grades for non-uniformly distributed structures due to the inherent need to employ a uniform global grid. FMM or QR techniques are better suited than FFT techniques; however, neither the FMM nor the QR technique can be used at all frequencies.

This method has been developed to efficiently solve for a desired parameter of a system or device that can include both electrically large FMM elements, and electrically small QR elements. The system or device is set up as an oct-tree structure that can include regions of both the FMM type and the QR type. The system is enclosed with a cube at a 0-th level, splitting the cube at the 0-th level into eight child cubes. This forms cubes at a 1-st level, recursively repeating the splitting process for cubes at successive levels until a desired number of levels is created. For each cube that is thus formed, neighbor lists and interaction lists are maintained.

An iterative solver is then used to determine a first matrix vector product for any electrically large elements as well as a second matrix vector product for any electrically small elements that are included in the structure. These matrix vector products for the electrically large and small elements are combined, and a net delta for a combination of the matrix vector products is determined. The iteration continues until a net delta is obtained that is within the predefined limits. The matrix vector products that were last obtained are used to solve for the desired parameter. The solution for the desired parameter is then presented to a user in a tangible form; for example, on a display.

This work was done by Vikram Jandhyala and Indranil Chowdhury of the University of Washington for Johnson Space Center. For further information, contact the Johnson Technology Transfer Office at (281) 483-3809.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Refer to MSC-24439-1, volume and number of this NASA Tech Briefs *issue, and the page number.*

Accelerated Adaptive MGS Phase Retrieval

NASA's Jet Propulsion Laboratory, Pasadena, California

The Modified Gerchberg-Saxton (MGS) algorithm is an image-based wavefront-sensing method that can turn any science instrument focal plane into a wavefront sensor. MGS characterizes optical systems by estimating the wavefront errors in the exit pupil using only intensity images of a star or other point source of light. This innovative implementation of MGS significantly accelerates the MGS phase retrieval algorithm by using stream-processing hardware on conventional graphics cards.

Stream processing is a relatively new, yet powerful, paradigm to allow parallel processing of certain applications that apply single instructions to multiple data (SIMD). These stream processors are designed specifically to support large-scale parallel computing on a single graphics chip. Computationally intensive algorithms, such as the Fast Fourier Transform (FFT), are particularly well suited for this computing environment. This high-speed version of MGS exploits commercially available hardware to accomplish the same objective in a fraction of the original time. The exploit involves performing matrix calculations in nVidia graphic cards. The graphical processor unit (GPU) is hardware that is specialized for computationally intensive, highly parallel computation.

From the software perspective, a parallel programming model is used, called CUDA, to transparently scale multicore parallelism in hardware. This technology gives computationally intensive applications access to the processing power of the nVidia GPUs through a C/C++ programming interface. The AAMGS (Accelerated Adaptive MGS) software takes advantage of these advanced technologies, to accelerate the optical phase error characterization. With a single PC that contains four nVidia GTX-280 graphic cards, the new implementation can process four images simultaneously to produce a JWST (James Webb Space Telescope) wavefront measurement 60 times faster than the previous code.

This work was done by Raymond K. Lam, Catherine M. Ohara, Joseph J. Green, Siddarayappa A. Bikkannavar, Scott A. Basinger, David C. Redding, and Fang Shi of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

The software used in this innovation is available for commercial licensing. Please contact Daniel Broderick of the California Institute of Technology at danielb@caltech.edu. Refer to NPO-47101.

Large Eddy Simulation Study for Fluid Disintegration and Mixing

This work is directly applicable to simulations of gas turbine engines and rocket engines.

NASA's Jet Propulsion Laboratory, Pasadena, California

A new modeling approach is based on the concept of large eddy simulation (LES) within which the large scales are computed and the small scales are modeled. The new approach is expected to retain the fidelity of the physics while also being computationally efficient. Typically, only models for the small-scale fluxes of momentum, species, and enthalpy are used to reintroduce in the simulation the physics lost because the computation only resolves the large scales. These models are called subgrid (SGS) models because they operate at a scale smaller than the LES grid.

In a previous study of thermodynamically supercritical fluid disintegration and