Citation Key

for more information see: http://open.umich.edu/wiki/CitationPolicy

Use + Share + Adapt

{ Content the copyright holder, author, or law permits you to use, share and adapt. }

PD-GOV **Public Domain – Government**: Works that are produced by the U.S. Government. (17 USC § 105)

PD-EXP **Public Domain – Expired**: Works that are no longer protected due to an expired copyright term.

PD-SELF **Public Domain – Self Dedicated**: Works that a copyright holder has dedicated to the public domain.

CC ZERO **Creative Commons – Zero Waiver**

CC BY **Creative Commons – Attribution License**

CC BY-SA **Creative Commons – Attribution Share Alike License**

CC BY-NC **Creative Commons – Attribution Noncommercial License**

CC BY-NC-SA **Creative Commons – Attribution Noncommercial Share Alike License**

GNU-FDL **GNU – Free Documentation License**

Make Your Own Assessment

{ Content Open.Michigan believes can be used, shared, and adapted because it is ineligible for copyright. }

PD-INEL **Public Domain – Ineligible**: Works that are ineligible for copyright protection in the U.S. (17 USC § 102(b)) *laws in your jurisdiction may differ

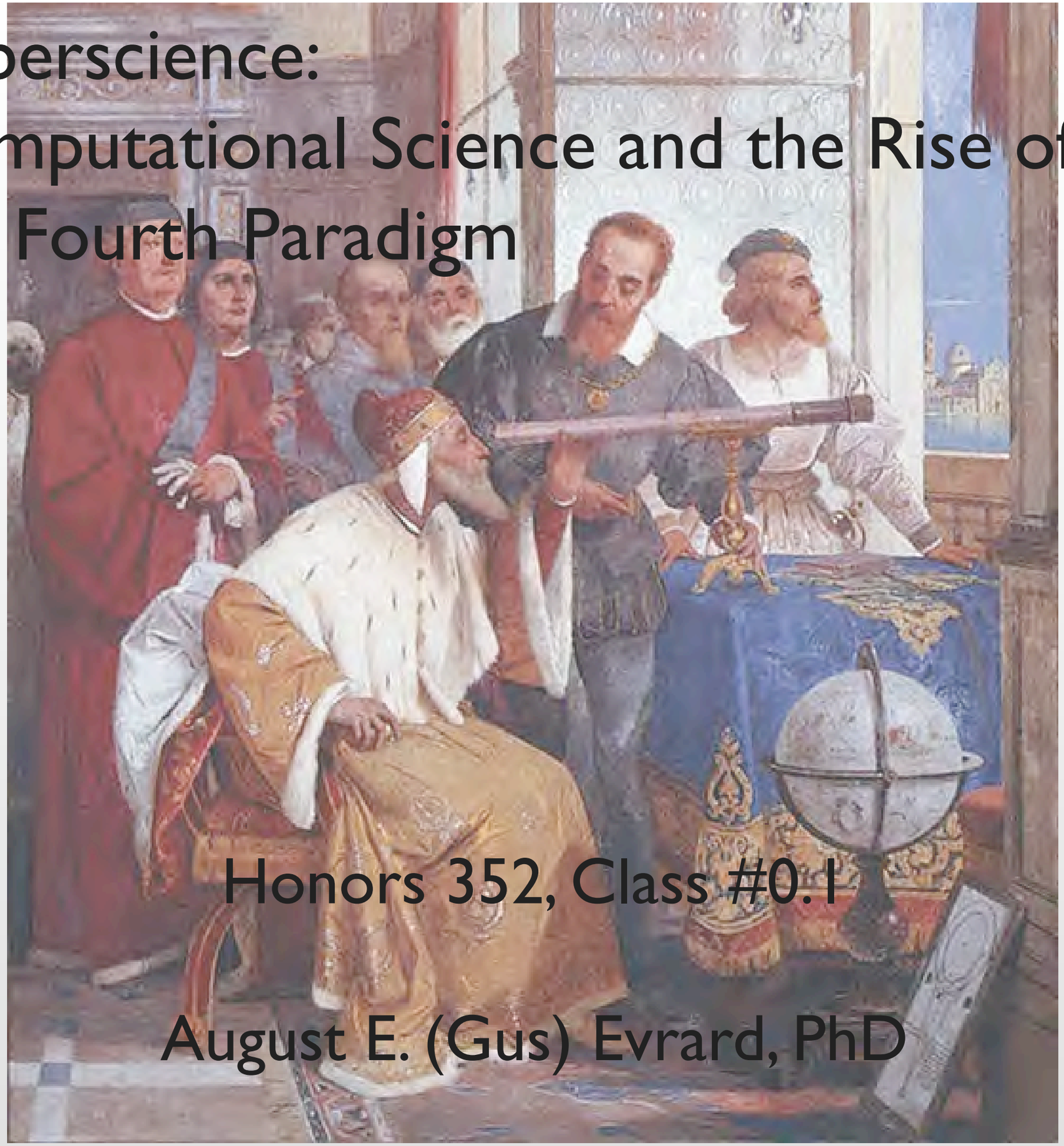
{ Content Open.Michigan has used under a Fair Use determination. }

