

Model Validation, Evolutionary Systems and Semantics of Information

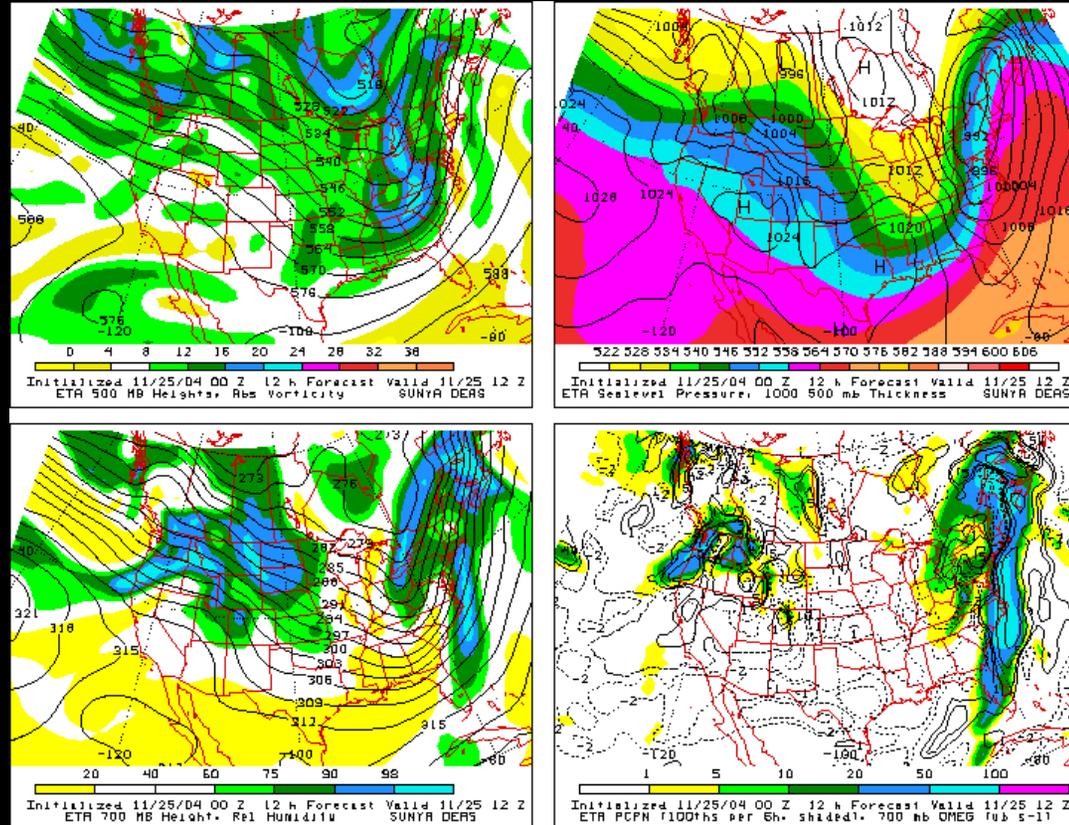
University of Pavia
18 December, 2004

<http://www.idt.mdh.se/~gdc>

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Modeling Complex Systems

- In modern science, technology, economy and a number of other fields we depend on (computational) models
- Do models yield information on which strategic decisions could be based?
- We argue that *meaningful data* does not necessarily have to be true to make *useful information*.
- Partially true information or even false information can lead to scientific/technological discovery. (e.g. serendipity)
- In *empirical sciences* we find *adequacy* more powerful and appropriate concept than *truth*.

What Sort of Information are We Dealing with in MBR?

Floridi's Theory of Strongly Semantic Information would like to impose the constraint of truth on information which would consist of *data and truth*. (data + truth)

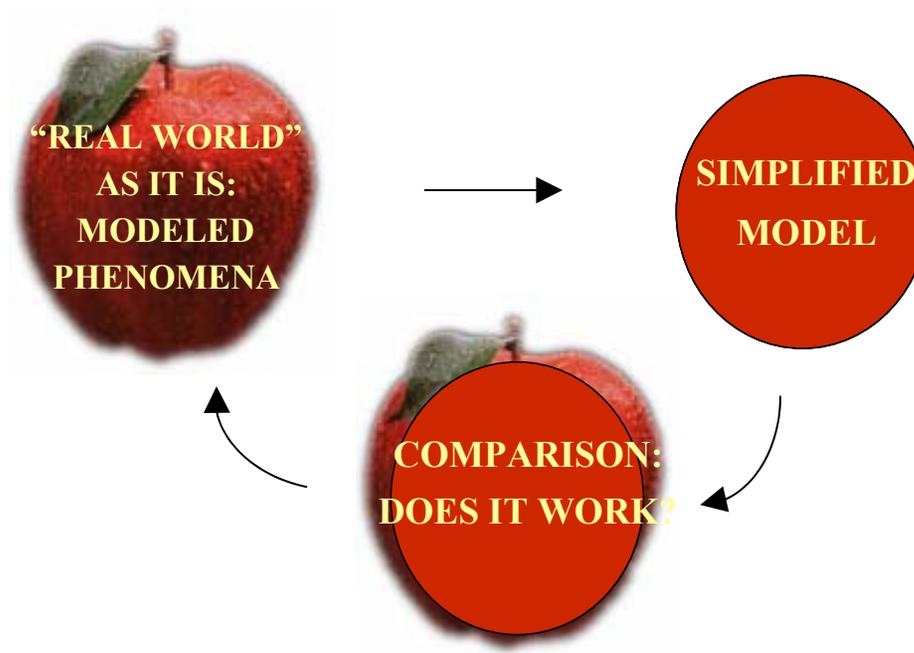
Empirical sciences use the concept of *information as meaningful data*. (data + meaning)

What is the difference between *meaning* and *truth*?

Truth guarantees that the appearance (utterance, or what we observe) corresponds to reality (is the case, constitutes the fact).

Meaning guarantees that we *can make sense* out of it which often is translated to *make use* of it.

Modelling



“Real world”	Model
Program	Compiler Theory
Computer Hardware	Computer Simulation

Model Verification vs. Model Validation

Model Verification is substantiating that the model is transformed from one form into another, as intended, with sufficient accuracy.

Model verification deals with **building the model right.**

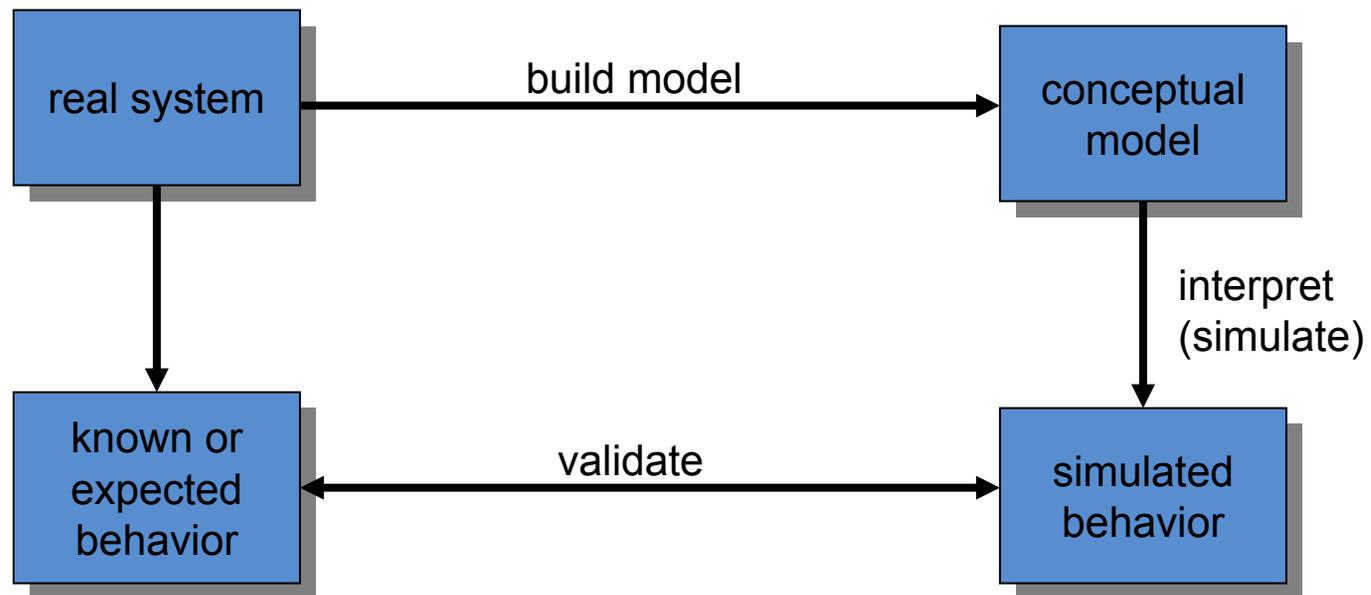
The accuracy of transforming a problem formulation into a model specification is evaluated in model verification.

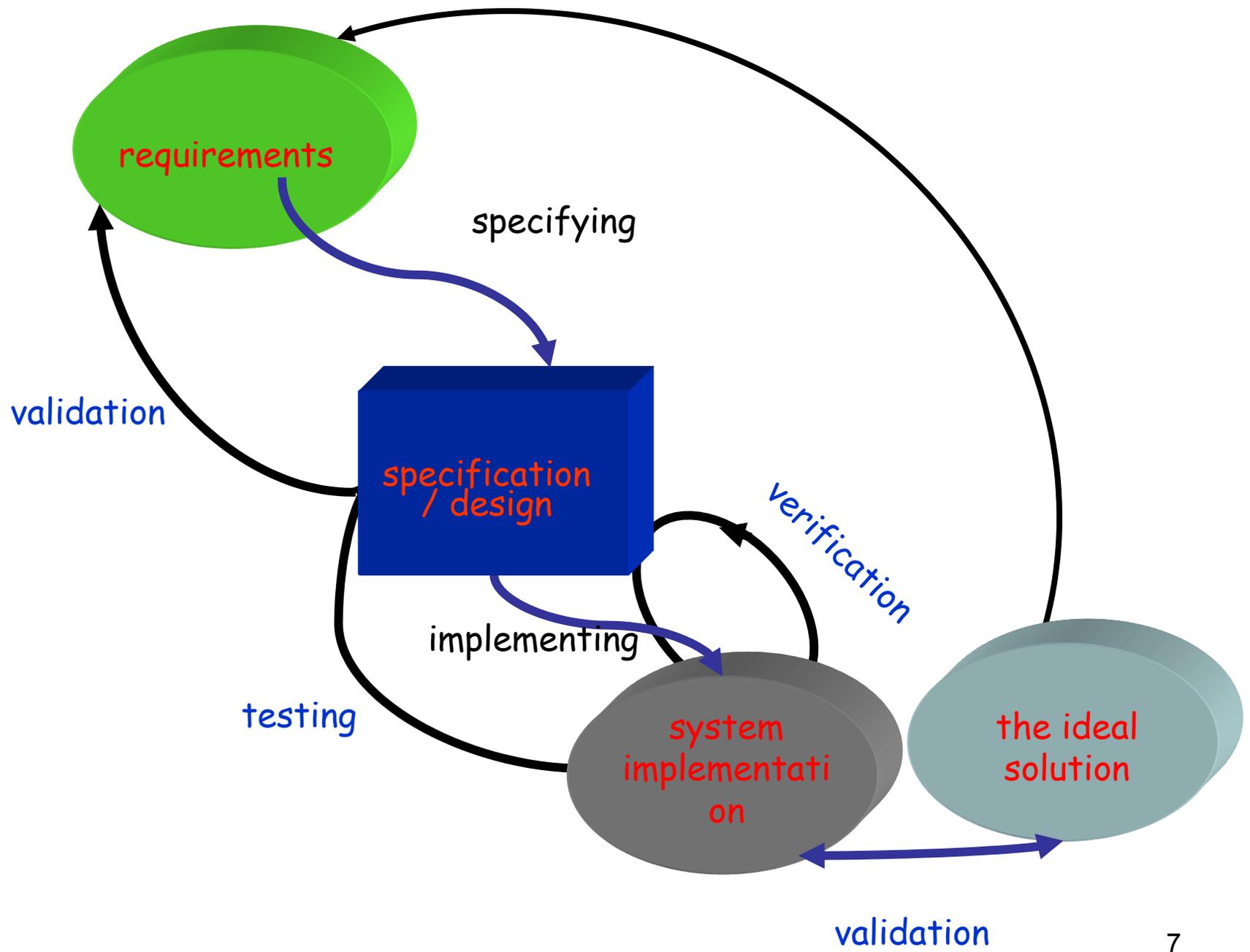
Model Validation is substantiating that the model, within its domain of applicability, behaves with satisfactory accuracy consistent with the M&S objectives.

Model validation deals with **building the right model.**

<http://www.cse.nd.edu/courses/cse439/www/Resources/balci3.pdf>

Simulation for Model Validation

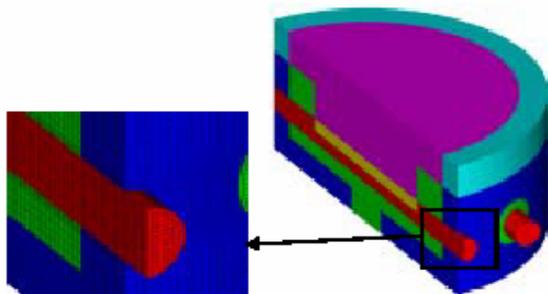




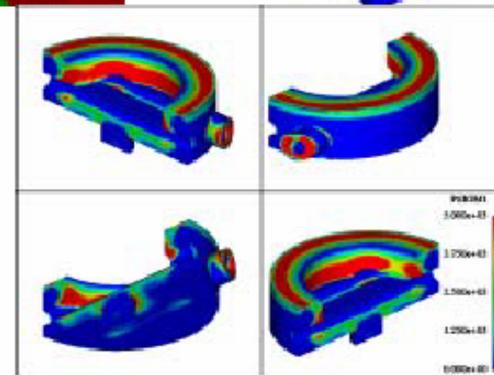
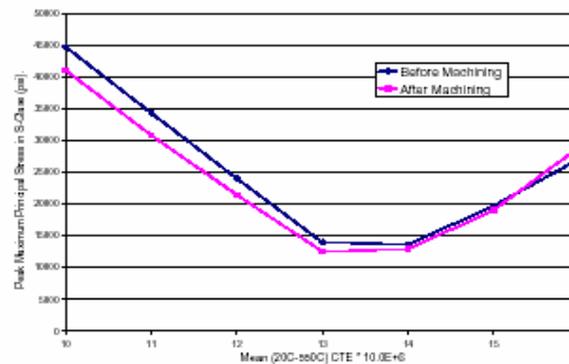
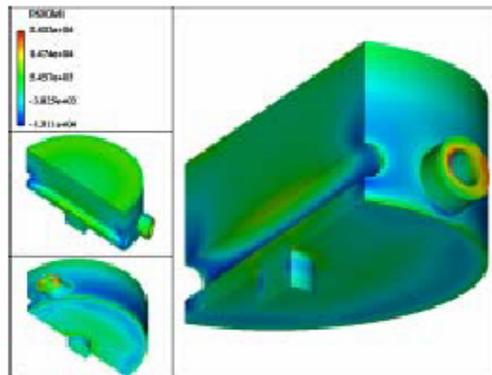
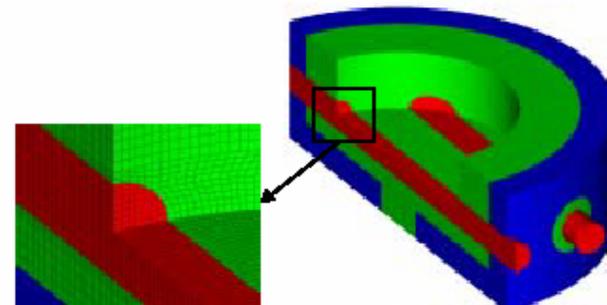
Simulation & Visualisation

Glass Ceramic-to-Metal Seals

Before Machining



After Machining



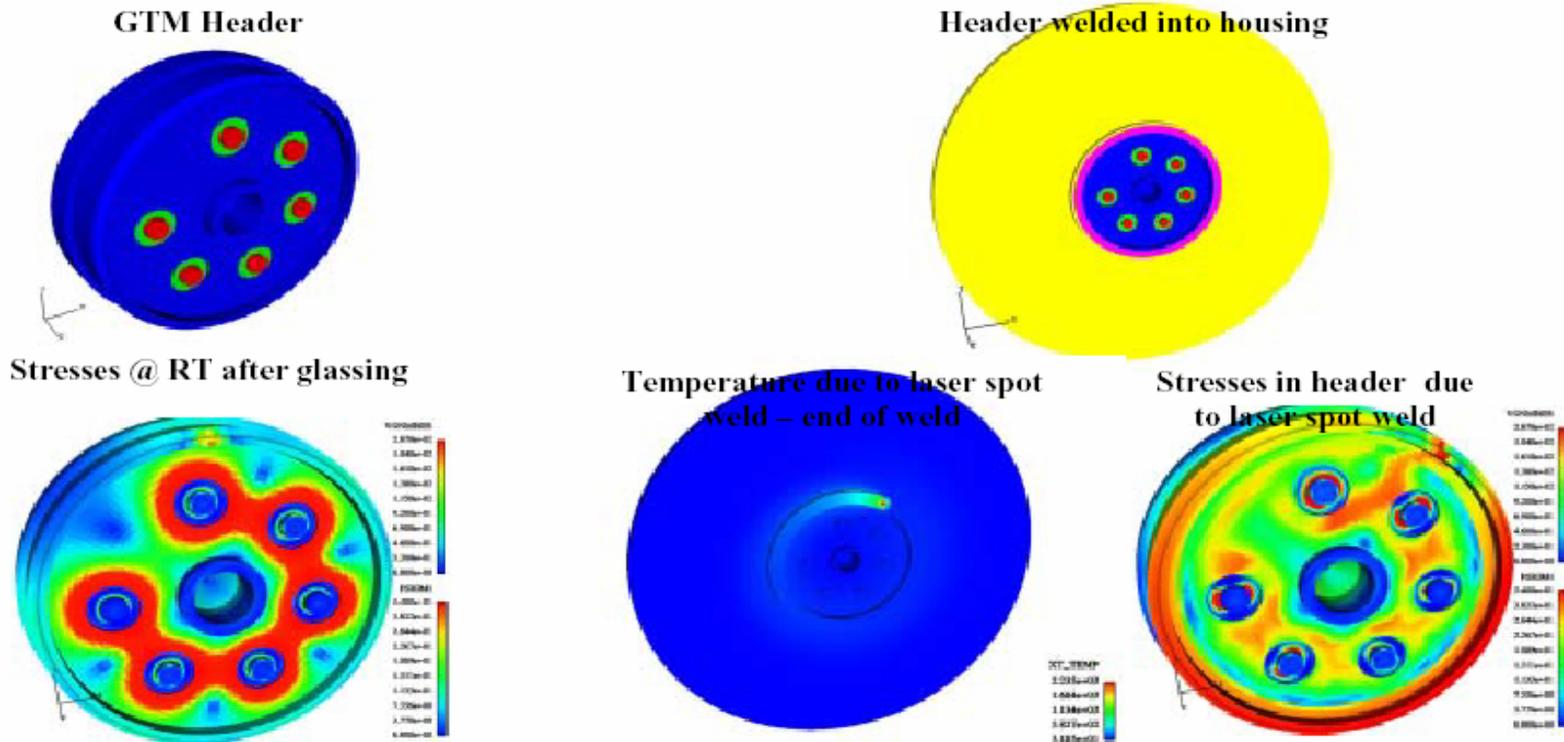
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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Simulation & Visualisation

GTM + Laser Weld



Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

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Model & Simulation

Rowley's original orrery, 1712. The orrery was made by John Rowley of London for Charles Boyle, fourth Earl of Orrery.

