

Letter to the Editor

On “The mechanism of subharmonic ultrasound modulation by  
forcibly oscillating bubbles”  
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In the above mentioned research note, A.J. Hardwick proposes that the generation of combination frequencies involving the subharmonic of the bubble resonance is linked to the excitation of surface waves on the bubble wall. He arrives at this through observing, with the naked eye, the coincidence of surface waves with the generation of the acoustic signal. The acoustic measurements are recorded for one bubble.

A study of the threshold acoustic pressure amplitudes required to stimulate the emission of combination frequencies involving the subharmonic of twenty-eight bubbles can be found in our paper “High resolution bubble sizing through detection of the subharmonic response with a two frequency excitation technique” [1]. Though Hardwick, as one of TGL’s former students, received a

pre-print of that paper before submitting his research note, and cites it in his doctoral thesis, this complementary work is not referenced in the *Ultrasonics* article.

Comparison of the experimental results with existing bubble pulsation models and surface wave theory in the *JASA* paper suggests that the mechanism for the generation of combination-frequency signals is the scattering of the imaging signal by the bubble, the target strength of which varies periodically as it oscillates. For the generation of combination frequencies involving the subharmonic, Faraday waves on the bubble wall provide the time-varying component at half the driving frequency in the scattering cross-section of the bubble.

#### References

- [1] A.D. Phelps and T.G. Leighton, *J. Acoust. Soc. Am.* 99 (1996) 1985.

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