FAIR USE **Fair Use**: Use of works that is determined to be Fair consistent with the U.S. Copyright Act. (17 USC § 107) *laws in your jurisdiction may differ

Our determination **DOES NOT** mean that all uses of this 3rd-party content are Fair Uses and we **DO NOT** guarantee that your use of the content is Fair.

To use this content you should **do your own independent analysis** to determine whether or not your use will be Fair.

Cyberscience: Computational Science and the Rise of the Fourth Paradigm



Honors 352, Class #0.1

August E. (Gus) Evrard, PhD

Fall 2010

 Giuseppe Bertini (1825–1898), "Galileo Galilei showing the Doge of Venice how to use the telescope"

University of Michigan

WANT TO EXPLORE TEACHING?

The IDEA Institute has many programs for you including

FUTURE

AND

SCIENCE SATURDAYS

The IDEA INSTITUTE offers many different ways for you to explore science and math teaching! We have two different opportunities available this semester for dedicated science and math undergraduate students to collaborate with high school and middle school teachers.

If you enjoy learning science and mathematics and would love to share your knowledge with others, get involved in

FUTURE OR SCIENCE SATURDAYS

For more information and application forms, look online:

WWW.IDEAINSTITUTE.UMICH.EDU

Attend an IDEA INSTITUTE informational meeting!

Monday, September 13, 4:00 - 5:30 p.m.
Tuesday, September 14, 4:00 - 5:30 p.m.

In the IDEA Institute:
3236 Undergraduate Science Building
Snacks provided

For more information, please go to www.ideainstitute.umich.edu.

In today's news...

Please see original quote from New York Times regarding Google Instant at
http://bits.blogs.nytimes.com/2010/09/08/google-speeds-queries-with-instant-results/.

Today

- ***reading quiz***
- ***short lecture (Prof. Gus) - Jim Gray's fourth paradigm = IBM's smarter planet?***
- ***discussion: the participants and processes of scientific research***
- ***blog / google site access***

N^{th} paradigm?

Thomas Samuel Kuhn (1922-1996) became one of the most influential philosophers of science of the twentieth century, perhaps the most influential—his The Structure of Scientific Revolutions is one of the most cited academic books of all time. His contribution to the philosophy science marked not only a break with several key positivist doctrines but also inaugurated a new style of philosophy of science that brought it much closer to the history of science. His account of the development of science held that science enjoys periods of stable growth punctuated by revisionary revolutions, to which he added the controversial 'incommensurability thesis', that theories from differing periods suffer from certain deep kinds of failure of comparability.

Original biographical information of Thomas Samuel Kuhn at http://plato.stanford.edu/entries/thomas-kuhn/.

N^{th} paradigm?