The instrument acquired its current name after it was popularised by 17th century essayist, Sir Richard Steele.

The solar system model showed the respective motions of the Earth and Moon around the Sun and was copied from an earlier example made by the famous clockmaker George Graham (1673-1713) for Prince Eugene of Savoy.



Science Museum London/ Science & Society
Picture Library

A Precedence to Verification Rules

There is a precedence to verification rules:

- Syntactic
(Does the syntax of the statement conform to the models syntactic rules?)
- Semantic
(Do the model components conform to the models semantic rules?)
- Relational
(Do the elements within the model correctly relate to each other?)
- Combinational
(Are all the combinations of rules consistent?)

The Paradox of Understandability

- We use models to understand complexity
- The most useful models are the simplest, because they are the easiest to understand
- Simple models do not accurately define what they are modeling
- Thus, we are always faced with the choice between *accuracy* and *comprehension*
- "... all models are wrong; the practical question is how wrong do they have to be to not be useful, "
[George Box and Norman Draper, *Empirical Model Building and Response Surfaces*, John Wiley, 1987, pg. 74].

The Philosophy of Model Validation

- Engineers are depending on simulation tools more than ever to reduce design cost and decrease design time.
- Every theory relies on simplifying assumptions; every numerical method is based on some theory; most numerical models are based on some type of approximate input data.
- Thus, modeling errors may build up and the modeler may not always be able to detect or justify the accumulation of discrepancies between the model and reality.
- Validation is a remedy to assess the quality of a model and simulation results in order to help the user make better decisions during the design process.

The Philosophy of Model Validation

Difficulties have their origin in the concepts underlying VV approaches.

Validation is a decision-making activities based on socio-technical data related to:

- fitness for purpose
- just good enough
- confidence assessment (argument-based confidence).

Challenges of V&V

Inference. Data availability to support assessment of simulation “predictions” is a fundamental problem, especially for the test and evaluation community on the operational side and the experimental community on the science side.

Comparison of simulation results with the available data can be described statistically and data-simulation result relationships can be specified in terms of *accuracy, error, resolution*, etc. for the region of the application domain for which data exist; *but no scientifically rigorous methods currently exist for making inferences about relationships between simulation results (“predictions”) and elsewhere in the application domain.*

Challenges of V&V

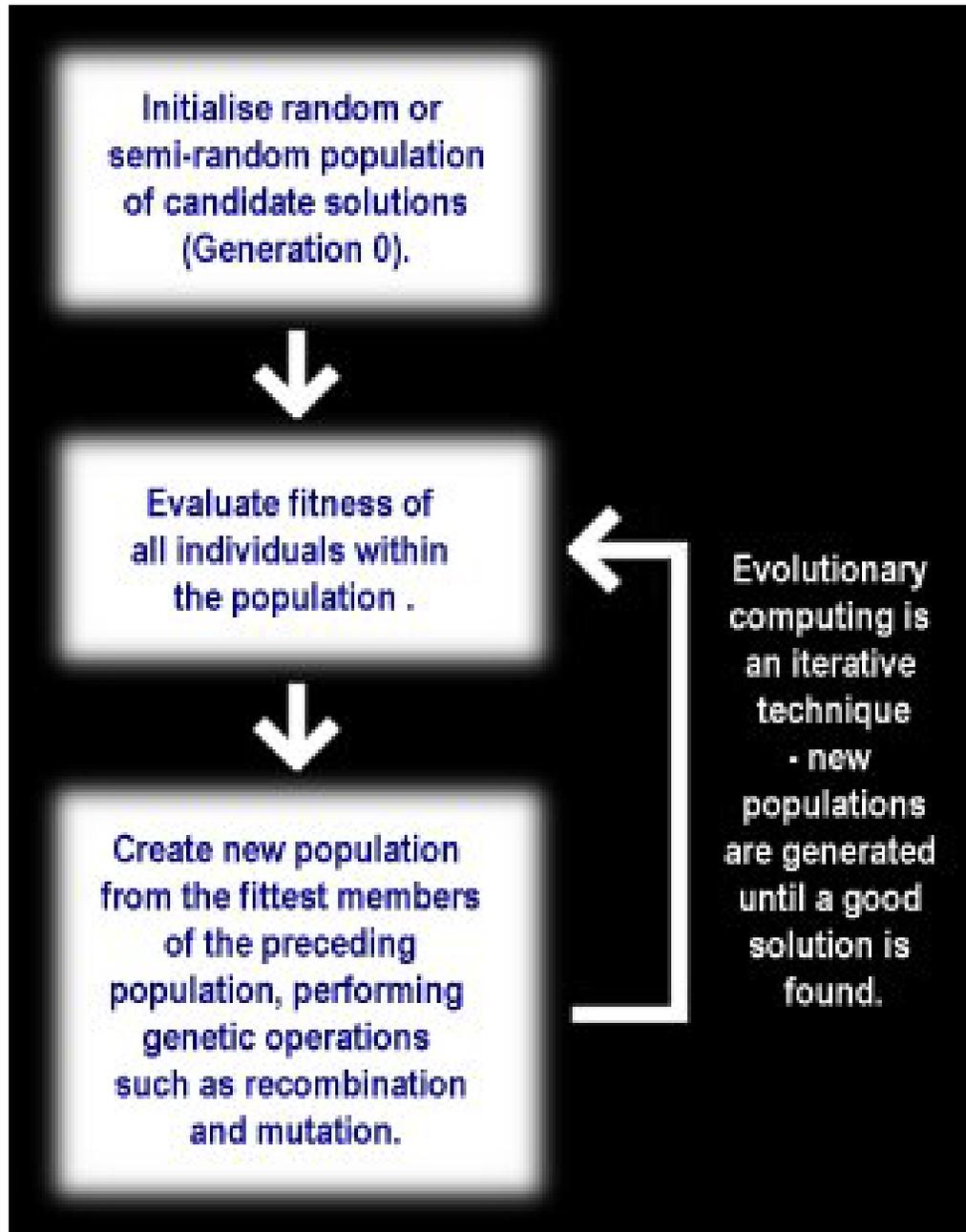
Adaptation. Advances in technology have led to a new genre of computational programming, termed adaptive programming. Techniques employed in adaptive programs include artificial intelligence (AI), expert systems, genetic algorithms, fuzzy logic, machine learning, etc. As adaptive processes become more capable and more widely incorporated in

Evolutionary computing

Evolutionary computing harnesses the power of natural selection to turn computers into automatic optimisation and design tools.

The three mechanisms that drive evolution forward are reproduction, mutation and the survival of the fittest – which enable lifeforms to adapt to a particular environment over successive generations.

Like evolution in nature, evolutionary computing also breeds progressively better solutions to a wide variety of complex problems.



Evolutionary Algorithms and Genetic Algorithms

An evolutionary algorithm is the product of a means of solving computer based problems using evolution as the main tool for design and implementation. There are several different types of Evolutionary Algorithm methods.

The main ones are genetic algorithms, evolutionary programming and the use of evolution strategy.

These methods are linked with aLife in that their main driving forces are akin to natural forces. Evolution and selection are heavily used as is the basic principle of genetics.

The Brain : From Fuzzy Arithmetic to Quantum Computing Studies in Fuzziness and Soft Computing

Da Rocha · Massad Pereira Jr.

A new understanding of the brain by taking into account novel achievements in Fuzziness and Quantum Information Theory bringing together Neuroscience, Soft Computing, Quantum Theory, and recent developments in mathematics the actual knowledge about the brain functioning.

This book develops new and powerful neural models providing formal descriptions of biochemical transactions in the brain. It demonstrates how the physiology of the neuron can be understood based on the fundamentals of fuzzy formal languages and introduces the basics of quantum computation and quantum information to the brain.

It discusses how molecular transactions at the cellular level implement such concepts, shows how certain neural structures, like the dendritic spine, are specialized to function as quantum computing devices and demonstrates how the brain can be viewed as a quantum processing intelligent system.

Challenges of V&V

M&S, the V&V challenge is clear: the M&S performance can differ from instance to instance and therefore presents fundamental challenges to the prediction and assessment of performance.

No scientifically rigorous methods currently exist to ensure future M&S performance will be as good as or better than past performance.

Challenges of V&V

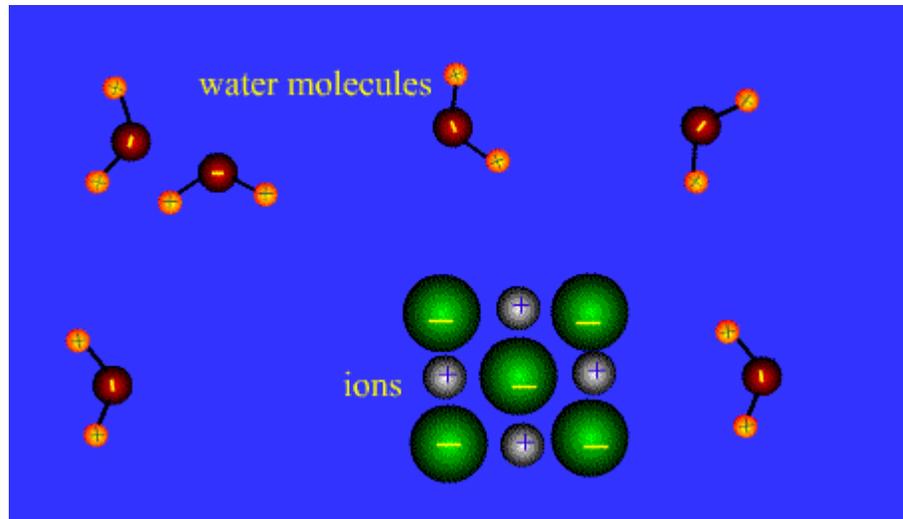
Aggregation. Elements and interactions of a simulation can be represented in varying levels of detail. As simulations become more complex, especially in the case of distributed simulations which may use more than one level of resolution for the same kind of element or interaction, better methods for determining the potential impact on simulation results from such variation in levels of detail are required to minimize potential misuse of simulation results.

Present theory and assessment processes related to this topic are embryonic.

Challenges of V&V

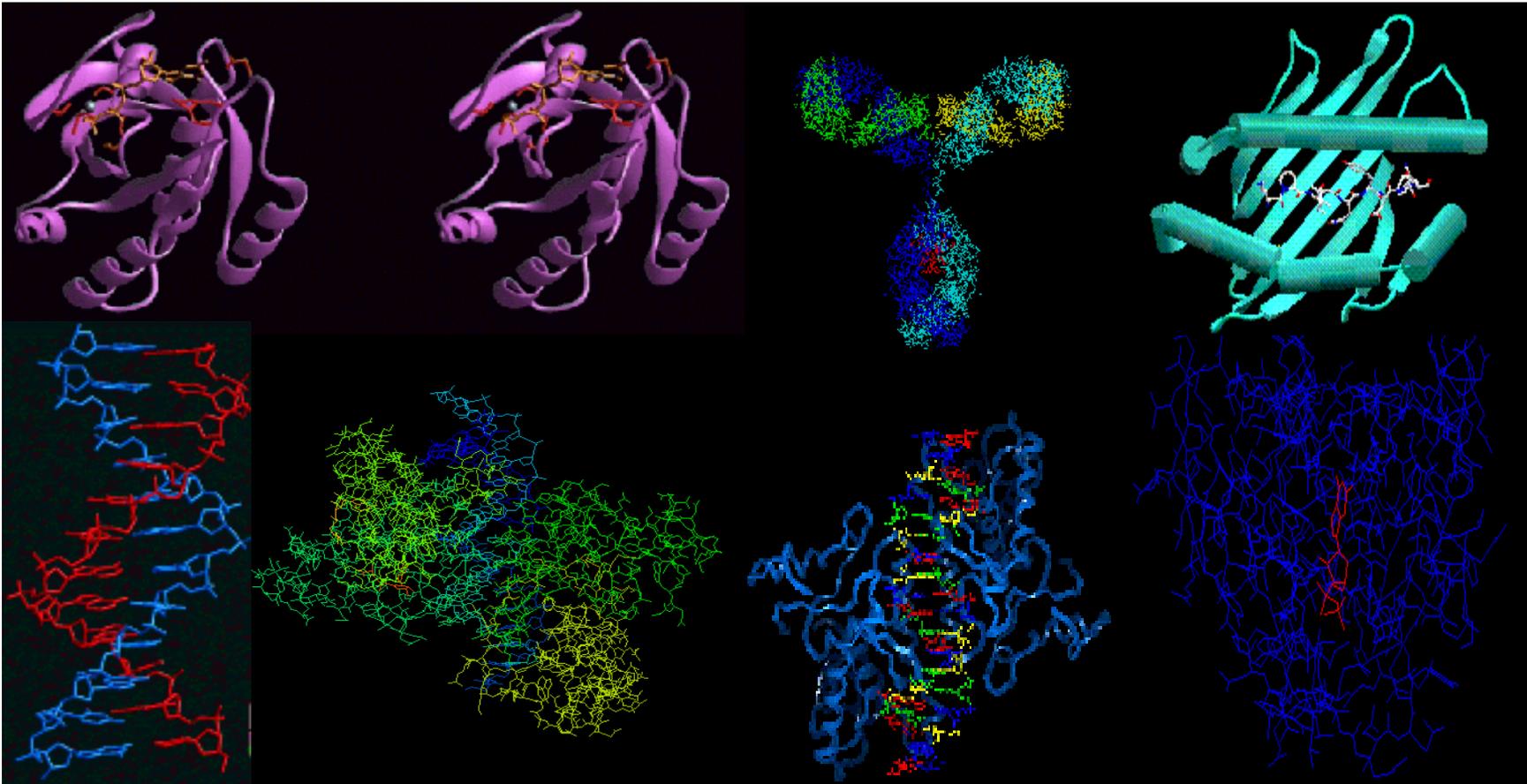
Human Involvement/Representation. Representation of human behavior in simulations is widely recognized as being critical; the complexity of representing the variety of human behavior in an automated way that appropriately reflects impacts of the simulated situation on human decision making and performance is a major challenge. The critical stumbling block is uncertainty about influences of factors and processes involved for many kinds of simulation applications.

