Motivation for Curricular Reform

Computational Applications to Physics, Other Sciences, and Engineering

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My Tasks

Overview of the conference

- Organization of sessions
- Framework for thinking about offerings

Introduction to this session

Conference Agenda

1. Roles of Scientific Computing in Physics and Other Fields

   How should research inform what we do in the undergraduate curriculum?

2. Integrating Computational Physics into the Curriculum

   What computational physics should be taught and where?

3. Computational Physics Education

   What exemplar strategies do we have now?

Motivation?

Case for urgency

- Employment of our graduates
- Cultural shock in the workplace

Need to change the way we think of physics

- Think numerical!
- Computational science vs. scientific computation

Whither our Graduates?

The wake-up call

- American Institute of Physics employment survey

Ivie, R. and K. Stowe (2002). "Early Careers of Physics Bachelors." College Park MD, American Institute of Physics.

A fundamental finding

- *Spread between academic preparation and responsibilities of the workplace is largest in areas of computing.*

AIP Bachelor Plus Five Study

Ivie, R. and K. Stowe (2002). "Early Careers of Physics Bachelors."

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Adaptive Optics (circa 1980)

Active mirror technology to "undo" the atmospheric aberrations.

Numerical modeling of atmospheric turbulence to "scale" the optics and control system
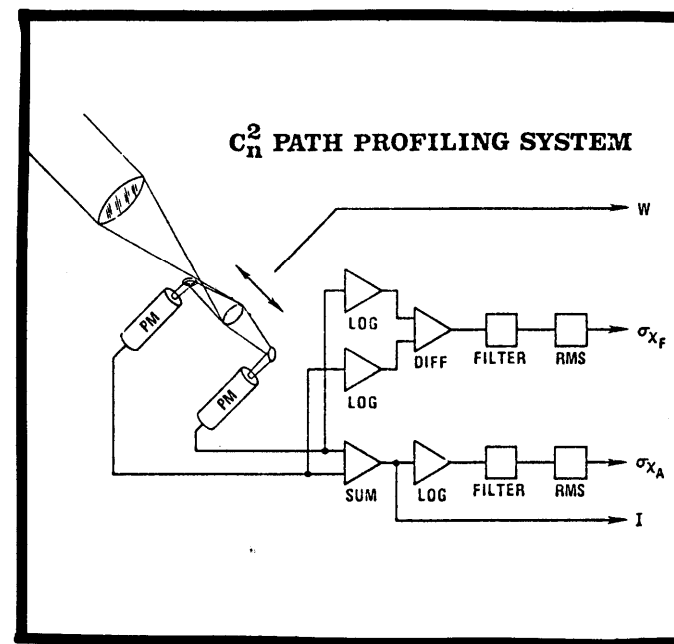
Optical Turbulence Profilimeter

Figure 5. Schematic diagram of the optical spatial filter and the electronics for the C_n^2 profiling system.
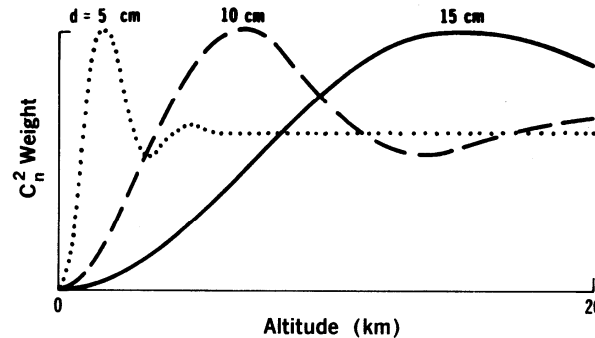
Profilimeter Performance Modeling

Figure 2. Weighting function of a finite two-dimensional array of detectors observing stellar scintillations for various spatial wavelengths d. The broad band effect of the light source has been included.
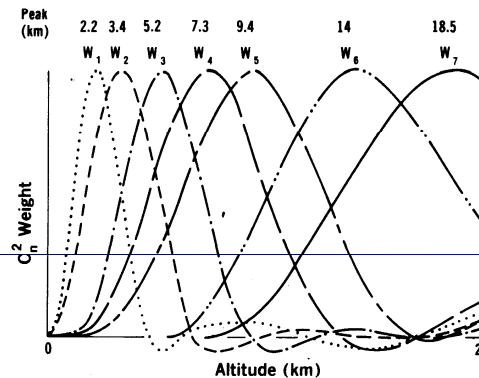
Figure 3. Composite path-weighting function by linearly combining the weighting functions at 3 different spatial wavelengths.