The historian of science Thomas Kuhn gave paradigm its contemporary meaning when he adopted the word to refer to ***the set of practices that define a scientific discipline at any particular period of time***. Kuhn himself came to prefer the terms ***exemplar*** and ***normal science***, which have more precise philosophical meanings. However in his book The Structure of Scientific Revolutions Kuhn defines a ***scientific paradigm*** as:

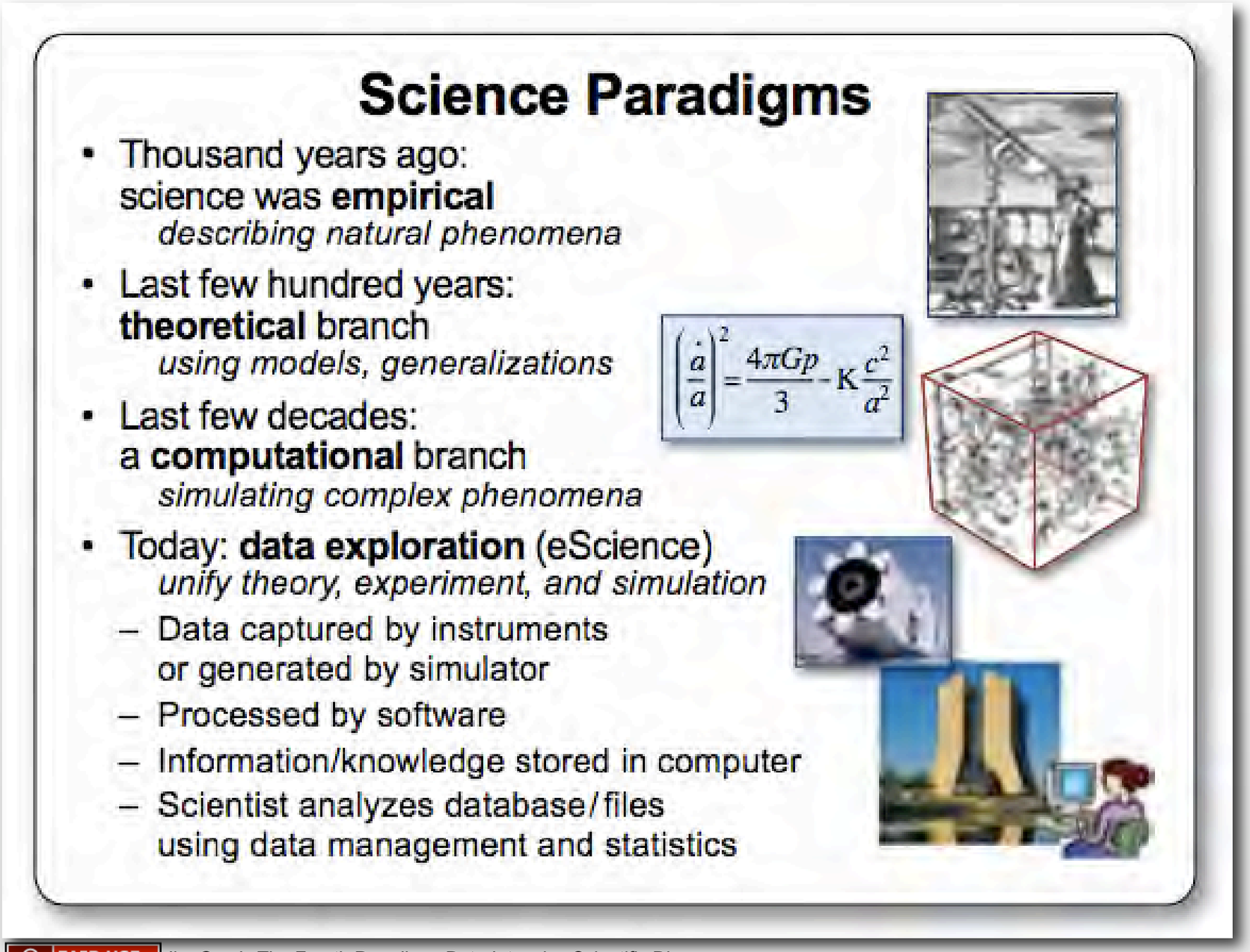
* what is to be observed and scrutinized
* the kind of questions that are supposed to be asked and probed for answers in relation to this subject
* how these questions are to be structured
* how the results of scientific investigations should be interpreted