Model vs "Reality"

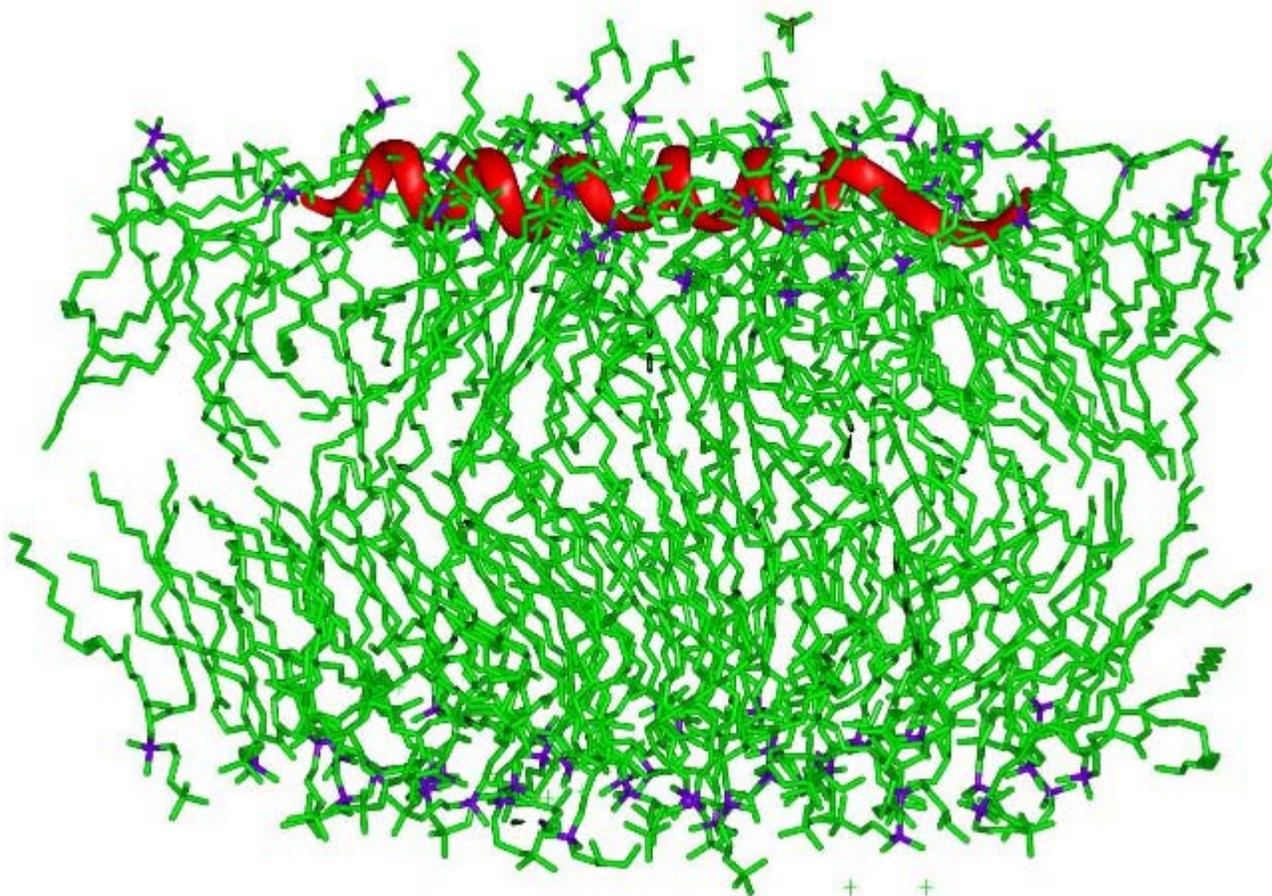


<http://www.iumsc.indiana.edu/cgi-bin/demoselect.cgi>

Models of Biological Molecules



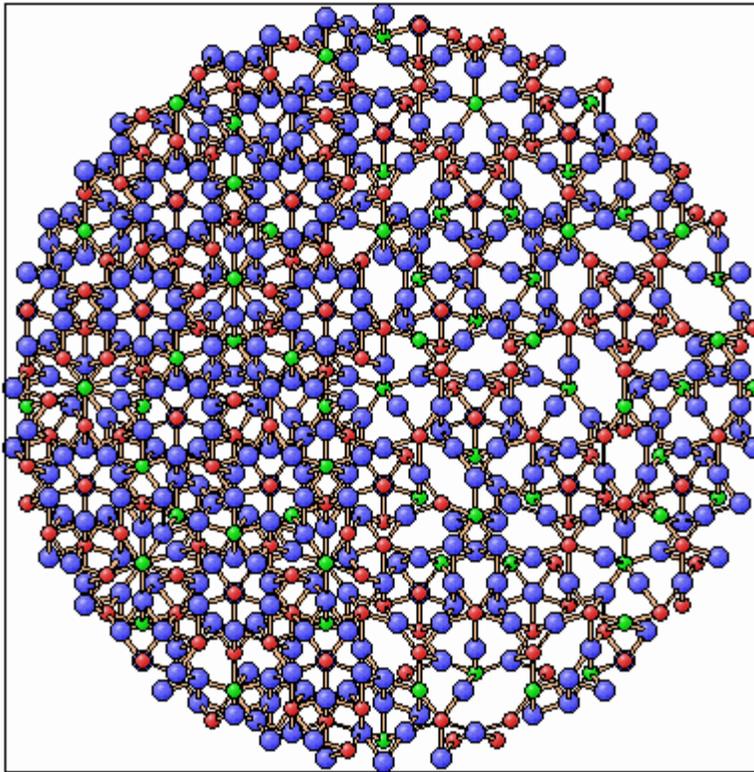
Molecular Dynamics Simulation of Melittin in a Membrane



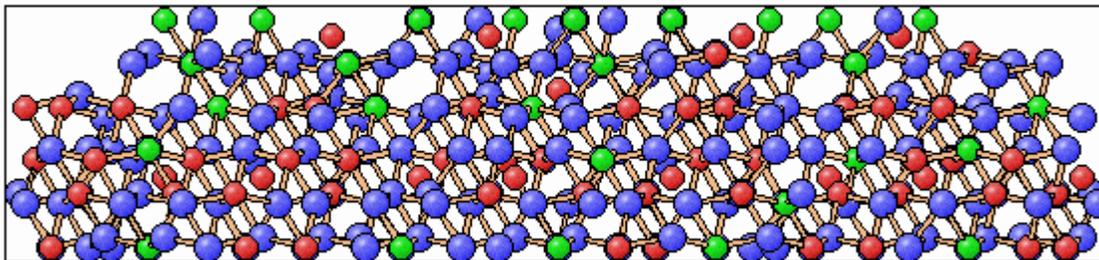


This supercomputer simulation shows the density changes in the material of a white dwarf star, a star that has burned most or all of its nuclear fuel. The star is smaller than Earth but much denser. A teaspoon of the material at its densest (shown in red), would weigh a ton on Earth. At its most diffuse (the regions in white and purple), the density becomes gaseous

<http://chronicle.uchicago.edu/040219/simulation.shtml>

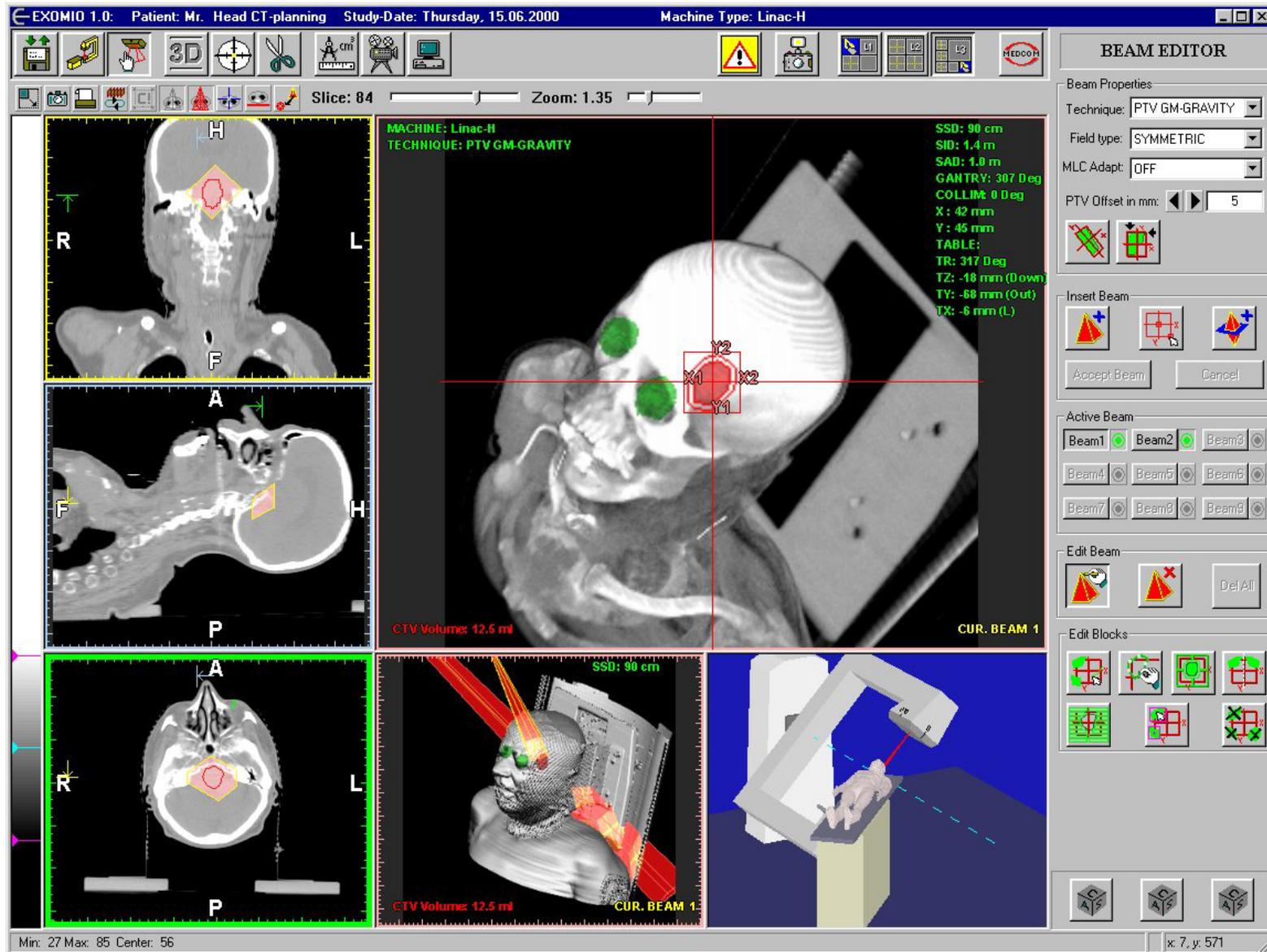


AlCuFe quasicrystal surface
with step: normal view
(atom coordinates by F. Shi and
M. A. Van Hove)



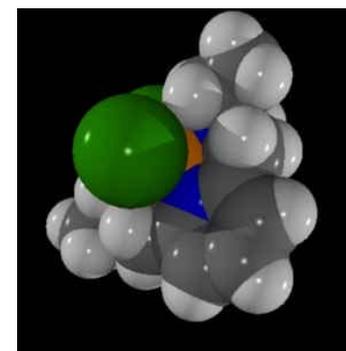
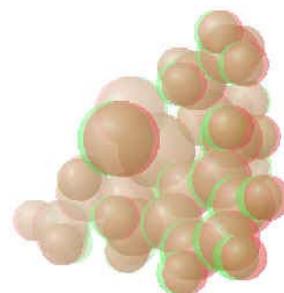
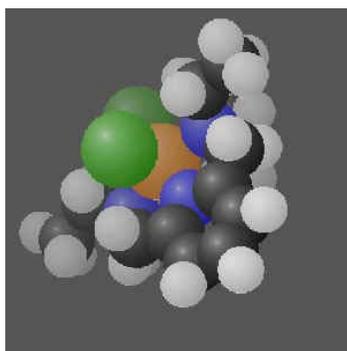
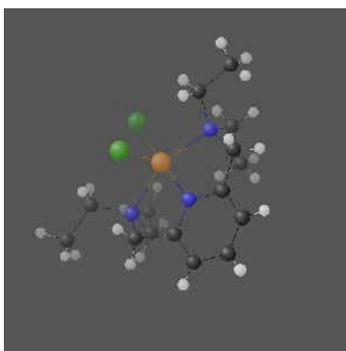
<http://www.fhi-berlin.mpg.de/th/personal/hermann/pictures.html>

3D Virtual Simulation for External Beam Radiation Therapy

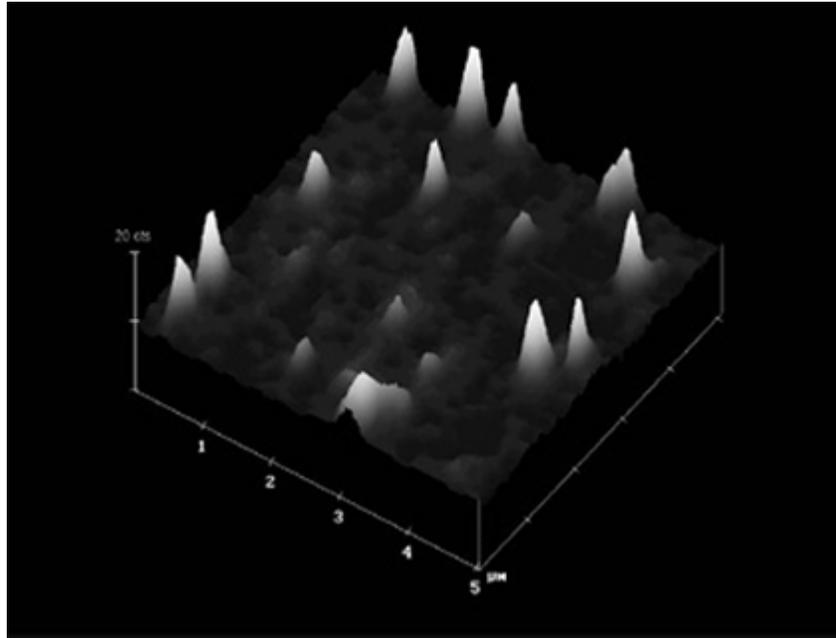


<http://a7www.igd.fhg.de/images-video/exomio/simulation.jpg>

Different Representations of the Same Molecule

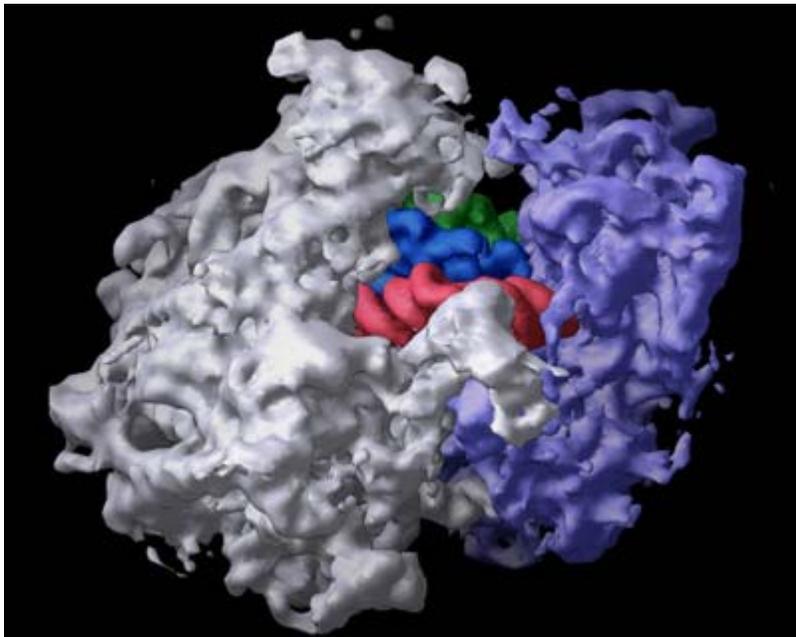


Images



Fluorescence images of rhodamine B molecules obtained by Fluorescence Imaging and Spectroscopy of Single Molecules

Ribosome Image

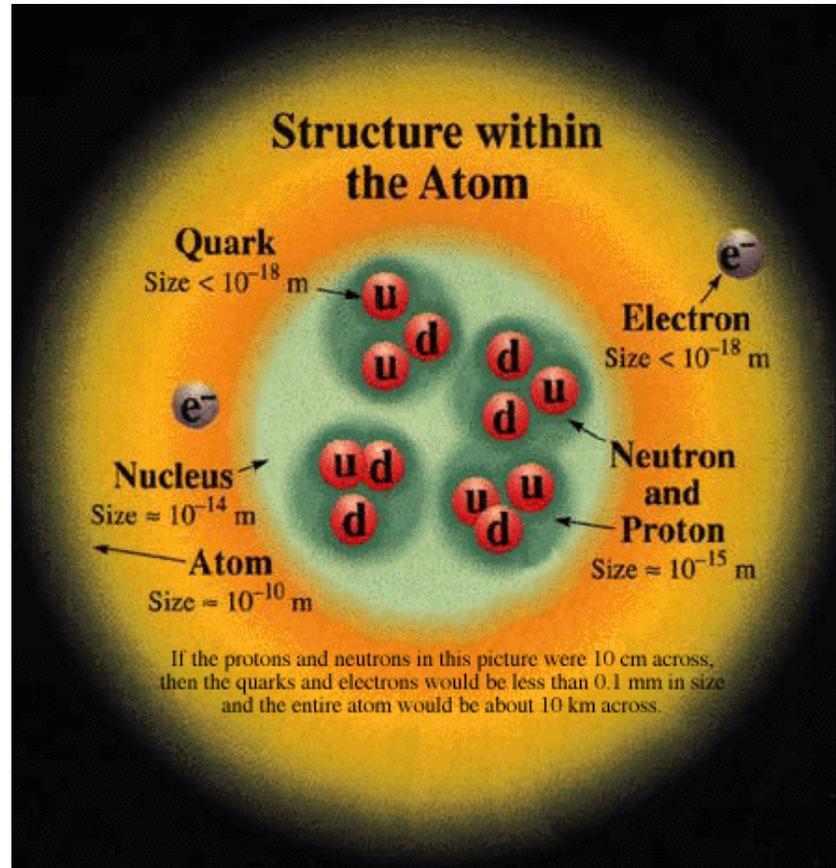


Santa Cruz scientists have for the first time taken a detailed picture, using x-ray crystallography, of a complete ribosome, the small cellular component which translates genetic information into proteins.

The bacterial ribosome is composed of three different RNA molecules and more than 50 different proteins arranged in two major subunits, which join together to form the complete ribosome.

