Andrew Christlieb

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BIO SKETCH

Andrew Christlieb is chair of the Department of Computational Mathematics, Science and Engineering, and an MSU Foundation Professor of Mathematics. Since 2004, he has worked very closely with the RDHE group at the Air Force research labs on the development of new methods for particle simulations of plasmas. In 2006, he joined the mathematics department at Michigan State University. That same year he was awarded a summer faculty fellow from the Air Force to work with AFRL Edwards on modeling of electric pupation. In 2007, Christlieb received the Air Force Young Investigator Award for his work on the development of novel methods for simulating plasmas. From 2008-2012, Christlieb was an IPA for the directed energy group at Kirtland Air Force Base. In 2010, he was promoted to associate professor and in 2014 he was promoted to professor. In 2015, he was named an MSU Foundation Professor.

Dr. Christlieb received his Ph.D. from the University of Wisconsin– Madison in 2001. Upon completing his Ph.D., he took a postdoc in the Aerospace Department at the University of Michigan with Iain Boyd, working on the simulation of micro air foils. He then transitioned to a postdoc in the Mathematics Department at the University of Michigan, where he worked with Robert Krasny on the development of mesh-free methods for plasma simulations.

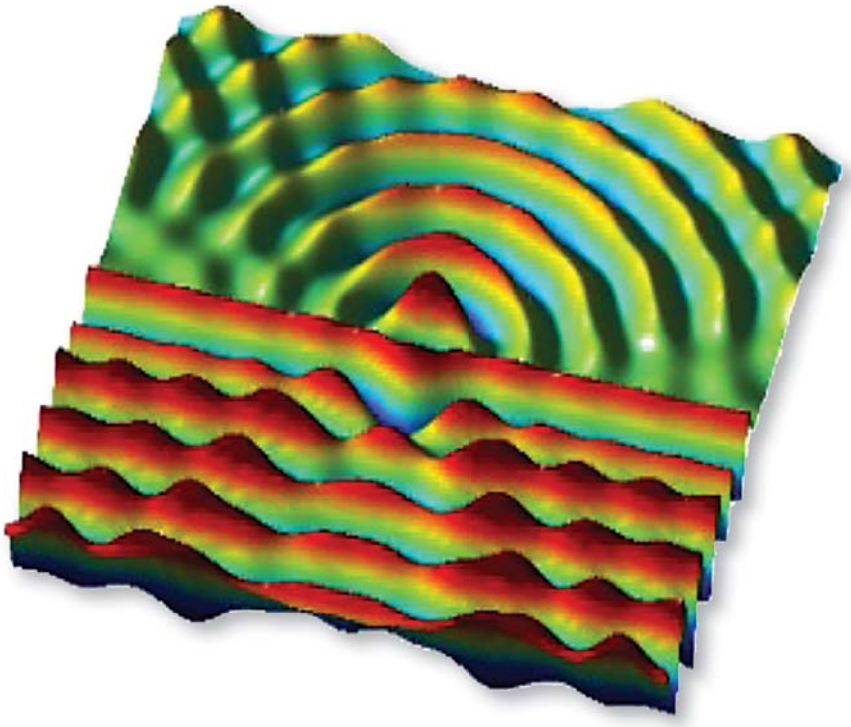

FIGURE 1. Slit diffraction problem, A-stable implicit Maxwell Solver.

RESEARCH INTERESTS

Scientific computing; multi-physics simulations; plasma physics; hyperbolic conservation laws; fast convolution methods; defect correction; sub-linear algorithms

LAB(S)/GROUP(S)

The Christlieb Lab

WEBSITE

https://cmse.natsci.msu.edu/directory/faculty/andrew-christlieb

GROUP MEMBERS:

CURRENT POST DOCS: Wei Gou, Yan Jiang, Aditya Viswanathan. CURRENT STUDENTS: Michael Crockatt, Hana Cho, Bosu Choi, Xiao Feng, Ruochuan Zhang, Thavappiragasam Mathialakan. VISITING STUDENT: Hyoseon Yang. SHARED STUDENTS: Gautham Dharuman, Guy Parsey; MSU COLLABORATORS: John Verboncoeur, Yingda Cheng.

CURRENT RESEARCH FOCUS

Dr. Christlieb's research focuses on modeling and simulating materials in extreme states. What makes these problems challenging is the large range of temporal and spatial scales that need to be resolved in order to accurately describe them.

One of the areas he is passionate about is developing methods to accurately describe plasmas. Plasma is the fourth state of matter, after solid, liquid, and gas. The plasma state occurs when enough energy is added to the system such that the electrons overcome their binding energy and the systems consists of positive and negatively charged particles with a wide range of masses. The plasma state can have densities well in excess of solids; an example is the core of a star where fusion is taking place. Plasmas may have a density as low as one particle per cubic meter (e.g., interstellar material). What makes this truly difficult is that at high densities, models for accurately capturing fundamental effects are very different from models that are good at describing low-density plasmas. In many of the problems, the densities can vary by eight orders of magnitude and the temporal scales of importance and can range over nine orders of magnitude.

Identifying and resolving critical scales is one of the largest challenges in accurately modeling these systems. Recently, Dr. Christlieb's group has targeted modeling of dense correlated plasmas. These are problems were the potential energy is much higher than the kinetic energy. This leads to situations were the ionized gas behaves like a solid. Another area his group works on is developing new numerical methods for modeling the casting of functionalized membranes in polymer science. Such membranes are used in batteries, fuel cells and solar cells. There are systems where casting of the membrane may

take as long as 24 hours, while critical chemistry happens in picoseconds.