Alternatively, the Oxford English Dictionary defines paradigm as "a pattern or model, an exemplar." Thus an additional component of Kuhn's definition of paradigm is:

* how is an experiment to be conducted, and what equipment is available to conduct the experiment.

http://en.wikipedia.org/wiki/Paradigm

Jim Gray's four scientific paradigms / branches



 Jim Gray's The Fourth Paradigm: Data-Intensive Scientific Discovery.

1. empiricism

observe phenomenon and attempt to classify

Ptolemy's universe of concentric spheres

2. theory

describe above classifications with mathematical models

Newtonian/Einsteinian gravity

3. computation

build `virtual' physical systems via solution of math models

Cosmic structure formation

4. data-driven synthesis (?)

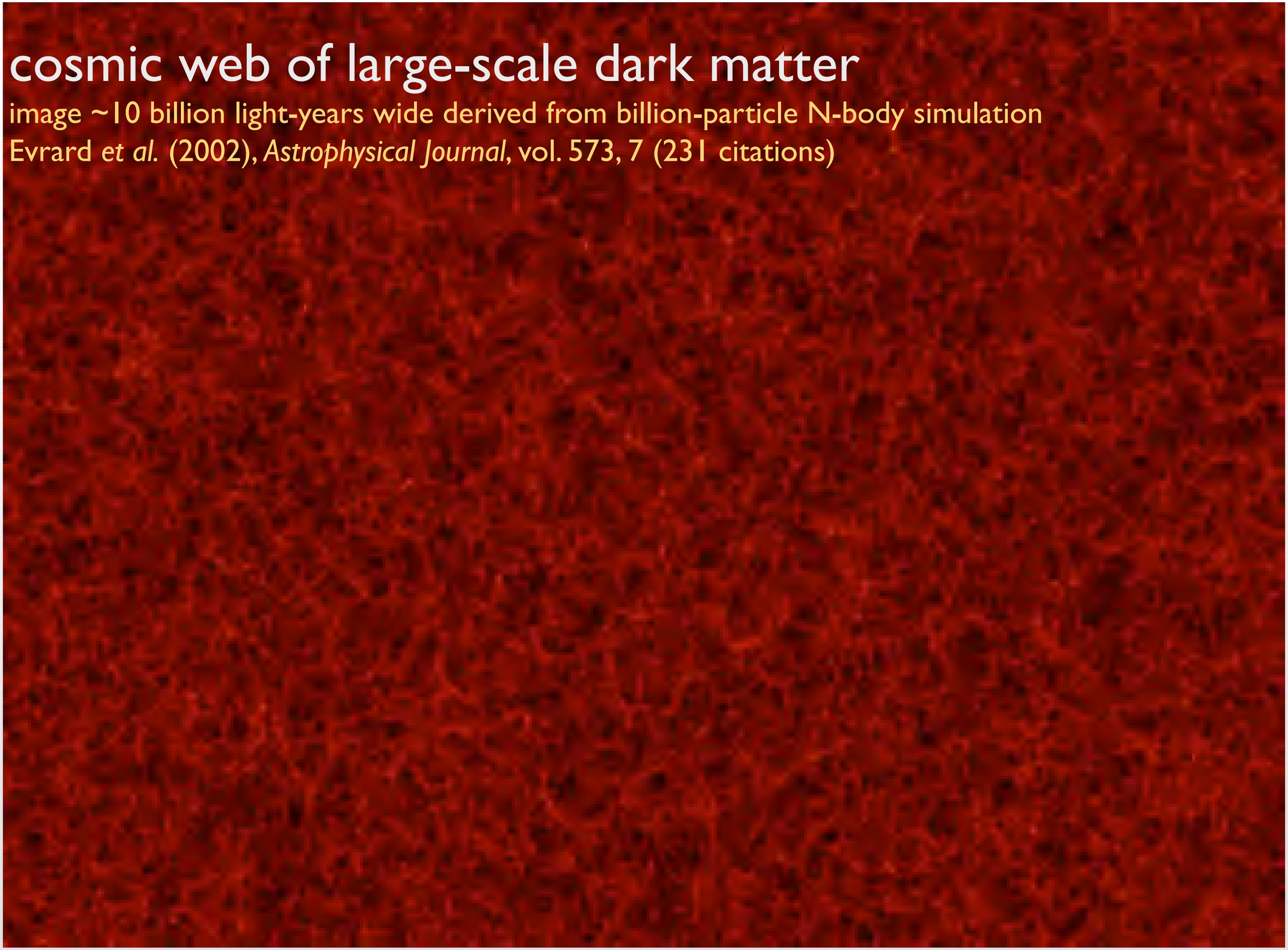
unite empirical, theoretical and computational branches with data (X-info and Comp-X)