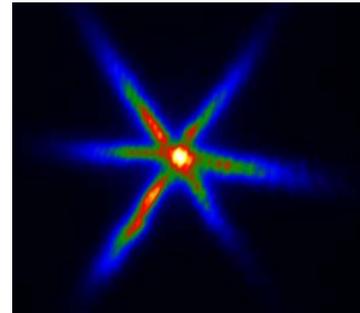
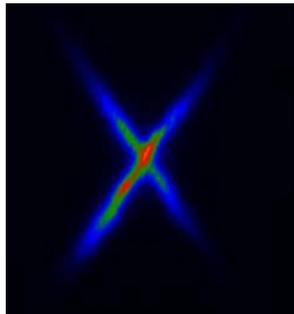
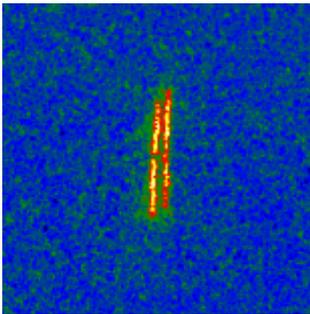
During protein synthesis, the ribosome binds transfer RNA molecules in three different sites.

Atom



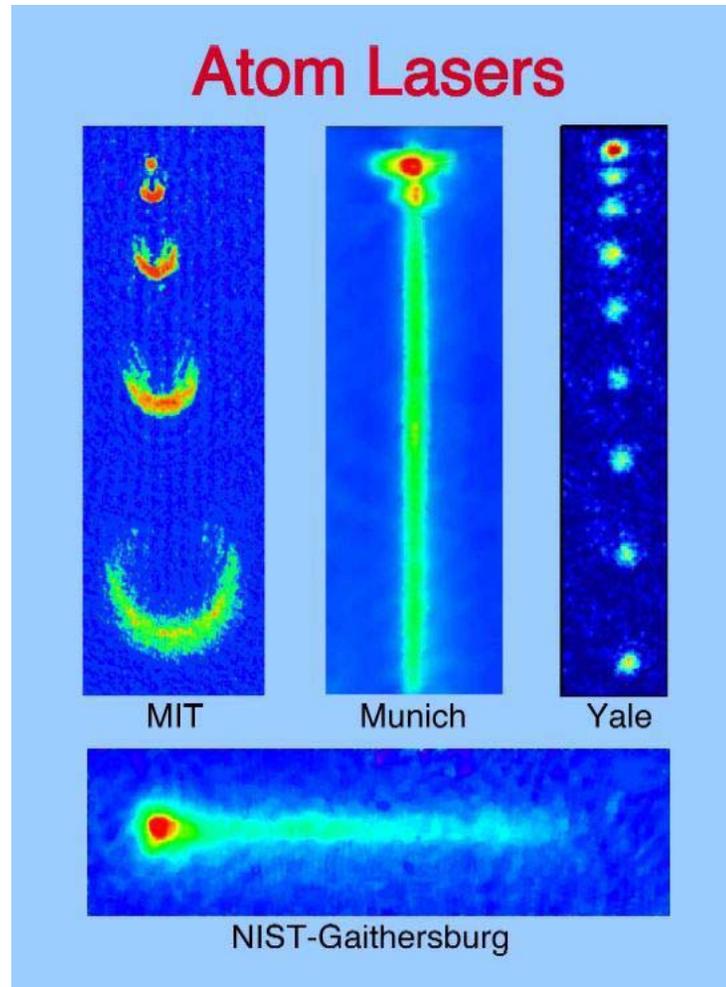
Atom Images

<http://www.aip.org/mgr/png/>

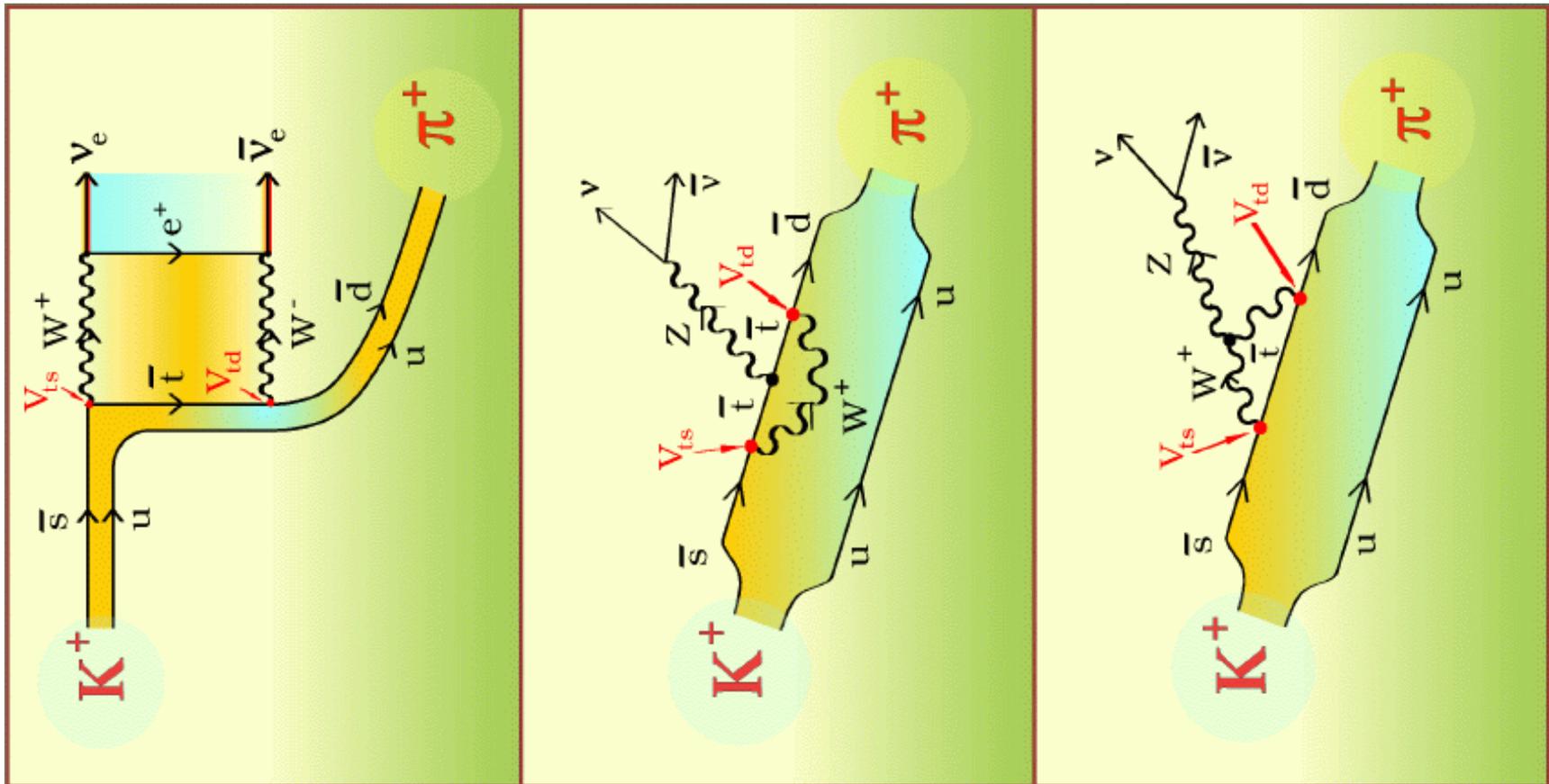


Images of ultracold rubidium atoms trapped in different configurations of laser beams. Left to right: dual 1-D traps, crossed 1-D traps, and 3-D lattice trap formed at trap intersections.

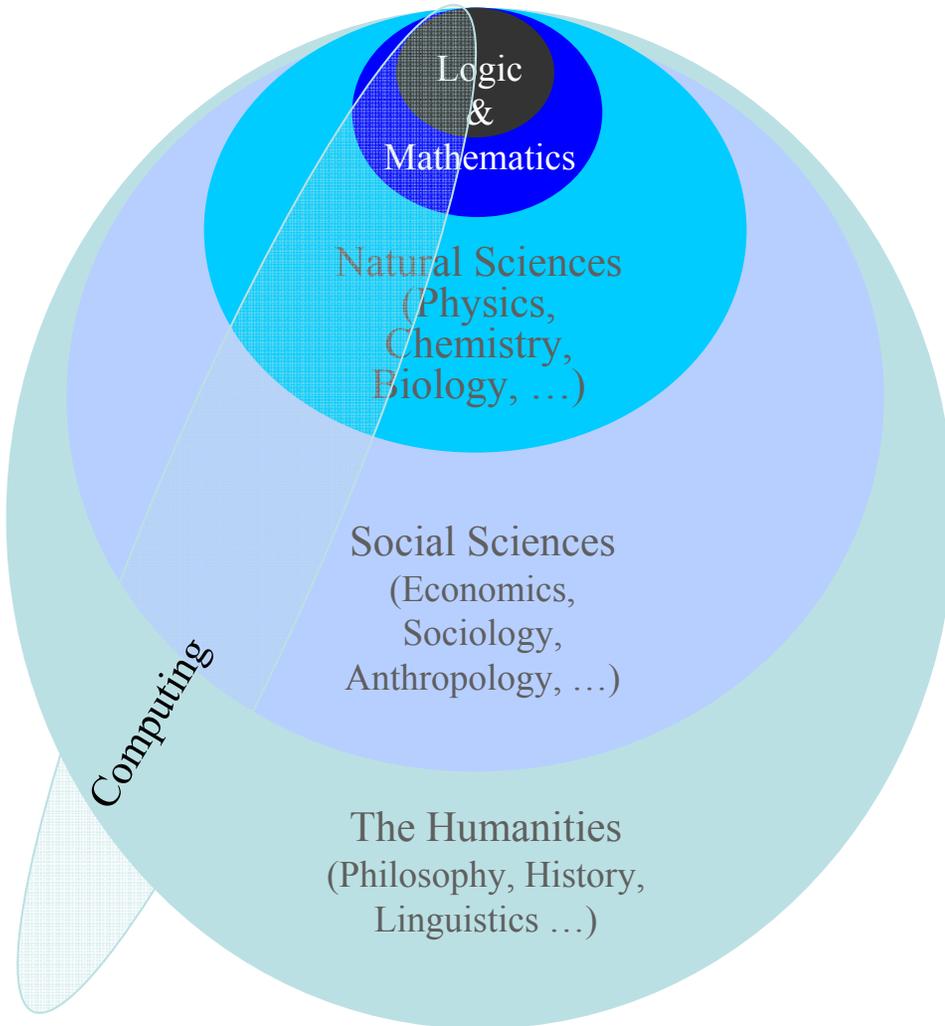
Atom Images



THEORY: The Rarest Observed Decay of the K^+ Meson



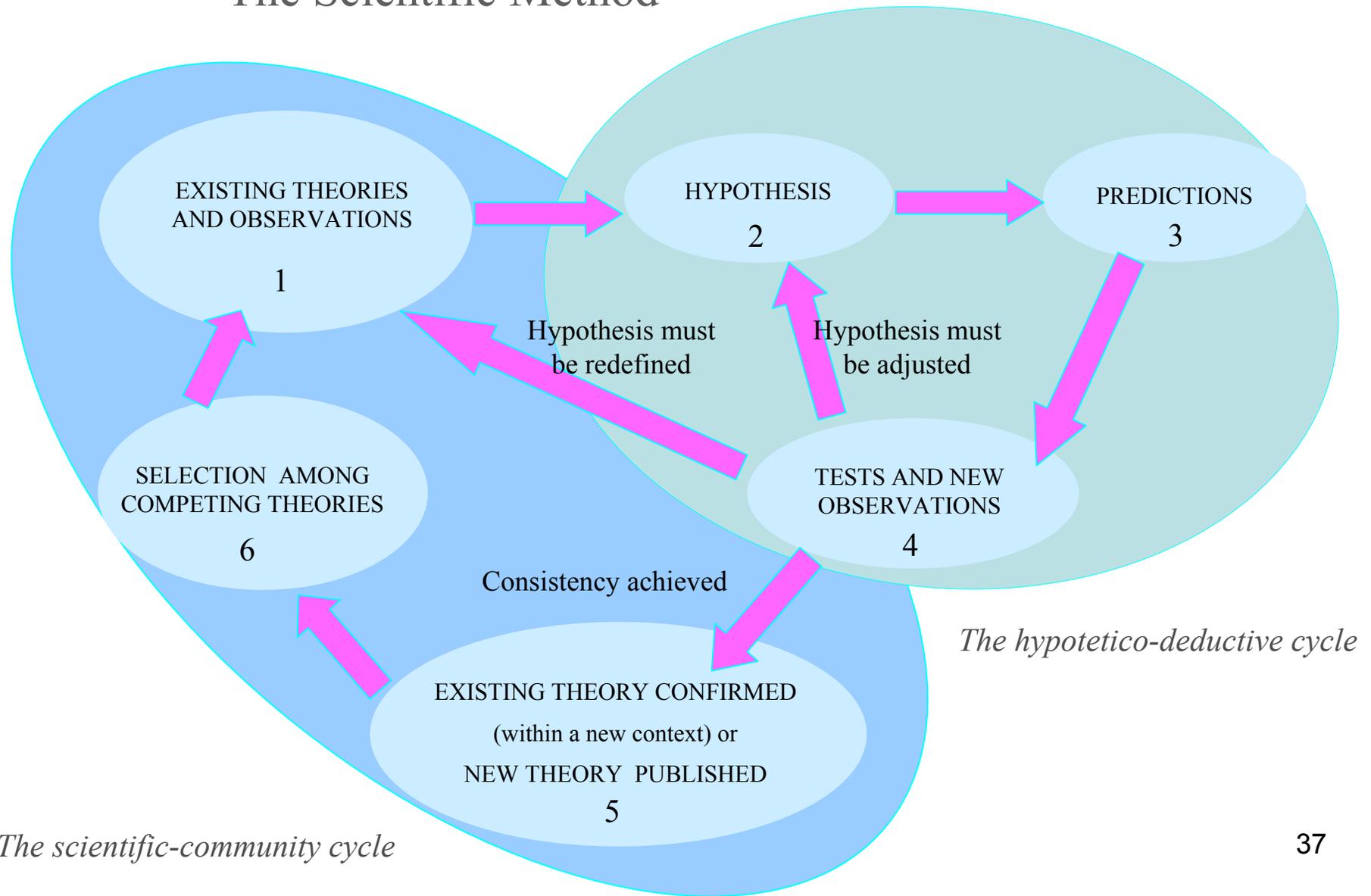
What is this Thing Called Science?



Culture
(Religion, Art, ...)

The whole is more
than the sum of its parts.
Aristotle, Metaphysica

The Scientific Method



The scientific-community cycle

The hypothetico-deductive cycle



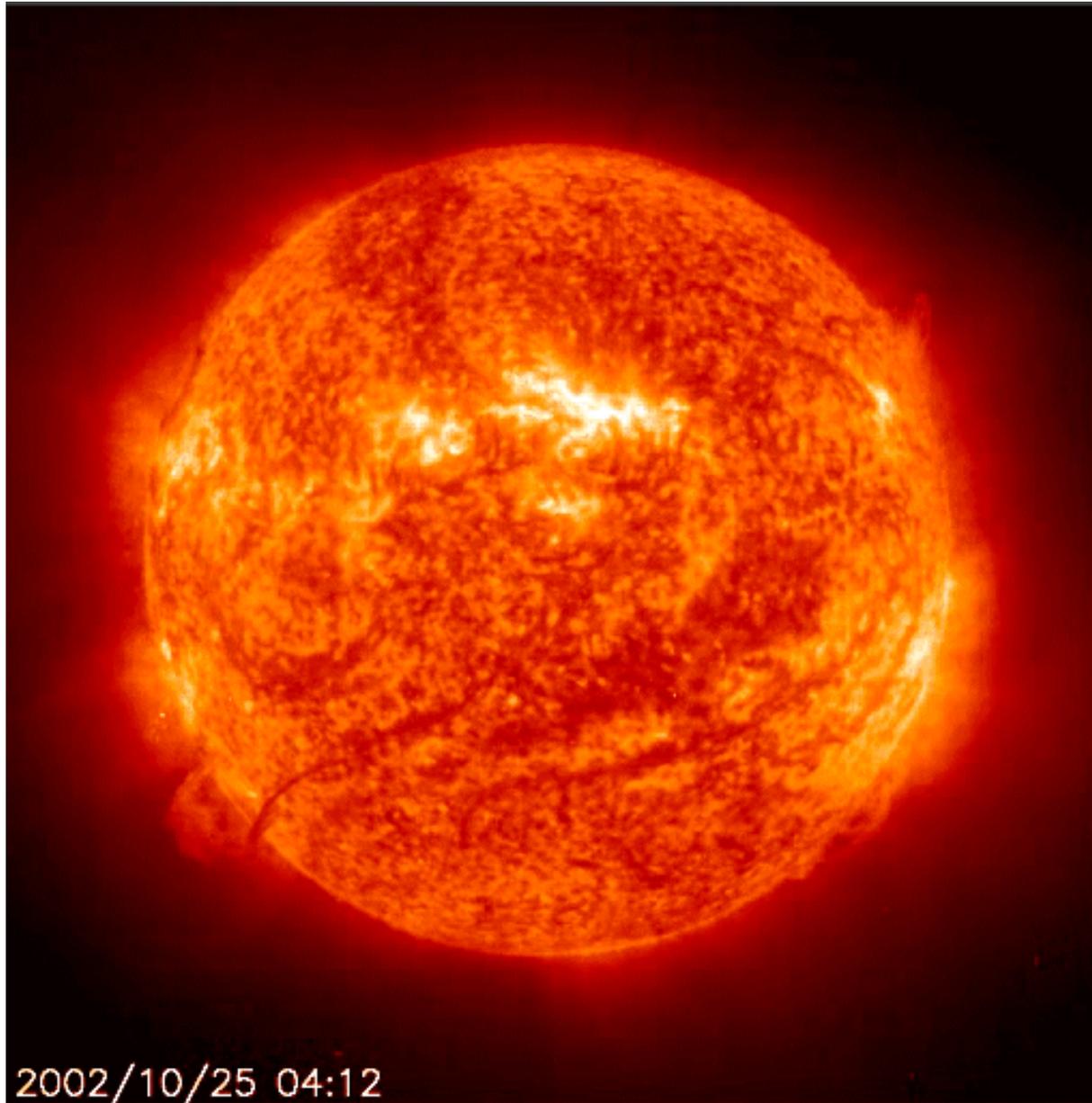
Macrocosm

SOLAR ECLIPSE

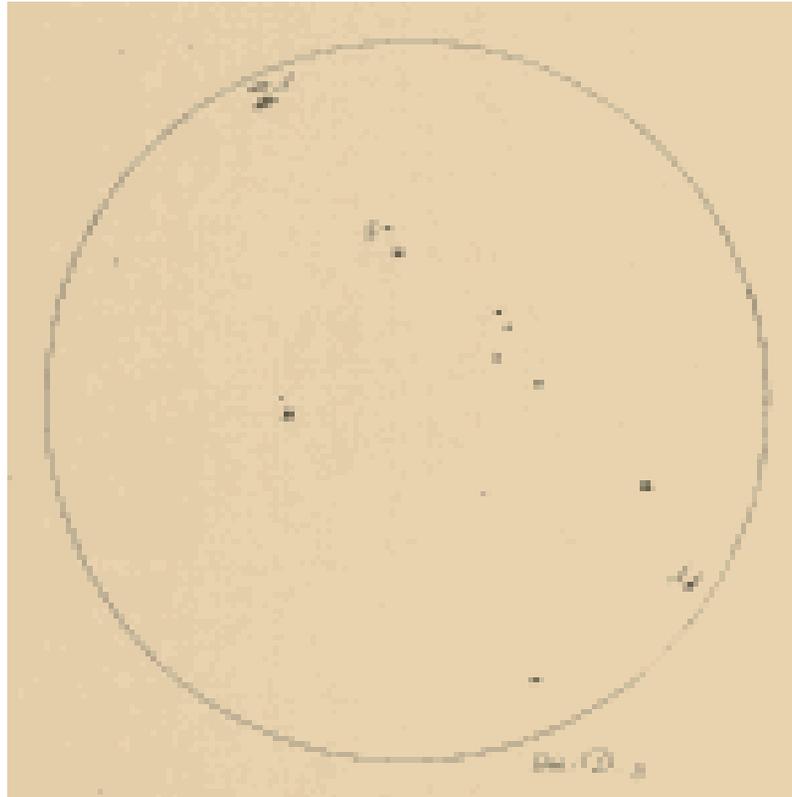
After first stage of total solar eclipse, 3 November 1994. Photograph showing the sun after the first stage of a total solar eclipse in which the moon moves in front of the sun and blocks off its light.

