Looking towards the future: Goals of the meeting

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1. CEMM Extension: Renewal or Re-compete ??
2. DOE Hardware plans
3. Software Roadmap
4. Science Opportunities
5. Kudos

CEMM Meeting
Marriott Hotel
Philadelphia, PA
Oct 29th, 2006

CEMM Extension: Renewal or Re-compete ??

Either way, reviewers will be looking for:

- projected ability to use up to 10,000 processors
  - improved scaling of present approaches
  - new approaches with better scaling
  - new intensive physics that scales well
- exciting science enabled by such deployment
  - relevance to ITER is a +

DOE Hardware plans

	NERSC		ORNL		ANL	
	#P	Tflops	#P	Tflops	#P	Tflops
2006	10,000	8(50)	10,000	8(50)	16,000	4(50)?
2007	20,000	8(50)	50,000	40(250)	32,000	(100)
2008	80,000? (option)	8(50)	96,000 Cray Baker	(1000)	Blue Gene/Q in 2010	(3000)

Software Roadmap

"Brute force" extrapolation from CDX-U to ITER gives a factor of 10^{12} in space-time points required (explicit, linear elements, uniform mesh)

This should be achievable as follows:

- 1.5 orders: increased parallelism
- 1.5 orders: processor speed and efficiency
- 4 orders: adaptive gridding
- 1 order: higher order elements
- 1 order: field-line following coordinates
- 3 orders: implicit algorithms

Should be possible. Requires manpower to implement and customize mostly known algorithms in leading codes

Note: Hardware (3) : Software (9) !!

SIAM News: Volume 39, Number 7, Sept 2006

Interview with David Keyes

"The current issue of SIAM News features an article by Michelle Sipics The article deserves not only interest but also praise. It is timely, absorbing, trenchant."

Paul Saylor (U. Illinois) in NA-Digest

Taking on the ITER Challenge, Scientists Look to Innovative Algorithms, Petascale Computers

By Michelle Sipics

The promise of fusion as a clean, self-sustaining and essentially limitless energy source has become a mantra for the age, held out by many scientists as a possible solution to the world's energy crisis and a way to reduce the amounts of greenhouse gases released into the atmosphere by more conventional sources of energy. If self-sustaining fusion reactions can be realized and maintained long enough to produce electricity, the technology could potentially revolutionize energy generation and use.

ITER, initially short for International Thermonuclear Experimental Reactor, is now the official, non-acronymic name (meaning "the way" in Latin) of what is undoubtedly the largest undertaking of its kind. Started as a collaboration between four major parties in 1985, ITER has evolved into a seven-party project that finally found a physical home last year, when it was announced that the ITER fusion reactor would be built in Cadarache, in southern France. (The participants are the European Union, Russia, Japan, China, India, South

Problems remain, however—notably the years, and perhaps decades, of progress needed to attain such a goal. In fact, even *simulating* the proposed ITER tokamak is currently out of reach. But according to David Keyes, a computational mathematician at Columbia University and acting director of the Institute for Scientific Computing Research (ISCR) at Lawrence Livermore National Laboratory, the ability to perform such simulations may be drawing closer.

Hardware 3, Software 9

"Fusion scientists have been making useful characterizations about plasma fusion devices, physics, operating regimes and the like for over 50 years," Keyes says. "However, to simulate the dynamics of ITER for a typical experimental 'shot' over scales of interest with today's most commonly used algorithmic technologies would require approximately 10^{24} floating-point operations." That sounds bleak, given the 280.6 Tflop/s (10^{12} flops/s) benchmark performance of the IBM BlueGene/L at Lawrence Livermore National Laboratory—as of June

Science Opportunities

- We all need to help identify "good science" problems that can be addressed with our codes
- Topics of interest to ITER on ITPA web site: http://itpa.ipp.mpg.de
  - NTMs, RWMs, and their active control
  - ELM modeling and control
  - Sawtooth control
  - Disruption effects and mitigation
  - Error Fields, Locked Modes
  - Pellet Injection

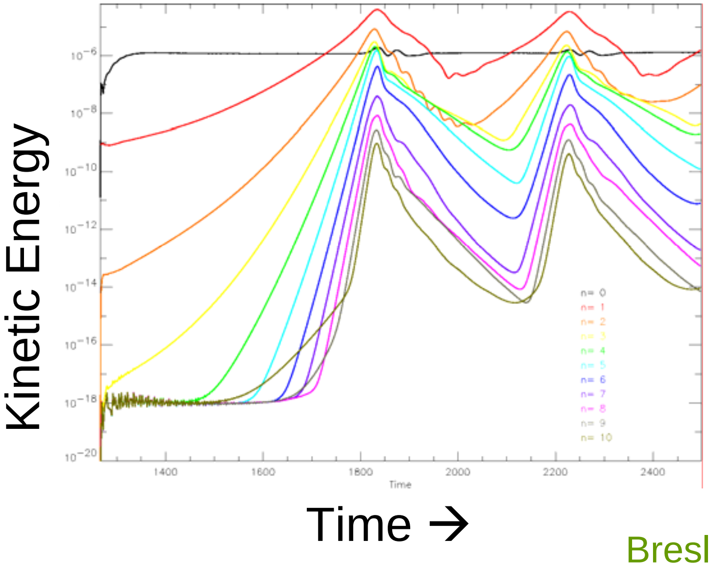
Kudos

- CDX-U Simulations:
- ELM Milestone
- APS Fellow

What Kind of Calculation can we do now in Extended MHD?

- M3D and NIMROD have been involved in a nonlinear benchmark on CDX-U
- The most recent M3D simulation used:
  - 10,000 x 50 = 500,000 elements
  - 400,000 time steps
  - ~2 x 10^{11} space time points

  (probably under-resolved)



Breslau

PPPL PRINCETON PLASMA PHYSICS LABORATORY

Straightforward Extrapolation from CDX-U to ITER

name	symbol	units	CDX-U	DIII-D	ITER
Field	B_0	Tesla	0.22	1	5.3
Minor radius	a	meters	.22	.67	2
Temp.	T_e	keV	0.1	2.0	8.
Lundquist no.	S		1×10^{4}	7×10^{6}	5×10^{8}
Mode growth time	$\tau_A S^{1/2}$	s	2×10^{-4}	9×10^{-3}	7×10^{-2}
Layer thickness	$aS^{-1/2}$	m	2×10^{-3}	2×10^{-4}	8×10^{-5}
zones	$N_R\times N_\theta\times N_\phi$		3×10^{6}	5×10^{10}	3×10^{13}
CFL timestep	$\Delta X/V_A$ (Explicit)	s	2×10^{-9}	8×10^{-11}	7×10^{-12}
Space-time pts			6×10^{12}	1×10^{20}	6×10^{24}

In the past, "Effective speed" increases came from both faster hardware and improved algorithms