The Ultrasound Needle Pulse

Kevin J. Parker, *Fellow, IEEE*, Shujie Chen, *Student Member, IEEE*, and Miguel A. Alonso

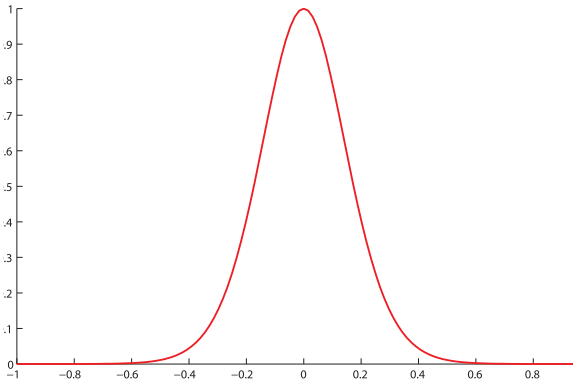
***Abstract*— Recent theoretical developments have defined the conditions for forming a broadband beam that is narrow in axial extent but extended in range. The formulation is based on the classical angular spectrum decomposition and the requirement for arranging all spatial and temporal frequencies such that all components have constant phase propagation between planes. Analytic formulations are given for a 1-D source and a 2-D axisymmetric source, and comparisons are made against conventional focused Gaussian beams under similar conditions relevant to medical imaging systems.**

***Index Terms*— Medical beamforming and beam steering, medical imaging, system and device design, underwater ultrasound.**

I. Introduction

THE study of beampatterns and their use in imaging systems has a long history in optics and acoustics. Imaging systems may transmit spherically spreading waves from small elements, as in synthetic aperture systems, or plane (unfo-

Fig. 2. Amplitude (left) and pressure waves (right) at three time instants (top to bottom, $t = -2$, 0, and 2 μs from peak) resulting from a 2-D array with a center frequency of 6 MHz, 70% bandwidth, and 16-mm square. The source excitation waveform was the real part of (7) with the parameters: $q = 0.4$, $\omega_L = 2\pi \cdot$


1
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
−1
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8

Shujie Chen (S'14) received the B.S. degree in communications engineering from the Nanjing University of Posts and Telecommunications, Nanjing, China, in 2007, and the M.S. degree in electrical engineering from the University of Rochester, Rochester, NY, USA, in 2013, where he is currently pursuing the Ph.D. degree with the Department of Electrical and Computer Engineering.

He was a Signal Processing Intern with MathWorks, Natick, MA, USA, in 2016. His current research interests include ultrasound imaging and image processing.

Miguel A. Alonso received the Engineering degree in physics from Universidad Autónoma Metropolitana, Mexico City, Mexico, in 1990, and the Ph.D. degree in optics from the University of Rochester, Rochester, NY, USA, in 1996.

He is currently a Professor with The Institute of Optics, University of Rochester. He is also a member of the Center for Freeform Optics and the Center for Coherence and Quantum Optics, University of Rochester.

Dr. Alonso is a fellow of the Optical Society of America. He was an Associate Editor and a Deputy Editor of the journal *Optics Express* from 2002 to 2013. He is an Associate Editor of the journal *Optica*.