Observed from the Altiplano in Peru, a mountain plateau approximately 4000 metres in height, in the early morning of 3 November 1994.

Sun

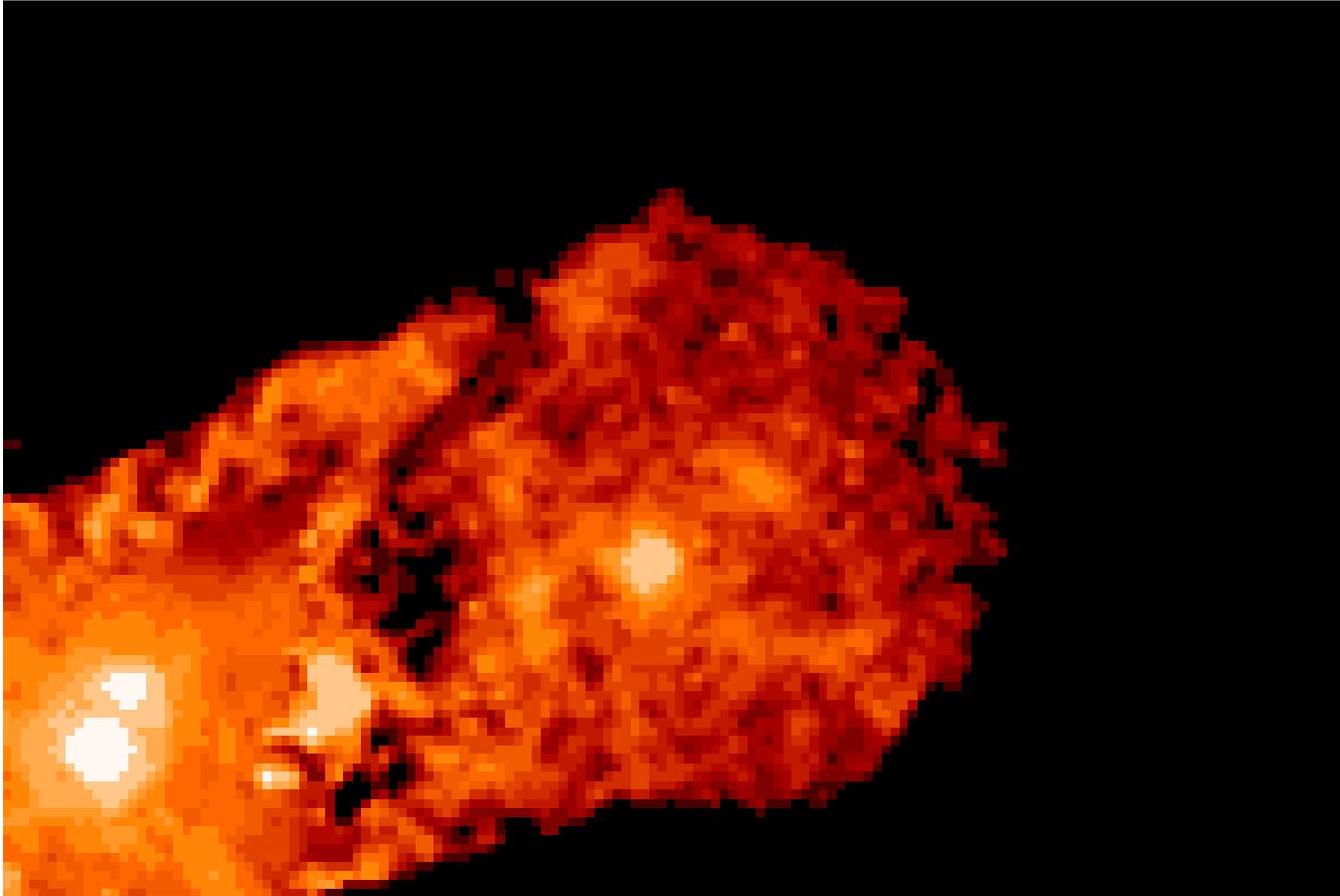


Sun



Long-lasting sunspots appear in this sequence of drawings made by Galileo himself as he observed the Sun from June 2nd to 26th, 1612

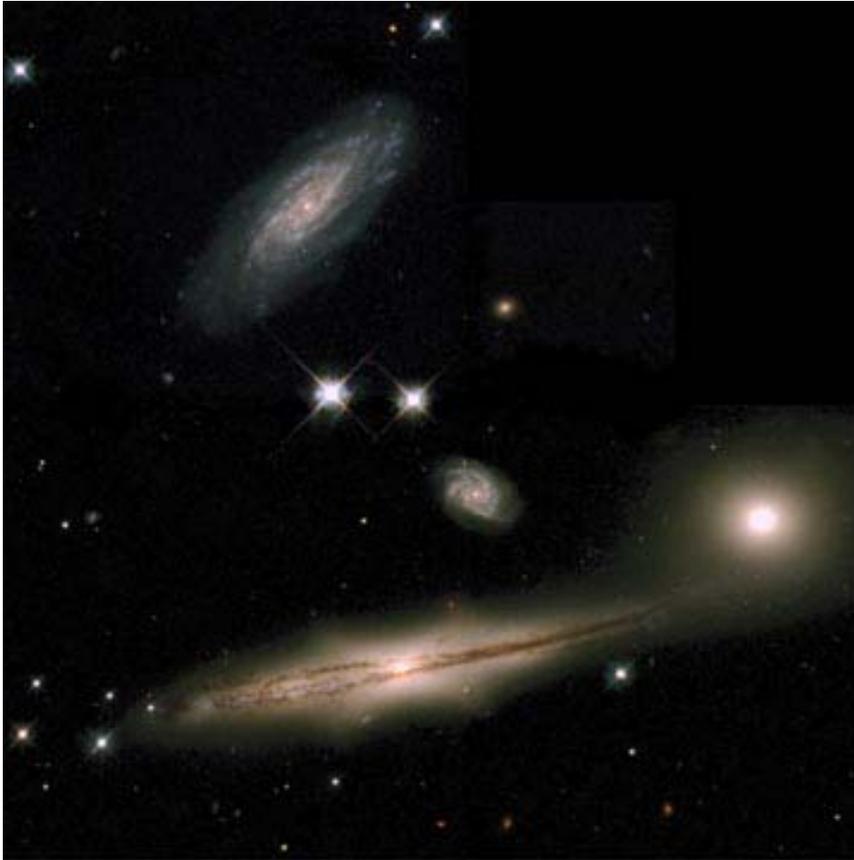
Stars



XZ Tauri

<http://hubble.gsfc.nasa.gov/image-gallery/>

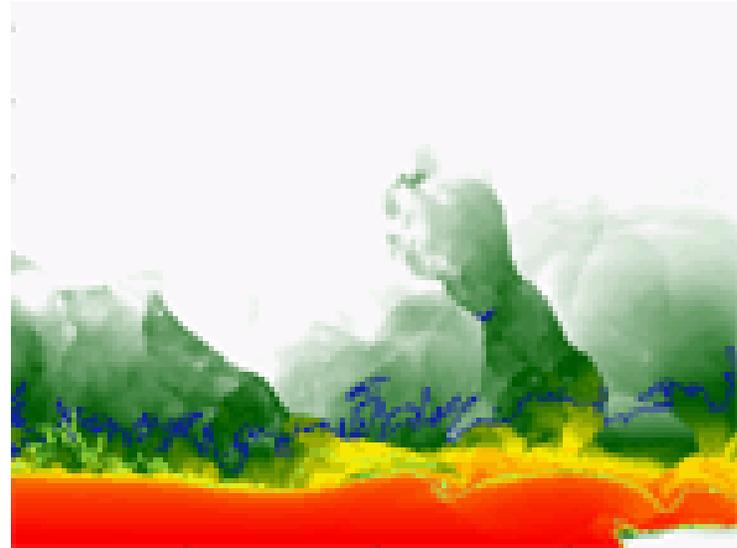
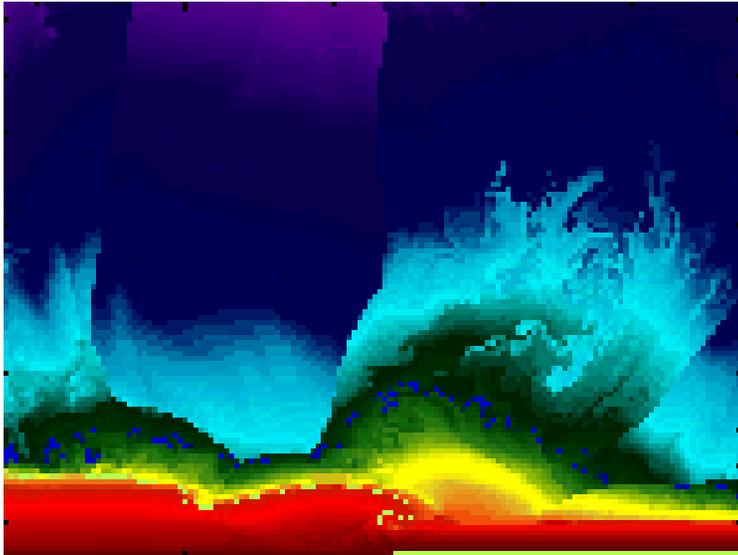
Galaxies



HICKSON COMPACT GROUP 87 or HCG 87 is a compact group of four galaxies bound together by their mutual gravitational attraction some 400 million light years distant toward the constellation Capricornus.

Gravitational interaction between galaxies is thought to trigger star formation activity. Astronomers believe that the galaxies that make up HCG 87 will eventually merge to form a single bright elliptical galaxy.

Computer Simulations of Nuclear Burning on a Neutron Star



The nuclear fusion creates a chain reaction, detonating across a surface of evenly spread gas. Within milliseconds, the polar regions erupt in X-ray light.

The computer simulations show surface waves that move much like ocean waves. When the surface wave moves ahead of the detonation front, it breaks just like a wave at the beach.

(Credit: University of Chicago ASCI)

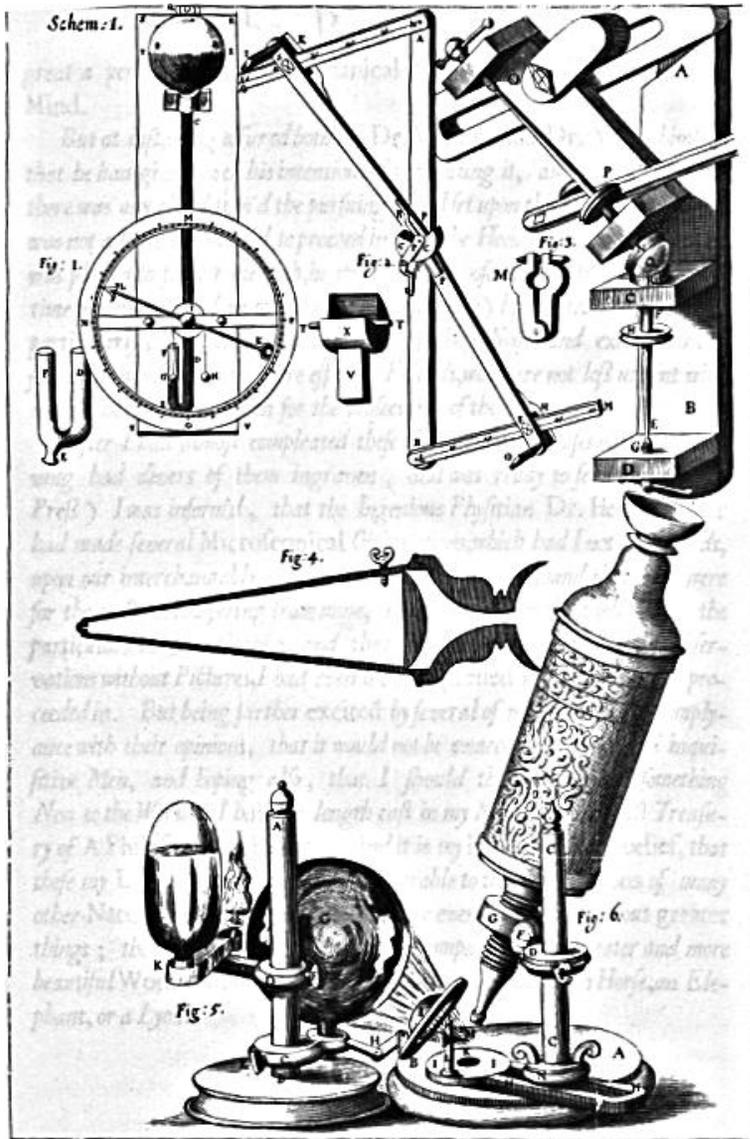
The Deepest View of the Universe Ever



THE HUBBLE DEEP FIELD is the deepest view of the Universe ever obtained. This image was recorded by the Hubble Space Telescope over a period of ten consecutive days in December, 1995.

The very faintest galaxies visible in the image are some four billion times fainter than the faintest objects that can be seen by the naked eye.

The most distant galaxies detected in the Hubble Deep Field, which are visible in the image as small red dots, are some 15 billion light years away, at the very edge of the observable Universe. Light from these very distant galaxies was emitted some 15 billion years ago, soon after the Big Bang.