Davidson College NC

Background work - a quick tour

Past two years - a concerted movement

Grass roots organizing

American Association of Physics Teachers

- Committee on Instructional Technology

American Institute of Physics

- *Computing in Science and Engineering* magazine

Cracker barrels

Surveys

Invited and Focus sessions

Most recently - a response to the grass roots

Visioning WORKshop at Argonne National Lab

Partnership for Computation in Undergraduate Physics (PICUP)

- Shodor / Supercomputing '07 / TeraGrid / *CiSE*

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Who are they and What are they doing?

Computing in Science and Engineering 2005 survey of computation in undergraduate physics

- ~250/700+ institutions with BS physics respond

- Mismatch between values and practice

- Large variability in degree and modes of use

- Polarization in attitudes toward the technology
  - * Fundamentalists
  - * Pragmatists
- Several stable paradigms for integration

What did we do about it?

Publish

- *Results CiSE* theme issue: Sep./Oct. 2006
  - ∗ "Computing in Undergraduate Physics"
  - ∗ One paper for each paradigm

Build Community

- ∗ Invited talks and posters in Syracuse - 2006
- ∗ Distributed issue to institutions of all survey respondent

Take next step

- PICUP - Partnership for Integration of Computation into Undergraduate Physics
  - ∗ Visioning WORKshop - Argonne May 2007

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Affiliation and collaboration

Growing a community of shared values

- Partnership for Integration of Computation into Undergraduate Physics (**PICUP**)
  - ∗ Shodor Education Foundation
  - ∗ Supercomputing '07 Education Program
  - ∗ TeraGrid Project Educational Outreach
  - ∗ *CiSE*
- Creating an instrument to envision a future
  - ∗ A WORKshop experiment
  - ∗ Joining issues to practice

# Sample results from the Visioning WORKshop

- Reforms easier in upper level courses
  - ∗ Students' preparations are more aligned
  - ∗ Case studies more obviously valuable

- Meaning of computation differs with discipline
  - ∗ Biology - statistics and combinatorics
  - ∗ Engineering - modeling and design

- Crossing disciplines is an important value
  - ∗ Multi-physics
  - ∗ Multi-scale

- White paper(s) to come

Computational Astrophysics

Work of John Blondin and colleagues at NCSU Illustrates:

- Mixing physics and spanning scales via numerical simulations

- Solving problems using a full palette of computing tools and resources

- Involving undergraduate students in research through High Performance Computing

