ing phase conjugation of harmonics in acoustic imaging and nondestructive evaluation, such as second harmonic imaging in tissue. [Work supported by RFBR, CRDF, and ONR.]

2:20

5pBB2. Mapping high power ultrasonic fields using a scanned scatterer. Bryan Cunitz and Peter Kaczkowski (Ctr. for Industrial and Medical Ultrasound, Appl. Phys. Lab, Univ. of Washington, Seattle, WA 98105)

The conventional method used to map the field of high intensity focused ultrasound (HIFU) transducers displaces a hydrophone over a grid of points in the zone of interest and provides a direct measure of the ultrasound pressure at each point. The approach has several major limitations: (1) the hydrophone is likely to be damaged while repeatedly measuring high intensity fields, (2) the resolution of the field map is limited to the size of the active area of the hydrophone which is typically on the order of 0.5 mm and large compared to some wavelengths of interest, and (3) cavitation can limit the accuracy of measurements. By placing a small scatterer in the HIFU field and measuring the scattered wave with a sensitive hydrophone from a safe distance, the field can be measured at full power without harm. We have used this technique to acquire single frequency field maps of HIFU transducers at high intensities without any damage to the hydrophone. We also have been able to improve the spatial resolution of the field map by an order of magnitude. In addition, this technique permits measurement of some non-linear behavior (e.g., harmonic content) at the focus at high intensities.

2:35

5pBB3. A study of angular spectrum and limited diffraction beams for calculation of field of array transducers. Jiqi Cheng and Jian-yu Lu (Ultrasound Lab., Dept. of Bioengineering, The Univ. of Toledo, Toledo, OH 43606, jilu@eng.utoledo.edu)

Angular spectrum is one of the most powerful tools for field calculation. It is based on linear system theory and the Fourier transform and is used for the calculation of propagating sound fields at different distances. In this report, the generalization and interpretation of the angular spectrum and its intrinsic relationship with limited diffraction beams are studied. With an angular spectrum, the field at the surface of a transducer is decomposed into limited diffractions beams. For an array transducer, a linear relationship between the quantized fields at the surface of elements of the array and the propagating field at any point in space can be established. For an annular array, the field is decomposed into limited diffraction Bessel beams [P. D. Fox and S. Holm, IEEE Trans. Ultrason. Ferroelectr. Freq. Control **49**, 85–93 (2002)], while for a two-dimensional (2-D) array the field is decomposed into limited diffraction array beams [J-y. Lu and J. Cheng, J. Acoust. Soc. Am. **109**, 2397–2398 (2001)]. The angular spectrum reveals the intrinsic link between these decompositions. [Work supported in part by Grant 5RO1 HL60301 from NIH.]

2:50

5pBB4. Reconstruction of normal velocity distribution at the face of an ultrasound source in liquid on the base of acoustic waveform measurements along a surface in front of the source. Oleg A. Sapozhnikov, Yuriy A. Pishchalnikov, and Andrey V. Morozov (Dept. of Acoust., Phys. Faculty, M. V. Lomonosov Moscow State Univ., Moscow 119899, Russia, oleg@acs366b.phys.msu.su)

Normal velocity distribution along a vibrating surface is an important characteristic of any acoustic source. When it is known, the acoustic pressure field can be predicted using Rayleigh integral or similar approach. However, up to now there are no reliable methods of the velocity distribution measurement in liquids or solids. Due to strong acousto-optic interaction in condensed medium, the well-developed laser vibrometers can be employed only when the transducer is contacting vacuum or gas. In this work a novel method is developed and tested for evaluation of the velocity distribution along the vibrating surface of a piezoceramic transducer in liquid. The technique consists of measuring acoustic wave amplitude and phase along a surface surrounding the source, changing the sign of the phase, and theoretically backpropagating it to the source using the Rayleigh integral. The method was studied numerically and tested experimentally. The acoustic field of ultrasound source was registered using a needle hydrophone, which was scanned along a plane surface in front of the transducer. It is shown that the proposed approach enables accurate detection of the normal velocity. The method can be used for a wide variety of acoustically radiating structures. [Work supported by CRDF, NIH-Fogarty, and RFBR.]

3:05

5pBB5. Cyclic and radial variation of the echogenicity from human carotid artery and porcine blood. Dong-Guk Paeng, Pei-Jie Cao, K. Kirk Shung (Penn State Univ., 205 Hallowell Bldg., University Park, PA 16802, paeng@psu.edu), and Richard Y. Chiao (GE Medical Systems, EA-54, 4855 W. Electric Ave., Milwaukee, WI 53219)

The cyclic and radial variation of the echogenicity from human blood and porcine blood was investigated using a linear M12L transducer with a GE LOGIQ 700 Expert system. The bright collapsing ring phenomenon, a bright echogenic ring converging from the periphery to the center of the tube wall and eventually collapsing during a pulsatile cycle from the cross-sectional B mode images, was observed from porcine blood in a mock flow loop with a diameter of 0.95 cm at certain flow conditions. The bright ring phenomenon from porcine blood was stronger as the peak speed increased from 19 to 40 cm/s while the mean echogenicity decreased. As the stroke rate increased from 20 to 60 beats/minute, the phenomenon was weaker. As the hematocrit increased from 12 to 45%, the phenomenon became obvious. The black hole phenomenon was also observed at certain flow conditions. The well-known nonlinear hematocrit dependence on echogenicity was observed near the wall but the dependence pattern was changed at the center of the tube. The similar bright ring phenomenon was also observed at the harmonic images *in vivo* on 10 human carotid arteries. Aggregation due to the shear rate and acceleration is thought to be the explanation of the phenomena.

3:20

5pBB6. Detection of thrombosis and restenosis in an endovascular stent. Junru Wu (Dept. of Phys., Univ. of Vermont, Burlington, Burlington, VT 05405, jwu@zoo.uvm.edu) and Eric Weissman (Noveon, Inc., Brecksville, OH 44141)

Endovascular stents that are implanted in an artery are often used in the interventional treatment of coronary artery disease. Its widespread applications are, however, limited by the development of subacute thrombosis (clot forming inside of the stent). *Ex vivo* experiments with pigs have shown that the broadband A-mode ultrasound is quite effective in detection thrombosis and restenosis in an endovascular stent. [Work supported by BFGoodrich and Noveon, Inc.]

3:35

5pBB7. A robust roughness quantification technique using a standard imaging array transducer. Stanley Samuel (Univ. of Michigan Medical Ctr., 200 Zina Pitcher Pl., Rm. 3315, Kresge III, Ann Arbor, MI 48109-0553, ssamuel@umich.edu), Ronald Adler (Hospital for Special Surgery, 535 E. 70th St., New York, NY 10021), and Charles Meyer (Univ. of Michigan Medical Ctr., 200 Zina Pitcher Pl., Rm. 3315, Kresge III, Ann Arbor, MI 48109-0553)

Our goal is to measure cartilage roughness using intra-articular ultrasound imaging, thus providing a useful diagnostic tool for the early detection of osteoarthritis. Measuring the effectiveness of possible chondroprotective pharmacological or mechanical interventions depends on the availability of such a device. We have developed an empirical model of roughness using sandpaper for angles ranging from 20 degrees to 60 degrees at distances ranging from 25 mm to 80 mm. Roughness quantification is achieved using a scattering replacement normalization technique. An ultrasound imaging system employing a broadband 7 MHz multi-element transducer was used for insonifying the flat sandpaper surface.