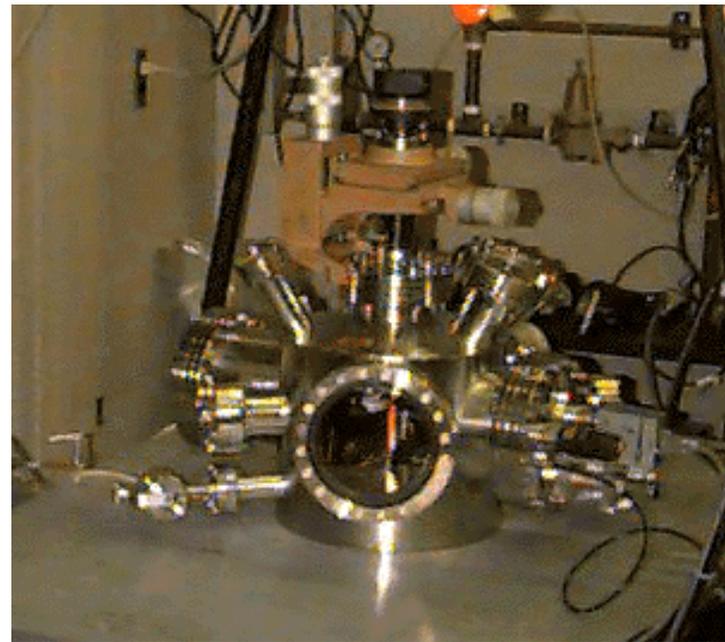
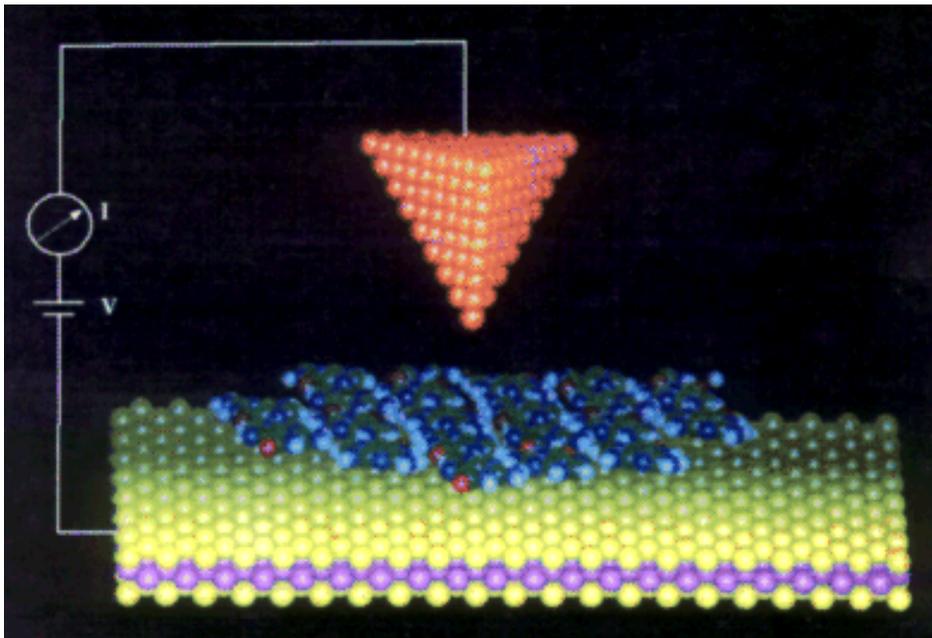


Microcosm

MICROSCOPE

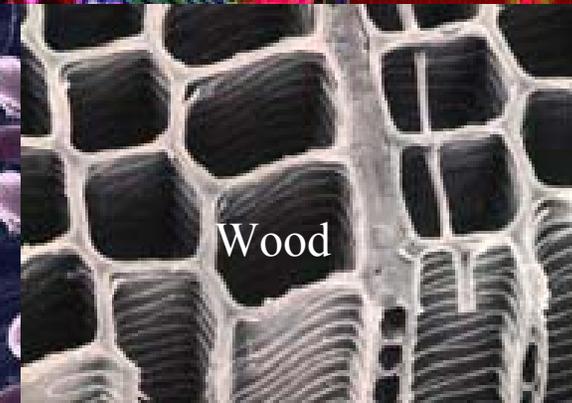
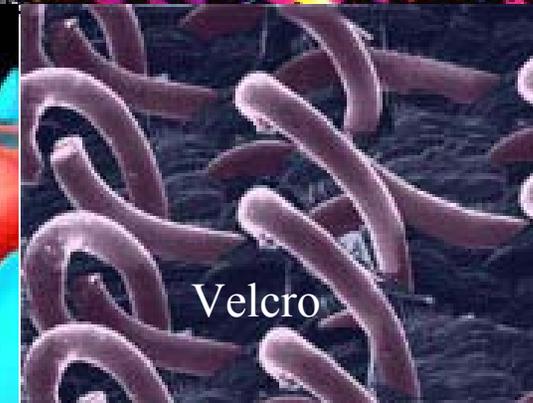
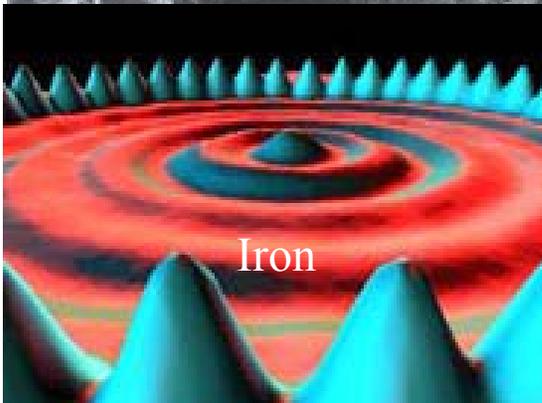
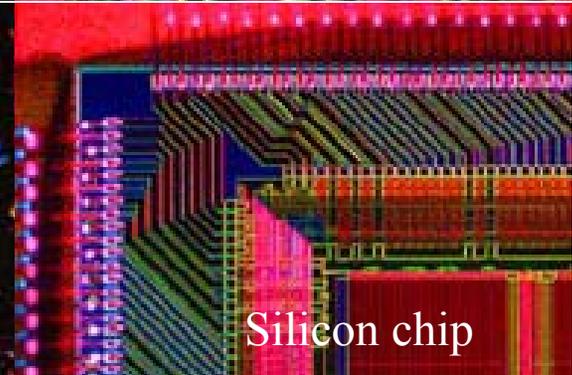
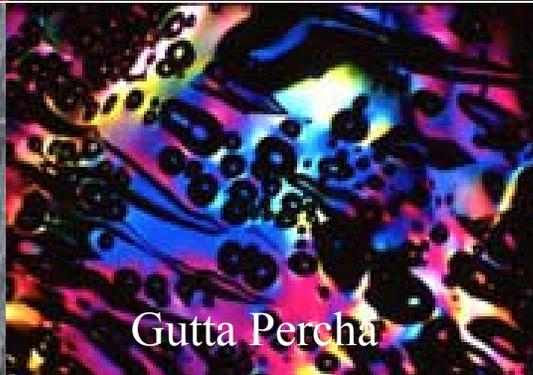
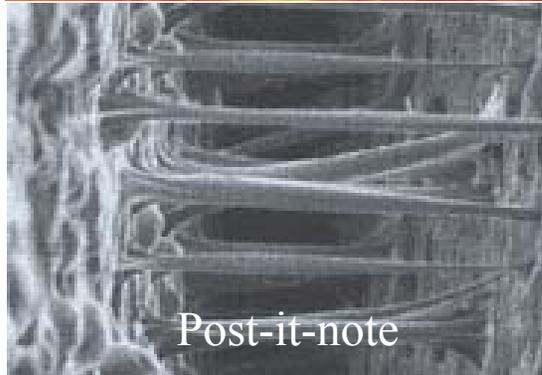
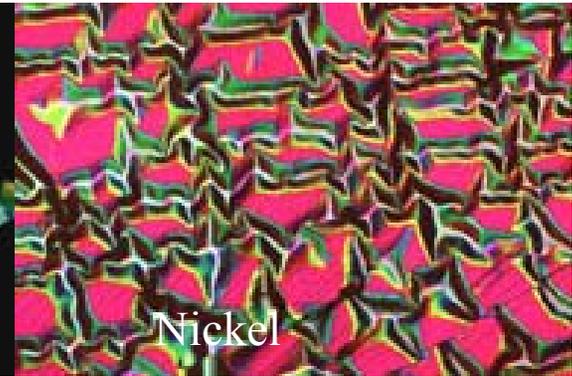
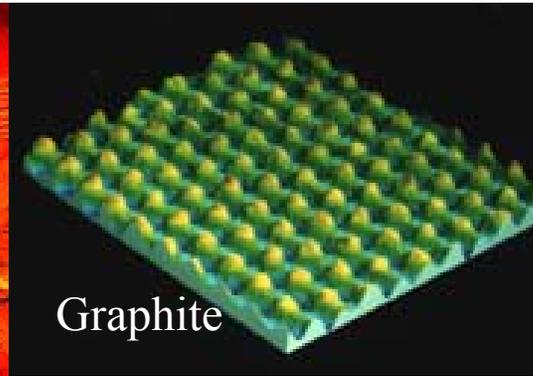
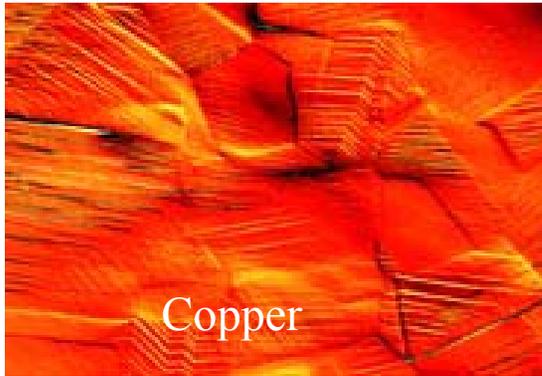
This illustration, from Robert Hooke's *Micrographia*, shows the plans for his lens-grinding machine and for his setup of the microscope.

Scanning Tunneling Microscope

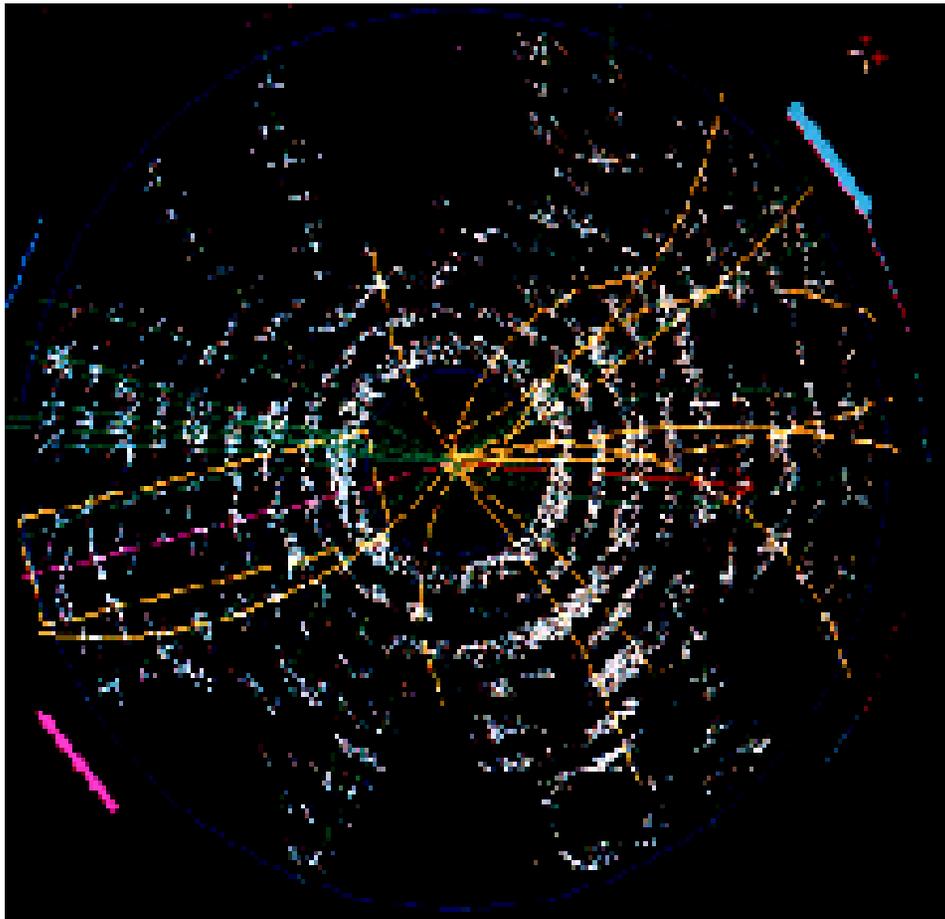


**The STM makes an image of the local electron density of states containing:
topographic information & spectroscopic information**

Microstructures



Direct Observation?!



Collisions of protons and antiprotons in the Tevatron accelerator at Fermilab provided evidence for the existence of elusive subatomic particle known as top quark.

Elementary Particles



Decay of positive pions captured on a streamer chamber image. CERN, 1990.

Detectors are used to measure properties of particles; some measure the tracks left behind by particles and others measure energy.

Founded in 1954, CERN is the world's leading particle physics research laboratory, and one of Europe's first joint ventures.

CERN/ Science & Society
Picture Library

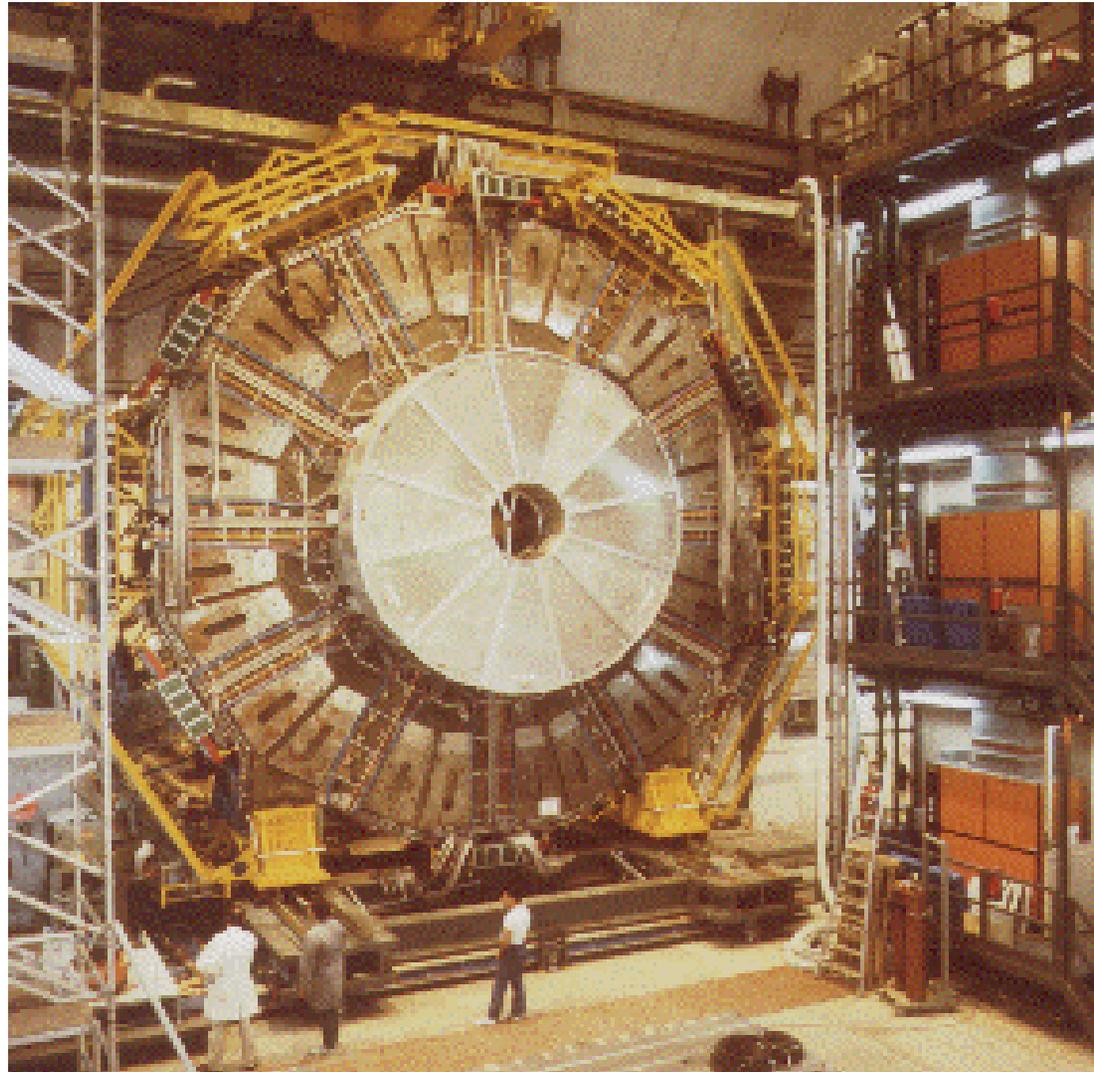
Elementary Particles



A lepton event (a neutrino interacting with an electron and emerging as a neutrino); the first observation of 'neutral currents' in the Gargamelle heavy liquid bubble chamber.

Here, detectors are used to measure properties of particles; some measure the tracks left behind by particles and others measure energy.

Cern Detector



Geant4

FEBRUARY 18–22, 2002

USERS' WORKSHOP

STANFORD LINEAR ACCELERATOR CENTER

ADDITIONAL INFORMATION:

<http://geant4.slac.stanford.edu/UsersWorkshop/>

email: G4usersworkshop-L@slac.stanford.edu

This workshop is the first Geant4 users workshop to be held in the U.S. The workshop consists of tutorials and presentations. Tutorials start at the novice level, which is aimed at the people who are new to Geant4, then proceed to advanced lectures for experienced users. Presentations are planned both from Geant4 users in various application fields and from Geant4 developers. Participants will be strongly encouraged to describe their own applications. Town meetings involving users and developers will also be held.

GLAST (NASA)

XMM (ESA)

Computer
Tomography Scans

BABAR (SLAC)

Geant4 is a general-purpose simulation toolkit for elementary particles interacting with matter. Its usage ranges from high energy cosmic or high energy particle physics, nuclear physics, the assessment of radiation shielding and satellites, and is expanding into medical physics studies.

Stanford Linear Accelerator Center (SLAC), Stanford, California, USA. The workshop is hosted by SLAC and co-sponsored by the US Department of Energy.



