1.3 EXPERIMENT WITH BOWTIE LIMITED DIFFRACTION BEAMS, Jian-yu Lu, Biodynamics Research Unit, Department of Physiology and Biophysics, Mayo Clinic and Foundation, Rochester, MN 55905.

Limited diffraction beams have a large depth of field and could have many applications. However, limited diffraction beams studied previously have high sidelobes when applied to pulse-echo imaging. Bowtie limited diffraction beams are a new type of limited diffraction beams. These beams can be used to reduce sidelobes dramatically while maintaining a large depth of field.

In this report, an experiment with a synthetic two-dimensional array was performed to produce bowtie limited diffraction beams in a water tank. The array was weighted according to the analytical bowtie limited diffraction solutions to the wave equation evaluated at an axial distance. Field responses of the array at many spatial positions were obtained by linear superposition of the responses of individual array elements. The central frequency and the diameter of the array are 2.5 MHz and 50 mm, respectively, and the size of the array element is about 1 mm.

Results show that bowtie limited diffraction beams produced with the synthetic array agree very well with our theoretical prediction and computer simulation. Pulse-echo responses (convolution of transmit and receive responses) calculated from the experimental data demonstrate that bowtie limited diffraction beams can be used to reduce sidelobes dramatically (to a maximum of around 40 dB) over a large depth of field (about 216 mm) when a bowtie beam is used in transmit and its 90° rotated response (around the beam axis) is used in receive.

This work was supported in part by NIH grants CA 43920 and CA 54212.

1.4 ULTRASPARSE, ULTRAWIDEBAND PHASED ARRAYS, Jodi L. Schwartz and Bernard D. Steinberg, University of Pennsylvania, 202 S. 33rd St., Philadelphia, PA 19104.

Highly thinned or sparsely filled arrays can reduce the quantity of electronics supporting the array and the data-handling requirements of an imaging system for a fixed number of array channels, greatly enlarge the aperture and correspondingly improve its resolving power. It is well-known that the cost is a dramatic decrease in dynamic range or contrast. Aperture thinning generally leaves the shapes of the main lobe and near-in sidelobes intact, but the loss in absolute gain implies that main lobe energy has been redistributed into the side radiation region. In conventional narrowband arrays, periodic thinning produces grating lobes of similar shape and strength to the main lobe. Aperiodic thinning destroys the coherent sidelobe buildup in the grating lobes but not the grating lobe energy, which becomes distributed throughout the visible region in a manner determined by the particular thinning procedure. It is common knowledge that sidelobe statistics are similar for a wide variety of thinning procedures, both deterministic and random, with a few notable exceptions [1]. Thus, many proposed designs for high resolution two-dimensional arrays are based upon a random distribution of elements [2].

Current technology in ultrasound and electromagetics is now able to construct radiating array elements that can transmit a high energy pulse that has only two or three cycles. The corresponding arrays are called ultrawideband (UWB) arrays. In a highly thinned UWB array, the distribution of side energy is very different from conventional narrowband (NB) arrays. Due to the UWB nature of the pulse, the radiated waveform from these arrays varies in time. As a result, the waveform has an extra dimension with respect to NB across which undesired side energy can be distributed. UWB arrays can be highly thinned and achieve a much lower side energy level than NB arrays. This paper presents a method for characterizing ultrasparse, ultrawideband, one- and two-dimensional arrays. Contrary to conventional wisdom, this analysis shows that in a highly thinned UWB array, a periodic array is preferred over a random array.

[1] Steinberg, B.D., *Principles of Aperture and Array System Design: Including Random and Adaptive Arrays* (John Wiley and Sons, Inc., New York, 1976).

[2] Turnbull, D.H., Lum, P.K, Kerr, A.T. and Foster, F.S., *Ultrasonic Imaging 14*, (1992).

1.5 FILTER-BASED REAL-TIME PARALLEL PROCESSING PULSE-ECHO ULTRASOUND IMAGING USING CODED-EXCITATION, Jian Shen and Emad S. Ebbini, Department of Electrical Engineering and Computer Science, The University of Michigan, Ann Arbor, MI 48109.

PROGRAM AND ABSTRACTS

21st International
Symposium on

Ultrasonic Imaging and Tissue Characterization

June 3-5, 1996

Rosslyn Westpark Hotel
Arlington, VA

In cooperation with:

IEEE, Ultrasonics, Ferroelectrics and
Frequency Control Society