Astrophysics Breakout Session

Welcome!

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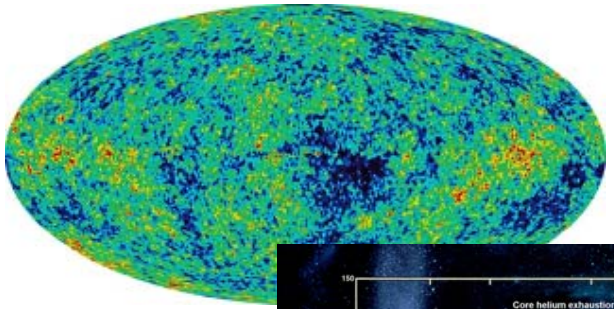
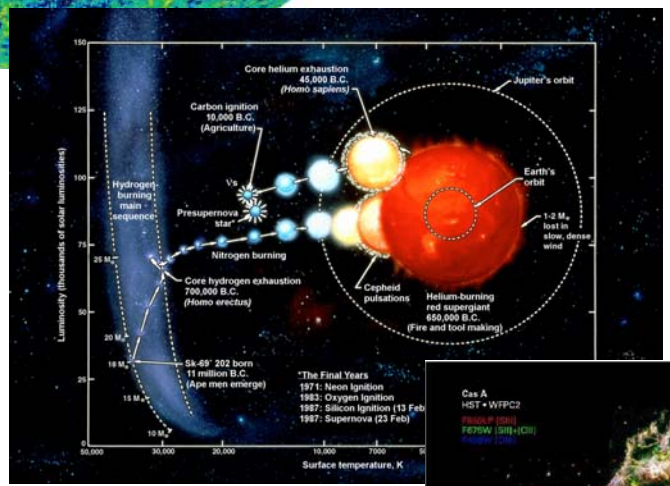
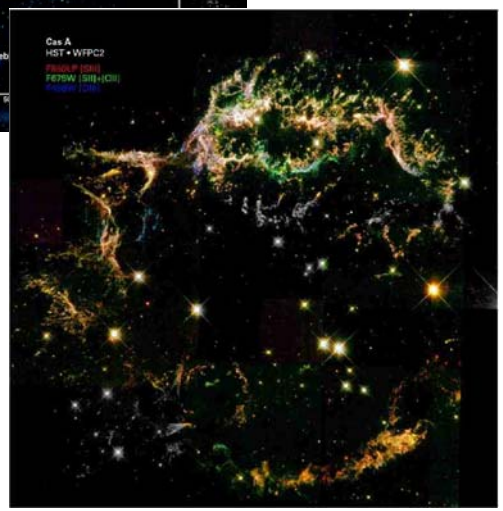
ORNL Exascale Town Hall

The Big Picture







Understanding our universe and our place in it will require an understanding of phenomena on all scales.

Large-Scale Structure

Galaxies

Formation and Evolution

Interaction

Stars and Planets

Formation and Evolution

Supernovae

Gamma-Ray Bursts

Compact Objects

Formation and Evolution

Neutron Stars

Black Holes

Interaction

Mergers

Today's Speakers

Large-Scale Structure

Mike Norman

Galaxies

Paul Ricker

Tom Quinn

Stars

Paul Woodward

Alexei Khokhlov

Bronson Messer

Compact Objects

Pablo Laguna

8 Questions for the Next 10 Years

1. What compelling scientific problem could you address with an exascale computer?

   Many compelling problems were identified across the scales of the Universe.

   Problems at each scale will be addressed with exascale computing. The relationships/coupling between scales are beyond the exascale.

2. What external factors make the solution to this exascale problem a pressing concern?
   (E.g., future satellite missions, etc.)

   Billions of dollars will be spent on space-based missions in the next decade. The benefit of such missions will depend greatly on the output of our community's numerical simulations.

3. Do you have an extant code you believe might have a path forward to the exascale?
   I.e., regardless of how the implementation might change, do you now have a coded version of the algorithm you anticipate using to solve the problem in (1)? Or do you believe a new algorithm should/must be used in the future?

   The general response was that existing algorithms will work, but the response in part depends on the nature of the planned exascale machines.

   Everyone anticipates (minor) changes to existing implementations (e.g., for multi-core processors), but again, the response depends on the details of the planned exascale architectures. How different will they be?

   In some cases, the algorithms do not yet exist or are not fully developed.

8 Questions for the Next 10 Years

4. Is there potentially important physics you neglect today for want of computational power that would be feasible to model on an exaflop computer? Why is this physics important in your problem?

   Exascale will enable higher resolution (grid and particle number), greater physical domain sizes, and additional physics. (Everyone cited known missing physics. Everyone cited higher resolution/larger number of particles.)

5. Given what you know about near-future computer architectures, do you see an immediate problem? E.g., will CPUs with 10's-100's of cores but only modest increases in memory bandwidth present a problem?

   Memory bandwidth, memory per processor, and total memory are all significant issues.

   Cache aware implementations of algorithms are already in widespread use. How effective will they continue to be?

   A more complete response will again depend on the nature of the planned exascale architectures.

6. Given how you program for today's biggest architectures, do you see an immediate problem for running on machines with 1-10 million cores? I.e., can you clearly see the end of scaling right now?

   Load balancing and fault tolerance were overarching issues for most/all involved.

   Use of AMR is widespread (spatial scales are disparate).
   Long runtimes characterize most/all astrophysical applications.

8 Questions for the Next 10 Years

7. Given how much time and energy you expend on the management and analysis of data from simulations now, do you foresee obvious problems when the compute rate and memory available for simulation increases 10,000x?

   The anticipated data will be astronomical.

   A key issue raised: to move the data or not to move the data? The community wants on-demand interactive analysis of simulation data. This will require considerable further discussion.

8. Do you anticipate using observational data in your simulation or simulation-analysis pipeline? How? Does that require an exaflop computer?

   Generally no.

   Models are validated against observations, of course. (This is what validation means to the computational astrophysics community ultimately.)

   Models help interpret observations and help guide the choice of future missions and observations.