Software Review Panel

Simulation and Physics

ALICE

René Brun, Federico Carminati, Andreas Morsch
For the ALICE Collaboration

6/5/99

Alice Offline Meeting

1



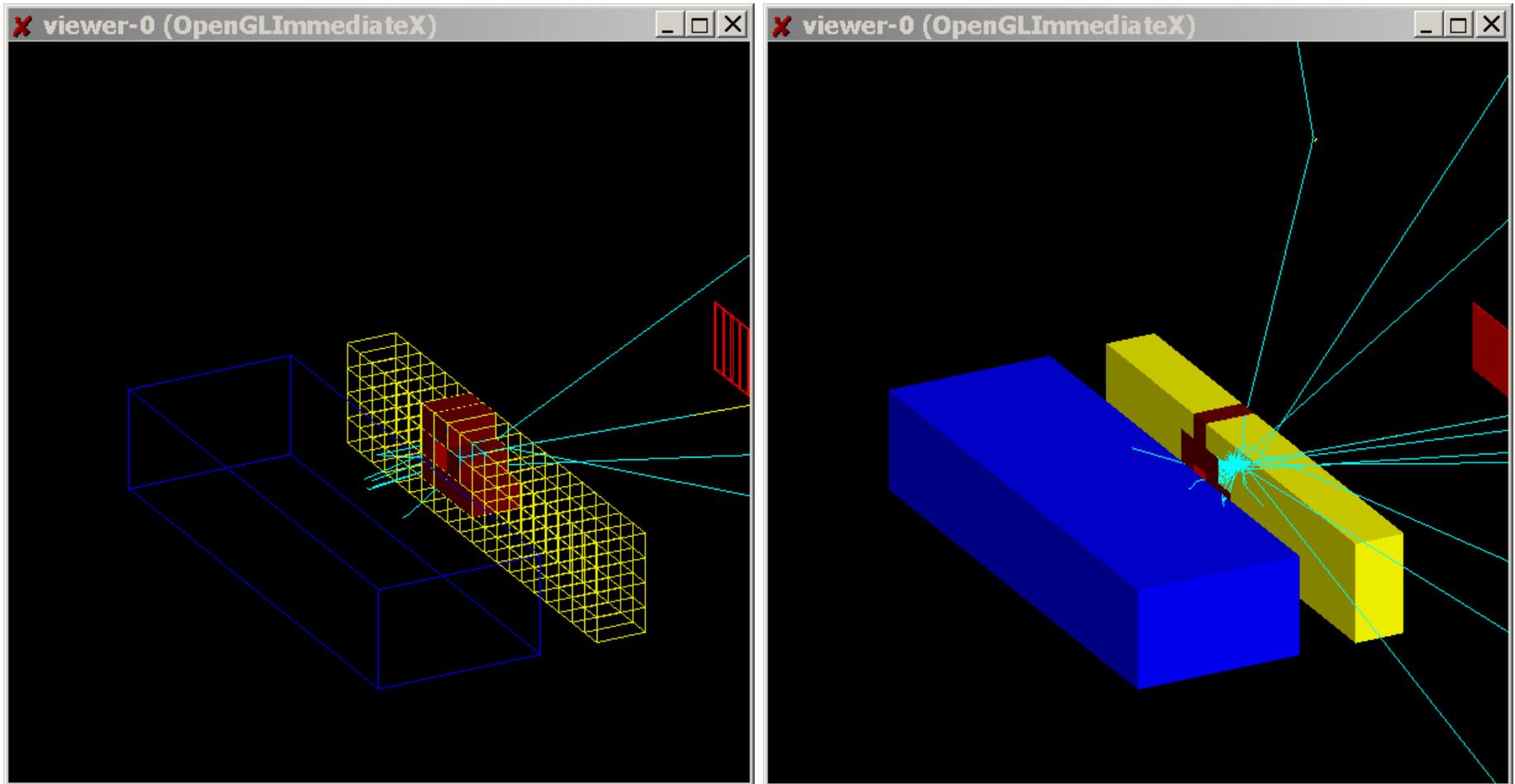


Alice Simulation Questions in 1998

- ◆ **Using GEANT 3.21**
 - ◆ Well-known environment + expertise in ALICE
 - ◆ Stay with FOR TRAN, shaky physics (for LHC)
 - ◆ No developments since 1993
- ◆ **Using GEANT 4**
 - ◆ *Flag ship of IT software*
 - ◆ *Fresh from the oven: can we trust it yet?*
- ◆ **Using FLUKA**
 - ◆ Solid and well tested physics
 - ◆ Difficult to use, limited geometry



Visualisation



Technology expands our ways of thinking about things,
expands our ways of doing things.

Herbert A. Simon

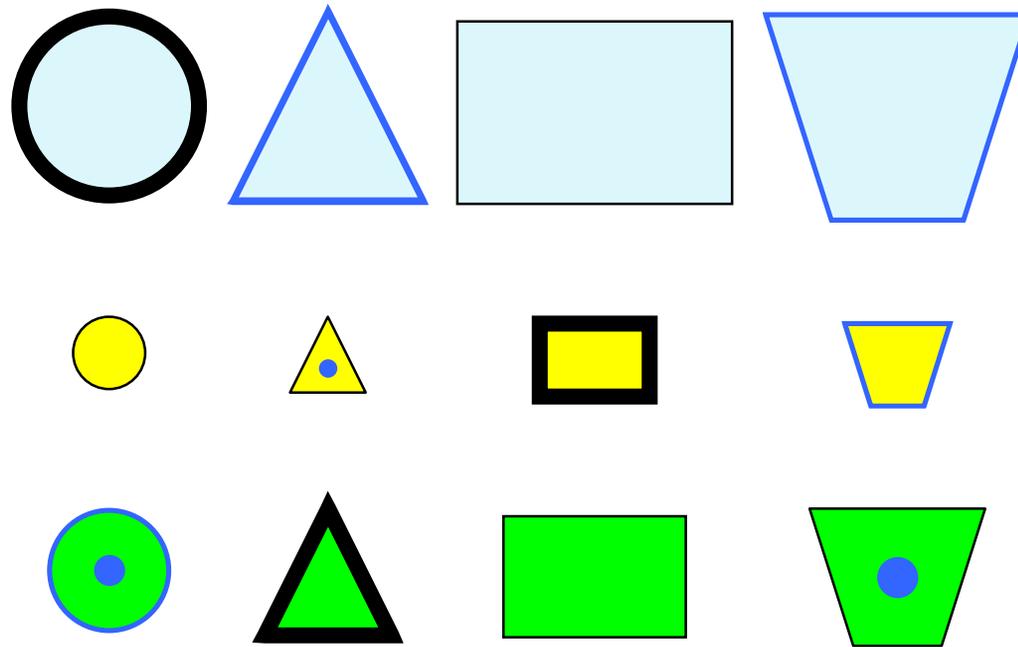
Three Most Fundamental Actions for Managing Phenomena

SEARCH (identify objects = divide universe in parts)

SORT (order, organize, what is the same, what is different)

SIMULATE (re-produce, re-create phenomenon)

Repetition, Similarity



As repetition is based upon similarity, it must be *relative*. Two things that are similar are always *similar in certain respects*.

REPETITION, SIMILARITY

Searching for similarity and differences leads to *classifications*
i.e. the division of objects or events in different groups/classes.

The simplest tool by for classification is the *binary opposition or dichotomy (dualism)*. When we use dichotomy, we only decide if an object is of kind A or of kind $\sim A$. Examples of frequent dichotomies are yes/no, true/false, before/after, more/less, above/below, etc.

IDENTITY

The basic feature of experimental method is its *reproducibility*:

It must be possible to establish essentially the same experimental situation in order to obtain the same results. This means that the experimental arrangement can be made with *essentially equivalent* parts.

What we call “essentially equivalent” (or we can call it “essentially the same”) depends on situation. Even here the principle of information hiding helps us to get a practical “level of resolution” which means information hiding for all objects below that level.

IDENTITY

Declaring two systems/particles/states as *identical* is entirely the *matter of focus*.

For example if we focus on question of how many people in this country are vegetarians, we just treat all people as equal units.

If on the other hand we want to know how many women in this country are vegetarian, we discriminate between men and women in our analysis of people, so they are no longer identical.

IDENTITY

Declaring two systems/particles/states as *identical* is entirely the *matter of focus*.

IDENTITY

We can e.g. assume that bacteria* of particular sort are interchangeable (indistinguishable) in certain context.

That enables us to make repeated experiments with different agents and to treat all bacteria of the same type as equal.

It does not mean that they are *identical in the absolute sense*. It only means that for our purpose the existing difference does not have any significance.

*The more popular example are snowflakes

IDENTITY

Example of ancient atomic theory. The problem of showing that one single physical body- say piece of iron is composed of atoms is at least as difficult as of showing that *all* swans are white. Our assertions go in both cases beyond all observational experience.

The difficulty with these structural theories is not only to establish the universality of the law from repeated instances as *to establish that the law holds even for one single instance.*

IDENTITY

A singular statement like “This swan here is white” may be said to be based on observation. Yet it goes beyond experience- not only because of the word “white”, but because of the word “swan”.

For by calling something a “swan”, we attribute to it properties which go far beyond mere observation. So *even the most ordinary singular statements are always the interpretations of the facts in the light of theories!*

Meaning

All meaning is determined by the method of analysis where the method of analysis sets the context and so the rules that are used to determine the “meaningful” from “meaningless”.

C. J. Lofting

Meaning

At the fundamental level meaning is reducible to distinguishing

- Objects (the what) from
- Relationships (the where)

which are the result of process of

- Differentiation or
- Integration

Meaning

Human brain is not *tabula rasa* (clean slate) on birth but rather contains

- behavioral patterns to particular elements of environment (gene-based)
- template used for distinguishing meaning based on the distinctions of “what” from “where”

Truth

- The correspondence theory
- The coherence theory
- The deflationary theory

TRUTH

The correspondence theory

A true statement corresponds to the facts.

But: how do we recognize *facts* and what kind of relation is this *correspondence*?

A theory of truth must be a part of a semantic theory which also explains what reference and meaning is; for an atomic sentence [of which every other sentence can be constructed] cannot be true unless its noun phrase *refers* to an existing object and before we can decide the truth value of a sentence we must know its *meaning*.

TRUTH

The correspondence theory

Wittgenstein elaborated this view in his *Tractatus Logico-Philosophicus*.

He conceived *a fact as a configuration of things*.

He claimed that the correspondence between language and fact could be analysed as a kind of picture; a true sentence correctly depicted the fact.

TRUTH

The correspondence theory

When discussing truth one cannot neglect two other semantic notions, *reference* and *meaning*.

A theory of truth must be a part of a semantic theory which also explains what reference and meaning is; for an atomic sentence [of which every other sentence can be constructed] cannot be true unless its noun phrase *refers* to an existing object and before we can decide the truth value of a sentence we must know its *meaning*.

TRUTH

The coherence theory

Statements in the theory are believed to be true because being compatible with other statements.

The truth of a sentence just consists in its belonging to a system of coherent statements.

The most well-known adherents were Spinoza, Leibniz and Hegel.

Characteristically they all believed that truths about the world could be found by pure thinking, they were rationalists and idealists. Mathematics was the paradigm for a real science; it was thought that the axiomatic method in mathematics could be used in all sciences.

TRUTH

The deflationary theory

The deflationary theory is belief that it is always logically superfluous to claim that a proposition is true, since this claim adds nothing further to a simple affirmation of the proposition itself.

"It is true that birds are warm-blooded " means the same thing as "birds are warm-blooded ".

For the deflationist, truth has no nature beyond what is captured in ordinary claims such as that 'snow is white' is true just in case snow is white. Philosophers looking for the nature of truth are bound to be frustrated, the deflationist says, because they are looking for something that isn't there.

Scientific Truth (1)

- Physics professor is walking across campus, runs into Math professor. Physics professor has been doing an experiment, and has worked out an empirical equation that seems to explain his data, and asks the Math professor to look at it.

Scientific Truth (2)

- A week later, they meet again, and the Math professor says the equation is invalid. By then, the Physics professor has used his equation to predict the results of further experiments, and he is getting excellent results, so he asks the Math professor to look again.
- Another week goes by, and they meet once more. The Math professor tells the Physics professor the equation does work, "but only in the trivial case where the numbers are real and positive."

Proof

The word **proof** can mean:

- originally, a test assessing the validity or quality of something. Hence the saying, "The exception that proves the rule" -- the rule is tested to see whether it applies even in the case of the (apparent) exception.
- a rigorous, compelling argument, including:
 - a logical argument or a mathematical proof
 - a large accumulation of scientific evidence
 - (...)

(from Wikipedia)

Mathematical Proof

In mathematics, a **proof** is a demonstration that, given certain axioms, and certain rules of inference (logic) some statement of interest is necessarily true.

Mathematical Proof

Proofs employ logic but usually include some amount of natural language which of course admits some ambiguity.

The distinction has led to much examination of current and historical mathematical practice, quasi-empiricism in mathematics, and so-called folk mathematics (in both senses of that term).

The philosophy of mathematics is concerned with the role of language and logic in proofs, and mathematics as a language.

Mathematical Proof

Regardless of one's attitude to formalism, the result that is proved to be true is a theorem; in a completely formal proof it would be the final line, and the complete proof shows how it follows from the axioms alone. Once a theorem is proved, it can be used as the basis to prove further statements.

The so-called foundations of mathematics are those statements one cannot, or need not, prove. These were once the primary study of philosophers of mathematics. Today focus is more on practice, i.e. acceptable techniques.

(from Wikipedia)

Critique of Usual Naïve Image of Scientific Method (1)

The narrow inductivist conception of scientific inquiry

1. All facts are observed and recorded.
2. All observed facts are analyzed, compared and classified, without hypotheses or postulates other than those necessarily involved in the logic of thought.
3. Generalizations inductively drawn as to the relations, classificatory or causal, between the facts.
4. Further research employs inferences from previously established generalizations.

Critique of Usual Naïve Image of Scientific Method (2)

This narrow idea of scientific inquiry is groundless for several reasons:

1. A scientific investigation could never get off the ground, for a collection of *all facts* would take infinite time, as there are infinite number of facts.

The only possible way to do data collection is to take only *relevant facts*. But in order to decide what is relevant and what is not, *we have to have a theory or at least a hypothesis about what is it we are observing.*

Critique of Usual Naïve Image of Scientific Method (3)

A hypothesis (theory) is needed to give *the direction* to a scientific investigation!

2. A set of empirical facts can be analyzed and classified in many different ways. Without hypothesis, analysis and classification are blind.
3. Induction is sometimes imagined as a method that leads, *by mechanical application of rules*, from observed facts to general principles. Unfortunately, such rules do not exist!

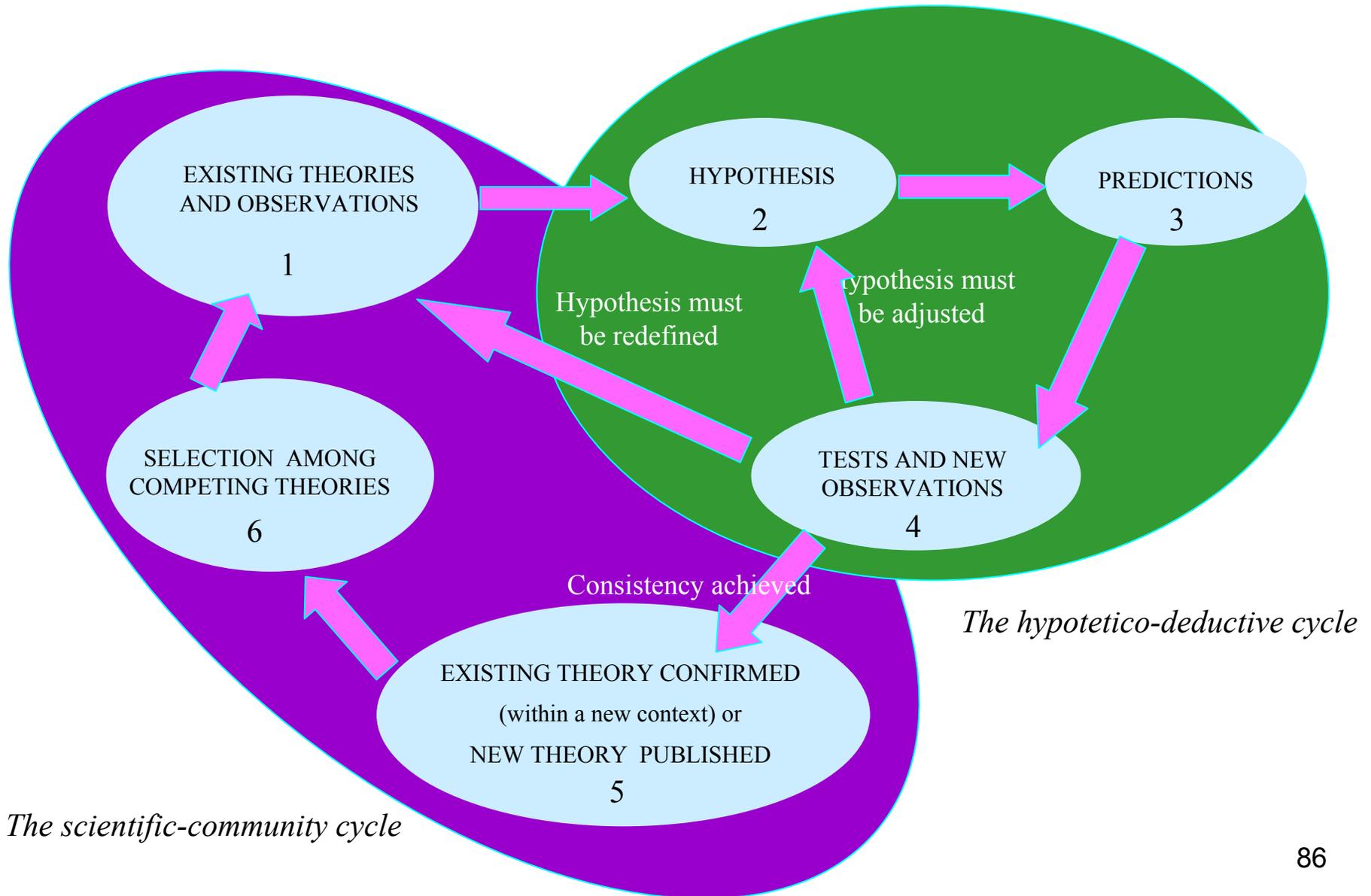
Why is it not Possible to Derive Hypothesis (Model/Theory) Directly from the Data? (1)

- For example, theories about atoms contain terms like “*atom*”, “*electron*”, “*proton*”, etc; yet what one actually measures are spectra (wave lengths), traces in bubble chambers, calorimetric data, etc.
- So the theory is formulated on a completely different (and more abstract) level than the observable data!
- The transition from data to theory requests creative imagination!