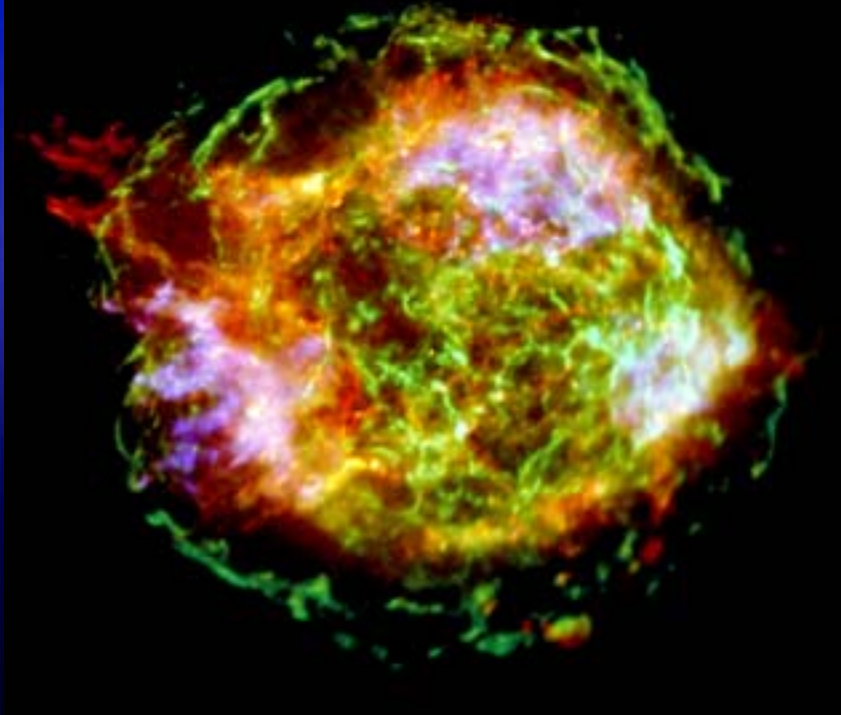# Discovering the Complexity of Supernovae through 3D Simulations
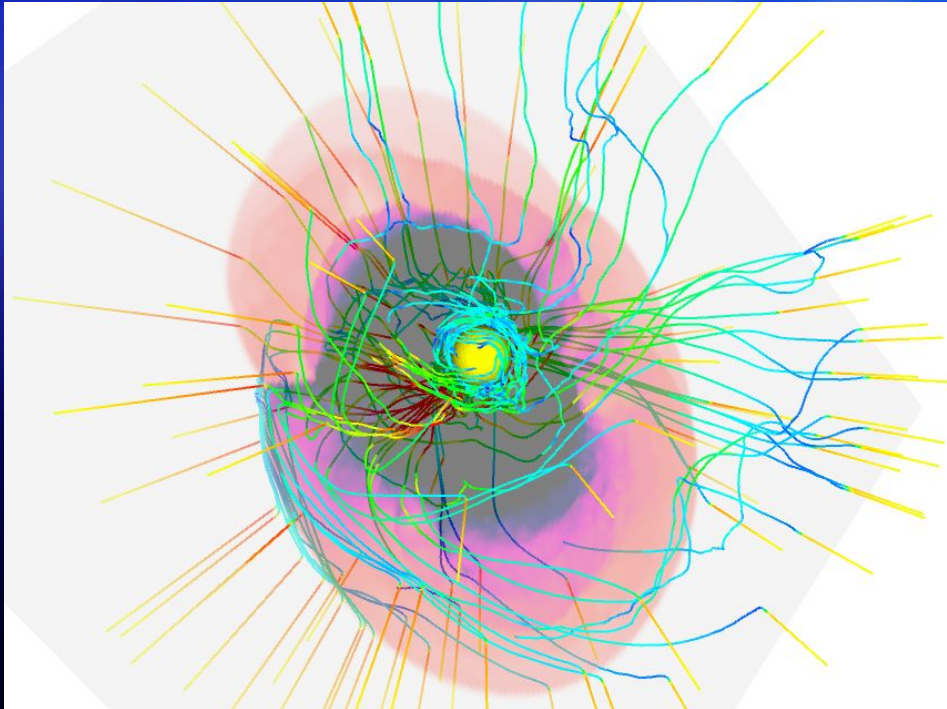
QuickTime™ and a
TIFF (Uncompressed) decompressor
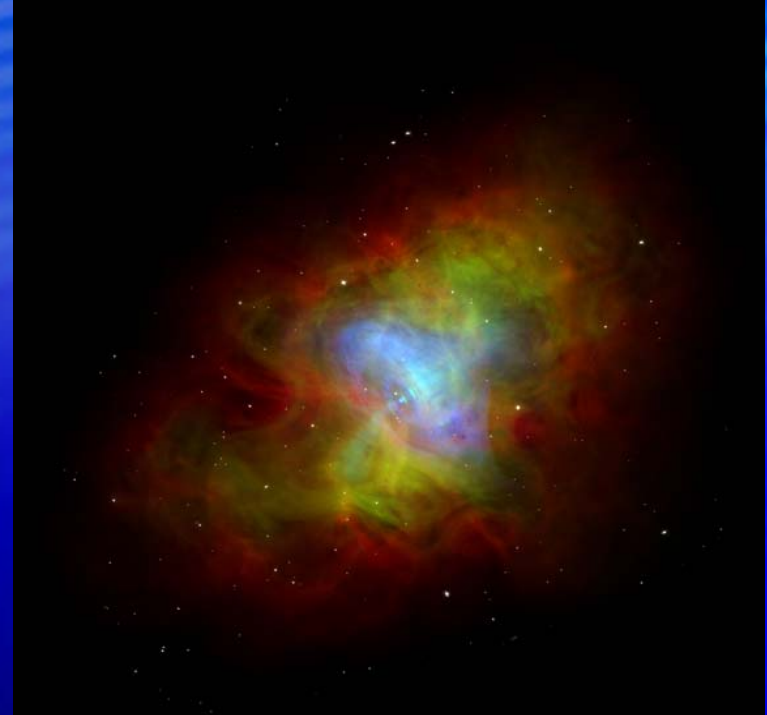are needed to see this picture.