To design algorithms to attack these problems, the Christlieb group works on methods well suited to heterogonous computing platforms in a high performance computing setting. This includes data science tools capable of extracting essential information from the simulations.

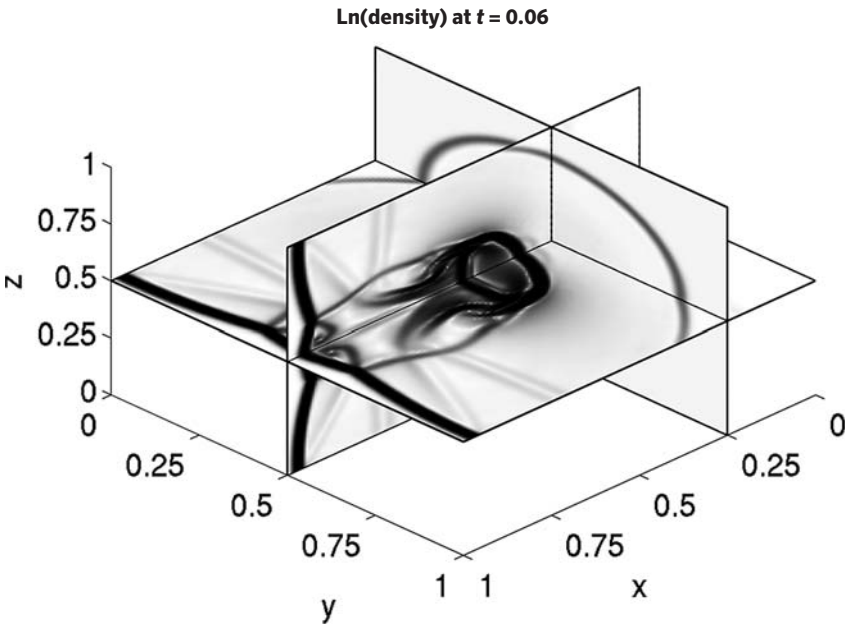

FIGURE 2. High-order simulation of on-course mesh of the plasma cloud shock problem. High-density shock collides with a high-density bubble of plasma.

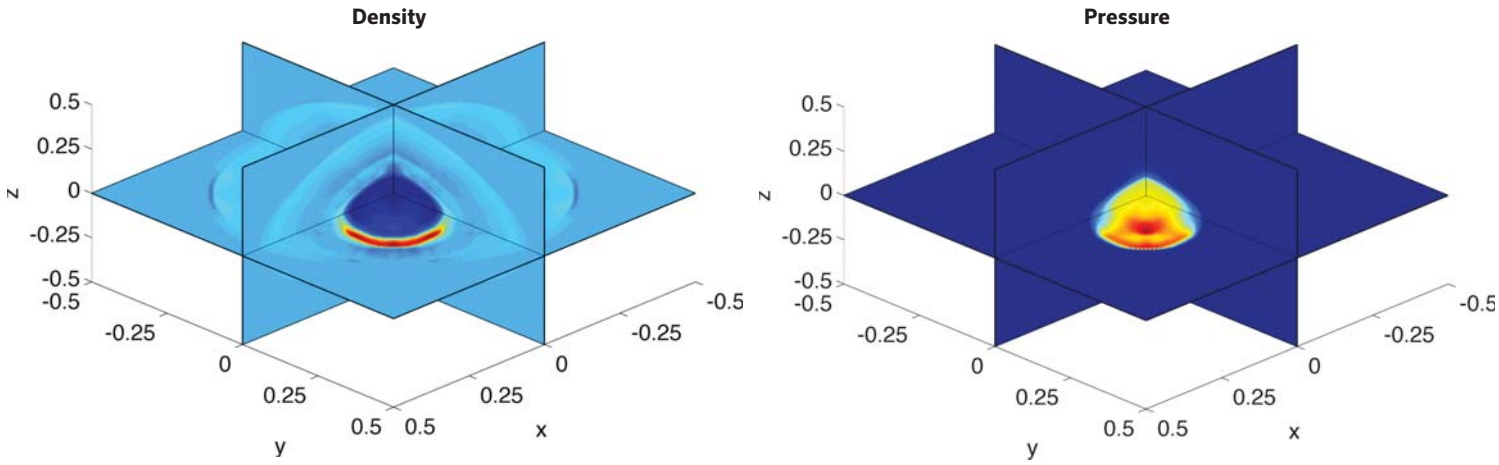

FIGURE 3. Illustrations of the blast wave problem in 3-D for MHD. These results require that the method be divergence-free as well as that the pressure stay positive. This is a challenging problem and we had to develop a new consternated transport method (divergence-free) as well as new flux-corrected transport method (positivity) to reduce the computational cost via a high-order method and guaranty computability.

RECENT PUBLICATIONS

A.J. Christlieb, J.A. Rossmanith, Q. Tang, "Finite Difference Weighted Essentially Non-Oscillatory Schemes with Constrained Transport for Ideal Magnetohydrodynamics," *Journal of Computational Physics*, 268, 302–325 (2014).

S. Olson, G. Raithel, A.J. Christlieb "Pressure-Driven Evaporative Cooling in Atom Guides," *Physical Review A*, 90, 043612 (2014).

Y. Cheng, A.J. Christlieb, X. Zhong, "Energy-conserving Discontinuous Galerkin Methods for the Vlasov-Maxwell System," *Journal of Computational Physics*, 279, 145–173 (2014).

A.J. Christlieb, C.B. Macdonald, B.W. Ong, R.J. Spiteri, "Revisionist Integral Deferred Correction with Adaptive Error and Stepsize Control," accepted, *Communications in Applied Mathematics and Computational Science*.