compared to a simplified expression which states that the dimensionless volumetric flux is equal to the dimensionless acoustic radiation force. Finally, we performed a comparison between the model for acoustic streaming to experimental results and we found good agreement, where the predicted volumetric fluxes, averaged over the beam full-width half-maximum, was well within the experimental uncertainties. The hope is that the model can be used to interpret experimental results relevant for enhanced drug delivery in tissue, and to assess the relative importance of acoustic streaming compared with other effects.

Participation

In-Person

References

[1] S. Snipstad, K. Vikedal, M. Maardalen, A. Kurbatskaya, E. Sulheim, and C. de Lange Davies, Ultrasound and microbubbles to beat barriers in tumors: Improving delivery of nanomedicine, Advanced Drug Delivery Reviews 177, 113847 (2021).

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