John M. Blondin
NC State University

AAPT -2007 Satellite Conference
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Remnants of Supernova Explosions
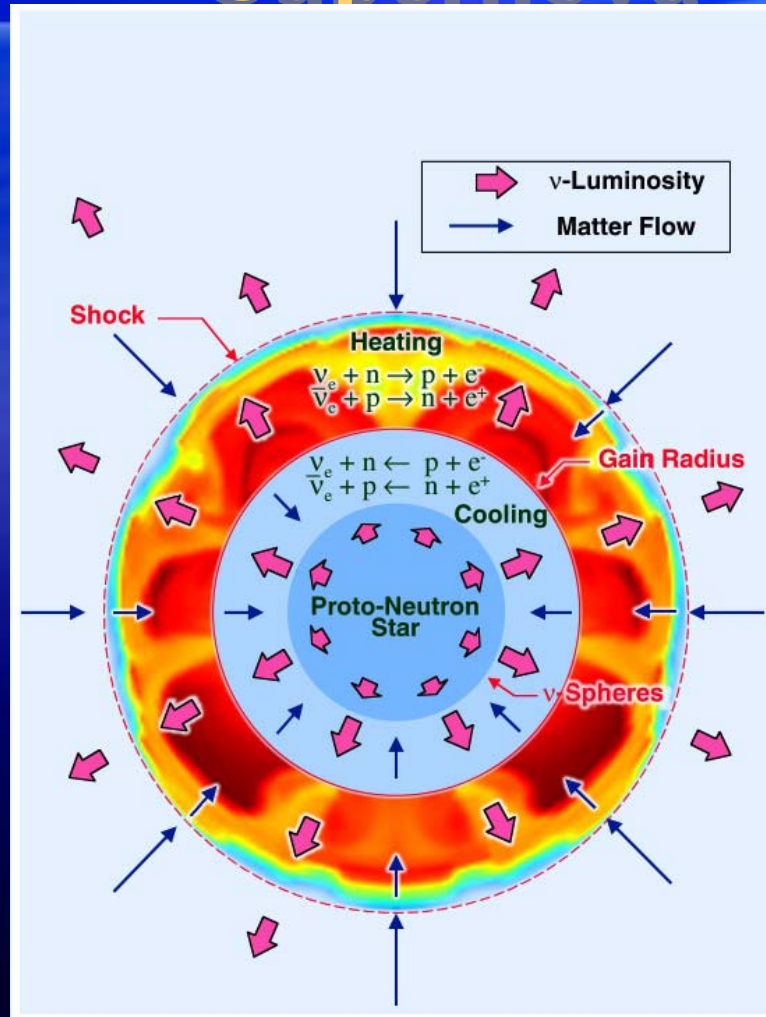

Relic Blast Wave

Spinning Neutron Star

It all starts with core collapse…

Anatomy of a Core-collapse Supernova

Spherical Accretion Shock Instability

Blondin, Mezzacappa, DeMarino 2003, ApJ, 584, 971

QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.
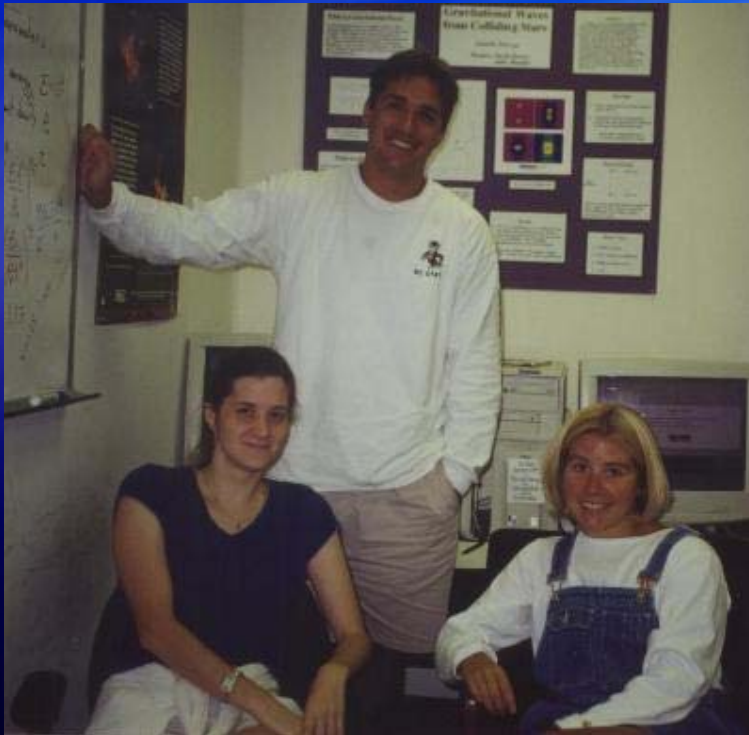
First Results: SASI Exists in 3D

- 3D Cartesian grid

- 100 Million zones

- 100's of processors

- 100's of GB in full run

QuickTime™ and a
Animation decompressor
are needed to see this picture.

Let's have another look at That!

QuickTime™ and a
Video decompressor
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NCSU REU Students, Summer 2000

Christine DeMarino
Brett Unks
Dana Paquin

Thank you

Parting recommendations

- Think broadly

- Think big

- Think together

  * PICUP needs more educators to sustain serious dialogue

- Think different!