Session 5aBVb

Bioresponse to Vibration/Biomedical Ultrasound: Medical Ultrasound II—Propagation, Media Characterization and Miscellaneous Topics

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Contributed Papers

9:15

5aBVb1. Are blood clots Biot solids? Pierre D. Mourad and Steven G. Kargl (Appl. Phys. Lab., UW, 1013 NE 40th St., Seattle, WA 98105, pierre@apl.washington.edu)

Blood clots are saturated porous solids. Their unwanted presence in veins and arteries is the source of a variety of medical problems. Their destruction (thrombolysis) via ultrasound and various enzymes (ultrasound-enhanced thrombolysis, or UET) is still a poorly understood phenomenon. The current view is that cavitation is the mechanism behind UET. This presentation begins with a review of the structure of blood clots and natural thrombolysis. Following that is a review of the literature on UET pointing out that cavitation is at best part of the story, at least *in vitro*, and more suspect *in vivo*. Next is a motivation of the Biot theory (a theory for how sound propagates through and interacts with porous solids) and its application to blood clots. The results of the work thus far predict that blood clots are Biot solids, which has implications for understanding UET. [Work sponsored by DARPA.]

9:30

5aBVb2. A stratified model for ultrasonic propagation in cancellous bone. Elinor R. Hubbuck, Timothy G. Leighton, Paul R. White (Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton SO17 3BJ, Great Britain), and Graham W. Petley (Southampton Univ. Hospitals NHS Trust, Southampton, Great Britain)

A new model for ultrasonic wave propagation in cancellous bone is presented here. The model treats cancellous bone as a stratified medium of periodically alternating solid–fluid layers, and considers propagation of two compressional modes, analogous to the fast and slow waves of Biot theory, in terms of slowness surfaces. The behavior of the two modes is examined *in vitro* using bovine bone samples over a range of incidence angles. Two modes are seen when the cancellous structure is parallel to the propagation direction, but only one mode propagates normal to the structure, and the velocity of the fast wave increases with angle of incidence away from the normal. This behavior can be explained in terms of an angular dependent inertial coupling effect, in keeping with the theory of propagation in stratified media of periodically alternating fluid–solid layers. Quantitative agreement with theory is good. Although the structure being analyzed is essentially an oversimplification of the structure of cancellous bone, the agreement with theory suggests the stratified model offers potential for future research.

9:45

5aBVb3. Effects of the structural anisotropy and the porosity on ultrasonic wave propagation in bovine cancellous bone. Takahiko Otani and Atsushi Hosokawa (Dept. of Elec. Eng., Doshisha Univ., 610-0321 Kyotanabe-shi, Japan)

Ultrasonic wave propagation in water-saturated bovine cancellous (spongy) bone has been experimentally studied *in vitro* by a pulse transmission technique. Fast and slow longitudinal waves have been clearly observed in the earlier investigation when the acoustic wave propagates to the direction of the trabeculae orientation [A. Hosokawa and T. Otani, J. Acoust. Soc. Am. **101**, 558–562 (1997)]. In the present study, propagation speeds of the fast and the slow waves were measured as a function of the propagation angle to the trabeculae orientation. Experimental results show that the propagation speed of the fast wave and the amplitude of the slow wave depend greatly on the angle to the trabeculae orientation, and the speed of the slow wave and the amplitude of the fast wave are little affected by the angle of the trabeculae orientation. The propagation speeds of both waves were also experimentally examined as a function of the porosity. Measured results are discussed in relation to the structural anisotropy and the porosity using Biot's theory.

10:00

5aBVb4. Wideband laser-acoustic spectroscopy of proteins. Alexander A. Karabutov and Natalia B. Podymova (Dept. of Phys., Moscow State Univ., Moscow, Russia 119899, karabut@gpwp1.phys.msu.su)

The absorption of ultrasound in a frequency range of 2–50 MHz in proteins was investigated with a wideband laser-ultrasonic spectrometer. It was found that for fresh chicken proteins ultrasonic absorption is proportional to the squared frequency. Denaturation of proteins transforms the spectrum of ultrasonic absorption to the first power of frequency dependence. In the hole frequency range the ultrasonic absorption in denaturated protein is higher than in the fresh one. The possibility of laser ultrasonic diagnostics of proteins is discussed.

10:15

5aBVb5. Wideband acoustics spectroscopy of liquid phantoms of biological tissues. Valery G. Andreev, Yury A. Pischalnikov (Dept. of Acoust., Phys. Faculty, Moscow State Univ., Moscow 119899, Russia, andreev@na.phys.msu.su), Alexander A. Karabutov, and Natal'ya B. Podymova (Moscow State Univ., Moscow 119899, Russia)

Biological tissues have a specific frequency dependence of the ultrasonic absorption and sound-speed dispersion. It makes fruitful the diagnostics of tissues by studying these parameters. It is necessary to carry out the spectroscopic investigation in a wide frequency band in a real time. Pulsed laser ultrasonic spectroscopy is the most useful technique to solve this problem. The method of wideband acoustic spectroscopy with laser thermo-optical source is proposed. A Q-switched YAG-Nd laser was explored to excite the short acoustic transients (pulse duration 12 ns, amplitude up to 8 MPa) by an especially produced thermo-optical generator. The acoustic transients transmitted through the medium under the testing were detected by a wideband transducer (frequency band 2–350 MHz). The absorption of ultrasound was calculated by FFT. The absorption in glycerol, acetic acid, and butanediol was investigated in a frequency band 2–50 MHz. The spectra of relaxation times were calculated. [Work supported by RFBR and CRDF.]