Matter/energy content of the universe

cosmic web of large-scale dark matter

image ~10 billion light-years wide derived from billion-particle N-body simulation

Evrard *et al.* (2002), *Astrophysical Journal*, vol. 573, 7 (231 citations)



Evrard *et al.* (2002), *Astrophysical Journal, 573*(7).

data-rich research permeates all domains (X)

X-Info

- The evolution of X-Info and Comp-X for each discipline X
- How to codify and represent our knowledge

The Generic Problems

- Data ingest
- Managing a petabyte
- Common schema
- How to organize it
- How to reorganize it
- How to share it with others
- Query and Vis tools
- Building and executing models
- Integrating data and literature
- Documenting experiments
- Curation and long-term preservation

 Jim Gray's The Fourth Paradigm: Data-Intensive Scientific Discovery.

challenges

1. unifying the tiers

– data collections across the scales, from small labs to international consortia

– published literature with underlying data (*raw, derived*) and data processing algorithms/codes

– ironing the seams across disciplines

Disciplinary scientists and organizations (e.g., National Academy of Science, National Science Foundation)

2. semantics

– describing objects, attributes, methods in a robust, scaleable manner

– curating and archiving collections

Disciplinary scientists, Librarians!

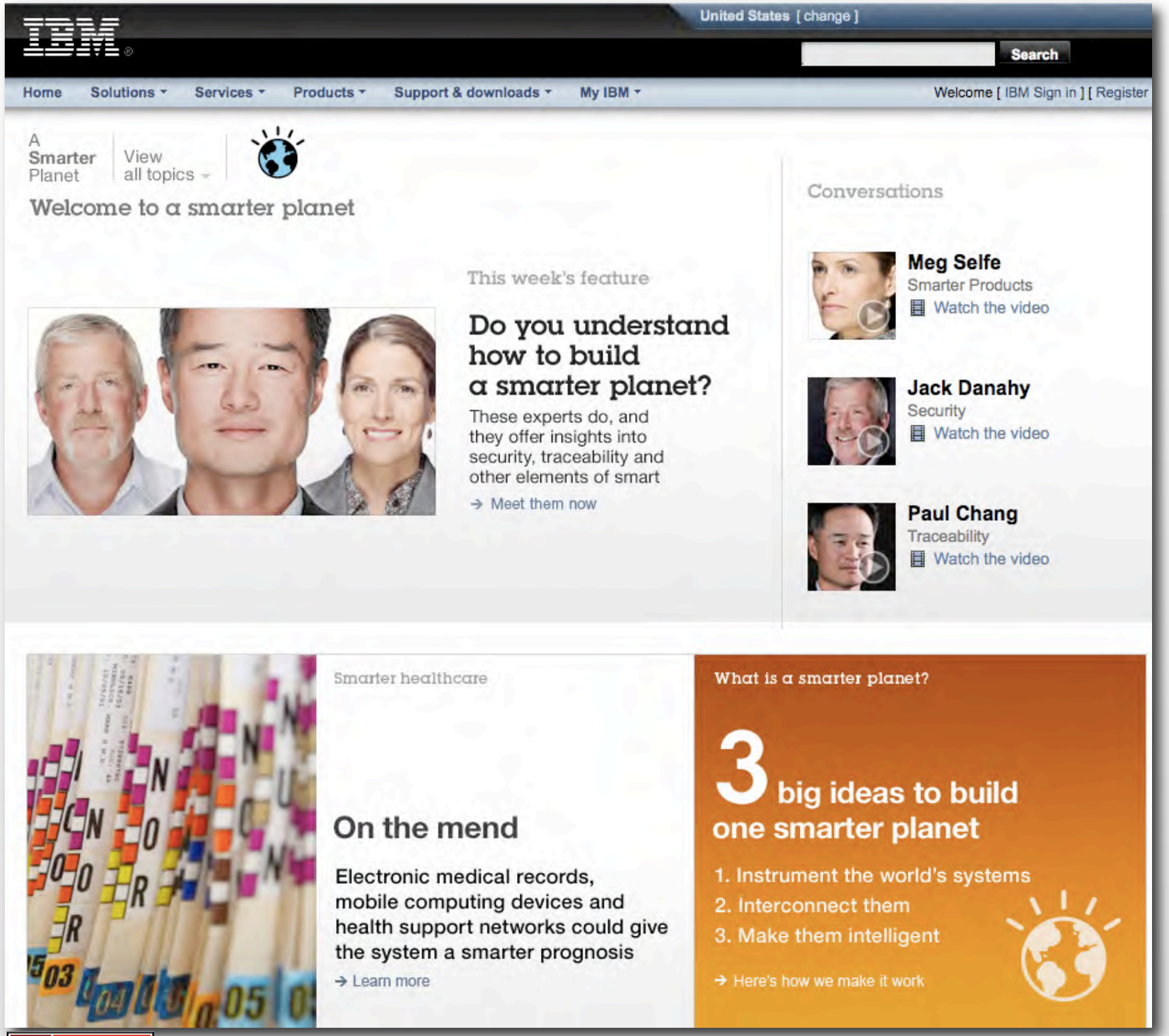
3. funding

– recognize value of data-driven synthesis (DDS) infrastructure

