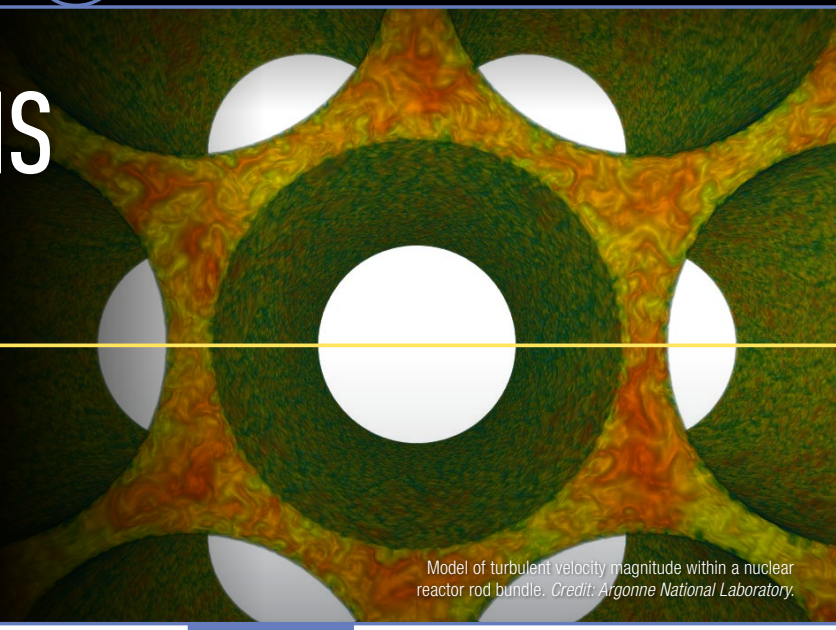
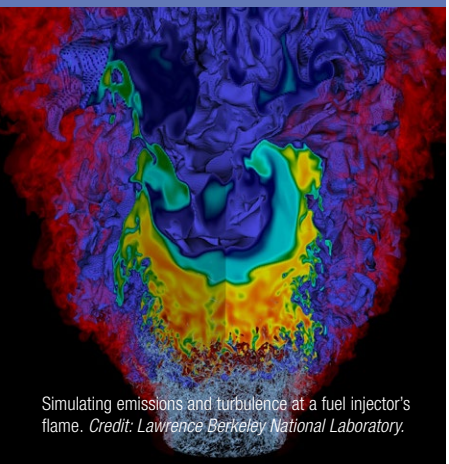
APPLYING EQUATIONS TO COMPLEX PROBLEMS

Building Models with Mathematics



Model of turbulent velocity magnitude within a nuclear reactor rod bundle. *Credit: Argonne National Laboratory.*

Scientists describe the world using mathematics. Equations for phenomena such as electromagnetism and fluid mechanics, for example, were derived in the 19th century. Although those equations help researchers understand natural phenomena, they rarely can be solved directly. In the early 1950s, mathematician John von Neumann recognized that digital computers programmed to translate equations into digestible mathematical problems could solve these scientific puzzles. To realize this vision, the Department of Energy's (DOE's) forerunner created the Applied Mathematical Sciences program.



Simulating emissions and turbulence at a fuel injector's flame. *Credit: Lawrence Berkeley National Laboratory.*

INNOVATIONS

NEW APPROACHES TO COMPLEX PROBLEMS

Scientists funded by the Advanced Scientific Computing Research (ASCR) program and its predecessors created methods for representing the mathematics of physical systems on a computer. This work has addressed several important issues, from representing key science features to creating predictable software. These methods have led to accurate and efficient simulations of complex phenomena.

- During World War II, researchers wanted to model shock waves to understand the dynamics of explosions. Simulating those fluid dynamics phenomena has led to efficient and accurate methods for computing more general high-speed fluid flows.
- Complex chemical reactions and other systems can involve processes that occur on both fast and slow time scales. Understanding the mathematics of those systems has led to various methods for determining when it is possible to skip over the fast time scales in computational simulations.

IMPACT

POWERFUL TOOLS FOR SCIENCE AND INDUSTRY

Mathematical and computational methods developed with ASCR's support are now used for modeling and simulation across numerous areas of science and technology. Modern computational science would not be possible without these foundational mathematical advances.

- Fluid dynamics codes are used to model astrophysics, aerodynamics, bioengineering and combustion and to design nuclear reactors.
- Industry has applied these tools to simulate chemical reactors, semiconductor etching and image processing.

TAKEAWAY

MATH UNDERLIES COMPUTING ADVANCES

Long-term investments in developing mathematical methods for computer simulations have paid off, both in solving the original DOE science problems that motivated them and in providing solutions for many other domains.

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