Why is it not Possible to Derive Hypothesis (Model/Theory) Directly from the Data?(2)

- *Scientific hypothesis* is formulated based on “educated guesses” at the connections between the phenomena under study, at regularities and patterns that might underlie their occurrence. *Scientific guesses are completely different from any process of systematic inference.*
- The discovery of important mathematical theorems, like the discovery of important theories in empirical science, requires *inventive ingenuity*.

The Scientific Method





In order to pose the question and *formulate hypothesis* we use different approaches:

Intuition – (Educated) Guess

Analogy

Symmetry

Paradigm

Metaphor

.... and many more...

What is Knowledge? Plato's Definition

Plato believed that we learn in this life by remembering knowledge originally acquired in a previous life, and that the soul already has all knowledge, and we learn by recollecting what in fact the soul already knows.

Plato offers three analyses of knowledge, [dialogues *Theaetetus* 201 and *Meno* 98] all of which he has Socrates reject.

What is Knowledge? Plato's Definition

The first Plato's definition:

"knowledge and perception are the same."

Socrates rejects this by saying that we can perceive without knowing and we can know without perceiving.

E.g., we can see and hear a foreign language without us knowing it. Therefore if we can without perceive knowing, then knowledge cannot be identical to perception.

What is Knowledge? Plato's Definition

Plato's second definition is that *knowledge is true belief*.

Socrates disproves this by saying that when a jury believes a defendant is guilty by just hearing the prosecutor, rather than of any solid evidence, it cannot be said to know that the accused is guilty.

What is Knowledge? Plato's Definition

Plato's third definition is:

Knowledge is justified, true belief.

The problem with this analysis revolves around the word “justified”. All interpretations of “justified” are deemed inadequate.

These analyses prove to be an excellent example of the attacking the inadequate theories of knowledge, but it does not prove an answer to what knowledge is.

What is Knowledge? Descartes' Definition

"Intuition is the undoubting conception of an unclouded and attentive mind, and springs from the light of reasons alone; it is more certain than deduction itself in that it is simpler."

"Deduction by which we understand all necessary inference from other facts that are known with certainty," leads to knowledge when recommended method is being followed.

What is Knowledge? Descartes' Definition

"Intuitions provide the ultimate grounds for logical deductions. Ultimate first principles must be known through intuition while deduction logically derives conclusions from them.

These two methods [*intuition and deduction*] are the most certain routes to knowledge, and the mind should admit no others."

What is Knowledge?

- *Propositional knowledge*: knowledge that such-and-such is the case.
- *Non-propositional knowledge (tacit knowledge)*: the knowing how to do something.

Knowledge and Objectivity Observations

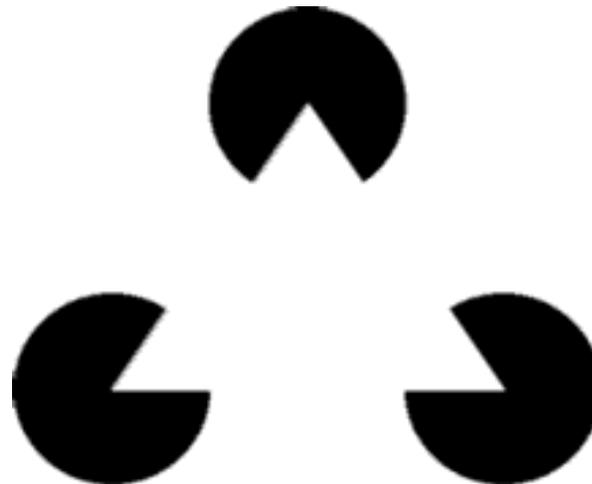
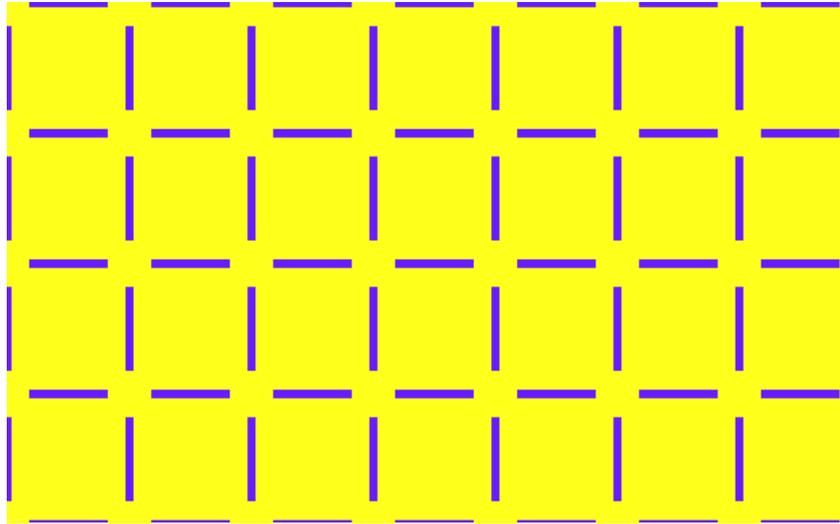
Observations are always interpreted in the context of an a priori knowledge. (Kuhn, Popper)

“What a man sees depends both upon what he looks at and also upon what his previous visual-conceptual experience has taught him to see”.

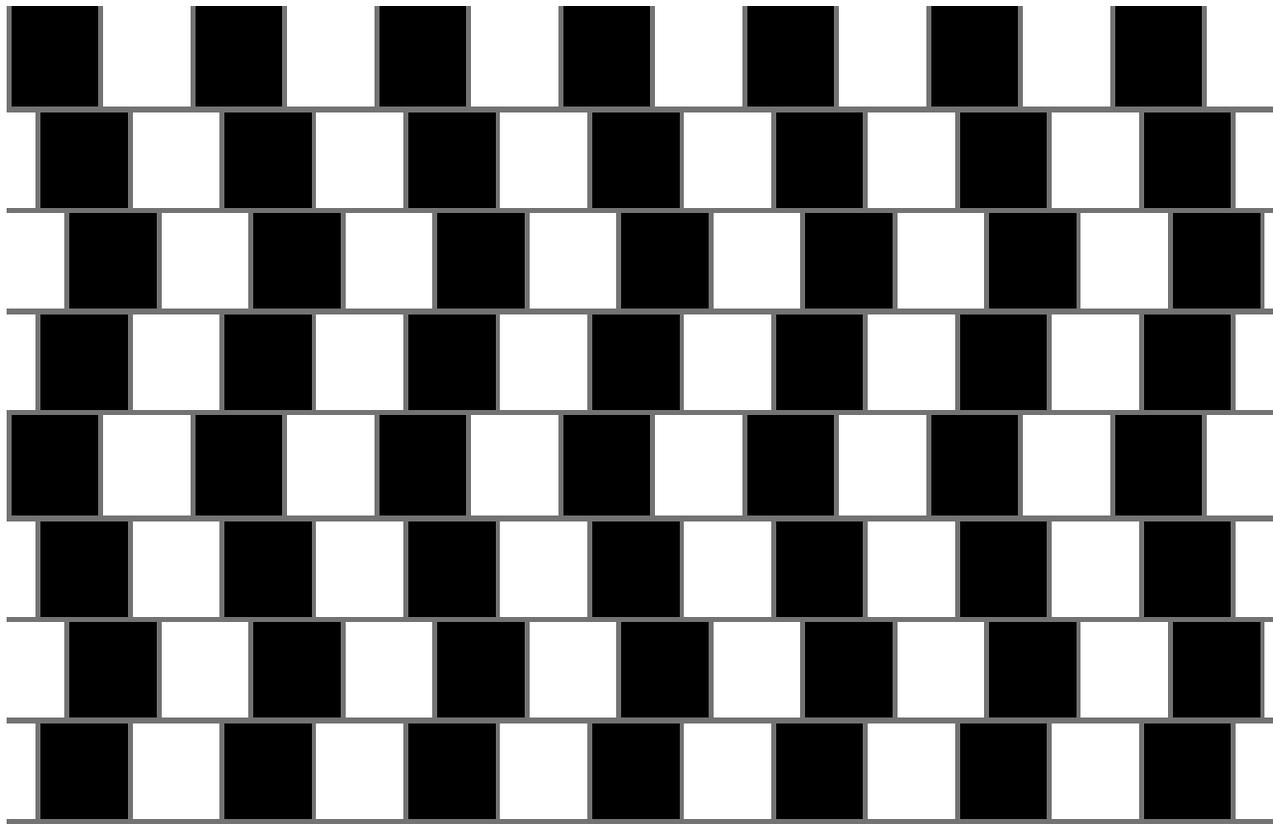
Knowledge and Objectivity Observations

- All observation is potentially "contaminated", whether by our theories, our worldview or our past experiences.
- It does not mean that science cannot "objectively" [inter-subjectivity] choose from among rival theories on the basis of empirical testing.
- *Although science cannot provide one with hundred percent certainty, yet it is the most, if not the only, objective mode of pursuing knowledge.*

Perception and “Direct Observation”

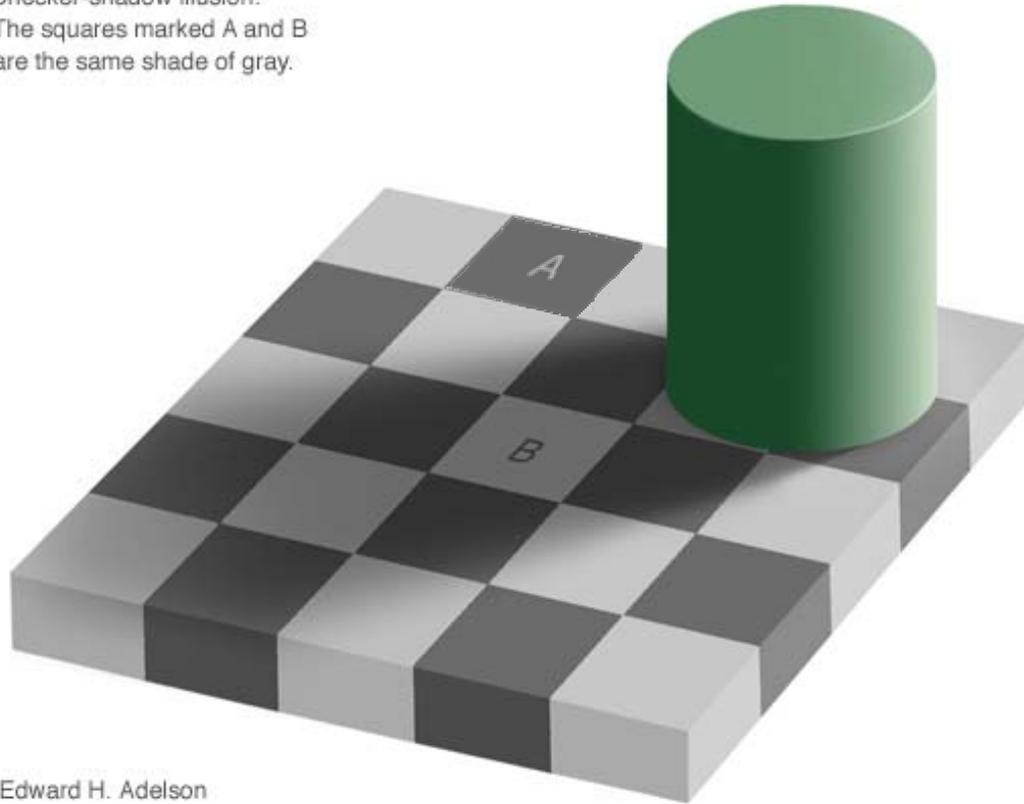


Perception and “Direct Observation”



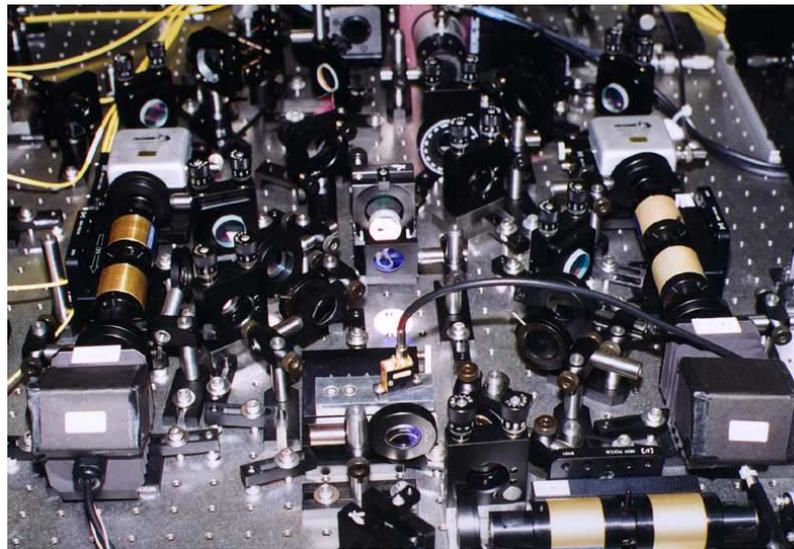
Perception and “Direct Observation”

Checker-shadow illusion:
The squares marked A and B
are the same shade of gray.



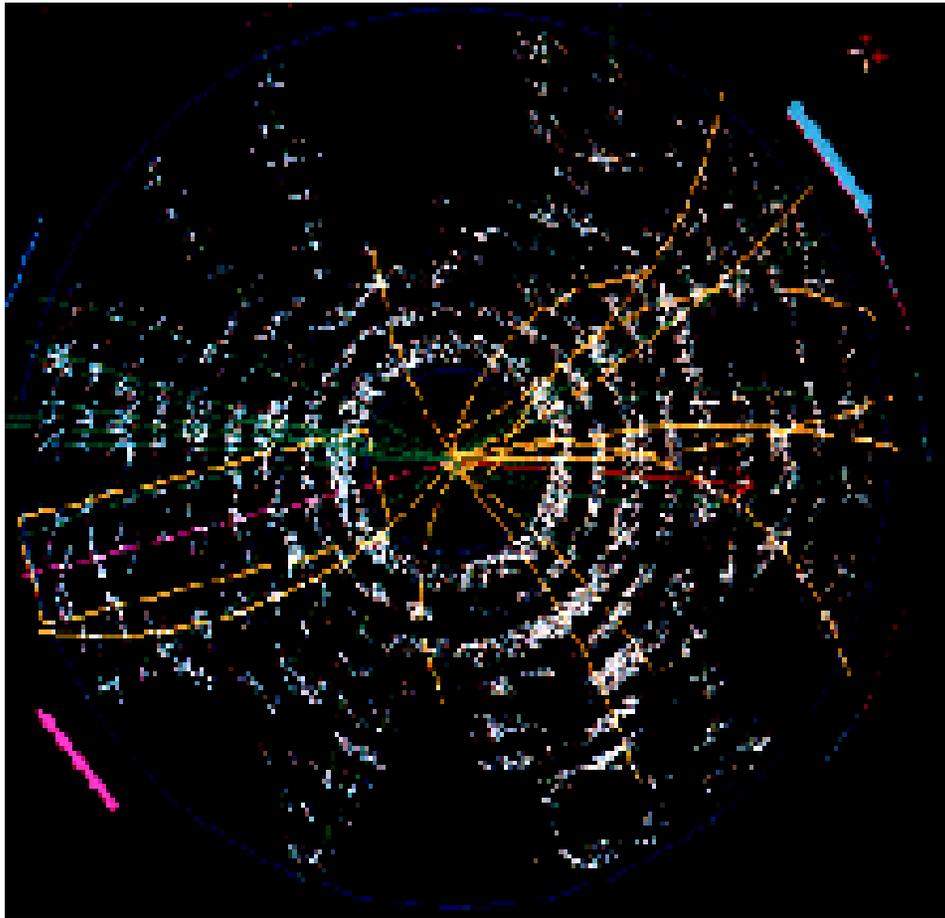
Edward H. Adelson

Direct Observation?!



An atom interferometer, which splits an atom into separate wavelets, can allow the measurement of forces acting on the atom. Shown here is the laser system used to coherently divide, redirect, and recombine atomic wavepackets (Yale University).

Direct Observation?!



Electronic signatures produced by collisions of protons and antiprotons in the Tevatron accelerator at Fermilab provided evidence that the elusive subatomic particle known as top quark has been found.

SUMMARY ON MODELS

- TRUE VS ADEQUATE
- CAUSAL LAWS VS EMPIRICAL LAWS
- MODELS ARE ALWAYS INSTANCES
(certain viewpoint, partial truth)
- MODELS ARE INVESTIGATIVE INSTRUMENTS
- ALTERNATIVE EXPLANATIONS
- GOOD TO USE THINGS THAT WE CAN GET FOR FREE!

SUMMARY ON MODELS

- ORDER OF CONSULTATION
- NOT ALWAYS "RATIONAL CHOICES"
- "DESIGN RESEARCH"
- COHERENCE BETWEEN MODELS (PARTIAL TRUTHS)
- MODELS AS TOOLS FOR MAKING INFERENCES
- MODELS MAKE INACCESSIBLE REALITY ACCESSIBLE AND COMMUNICABLE

MAKING DECISIONS BASED ON MODELS

- THE RELEVANT QUESTION IS: WHAT WOULD BE THE ALTERNATIVE?
- WITHOUT MODEL (SIMULATION) OUR PREDICTION OR IN GENERAL OUR UNDERSTANDING OF SYSTEMS BEHAVIOUR WOULD BE BASED ON GUESSES THAT MIGHT BE MUCH MORE MISLEADING THAN THE MODELS/SIMULATION RESULTS UNDER THE ASSUMPTION THAT WE BUILT IN OUR BEST KNOWLEDGE INTO THE MODEL.