– maintain `single investigator' support while growing new capabilities

Federal and state government agencies, scientific industry partners, universities!

Building a smarter planet, for business (and science?)



 Screen shot of IBM website from http://www.ibm.com/smarterplanet/us/en.

Discuss: Nature of Scientific Research

- who participates?
- what are the processes involved? (end-to-end view)
- how are the participants rewarded?

Lab next Tuesday

- three groups: PC / Mac / Linux
- bring cameras

Additional Source Information

for more information see: http://open.umich.edu/wiki/CitationPolicy

Slide 3: Giuseppe Bertini (1825–1898), "Galileo Galilei showing the Doge of Venice how to use the telescope"

Slide 4: Image of a flyer regarding an event that has already taken place. For more information, please go to www.ideainstitute.umich.edu.

Slide 5: Please see original quote from New York Times regarding Google Instant athttp://bits.blogs.nytimes.com/2010/09/08/google-speeds-queries-with-instant-results/.

Slide 7, Image 1 (left): Please see original biographical information of Thomas Samuel Kuhn at http://plato.stanford.edu/entries/thomas-kuhn/.
Slide 9: Jim Gray's The Fourth Paradigm: Data-Intensive Scientific Discovery.

Slide 10: Evrard *et al.* (2002), *Astrophysical Journal, 573*(7).
Slide 11: Jim Gray's The Fourth Paradigm: Data-Intensive Scientific Discovery.

Slide 13: Please see original image of screen shot of IBM website at http://www.ibm.com/smarterplanet/us/en.