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Models in Science:

Modeling the Sun

The Sun and Solar Wind

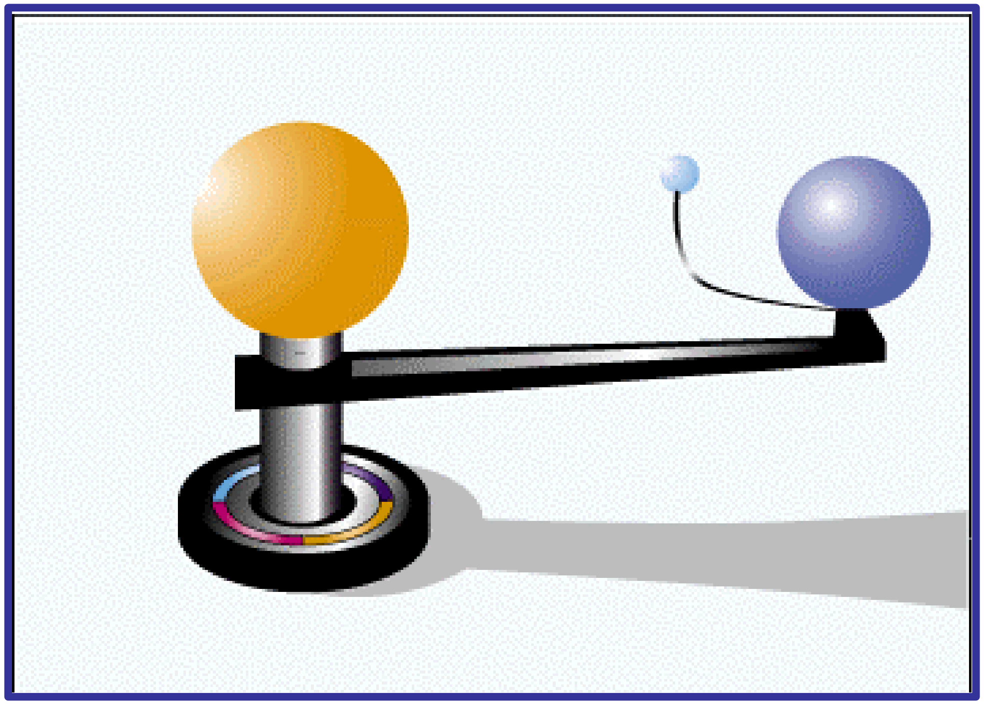
The forging of new science is frequently dependent on the development of models. Reasons for models in science are:

- The objects of a scientist's attention are too small to be observed directly.
- Objects may be inaccessible for direct visual study.
- Some topics of study can best be studied through their effects on matter.

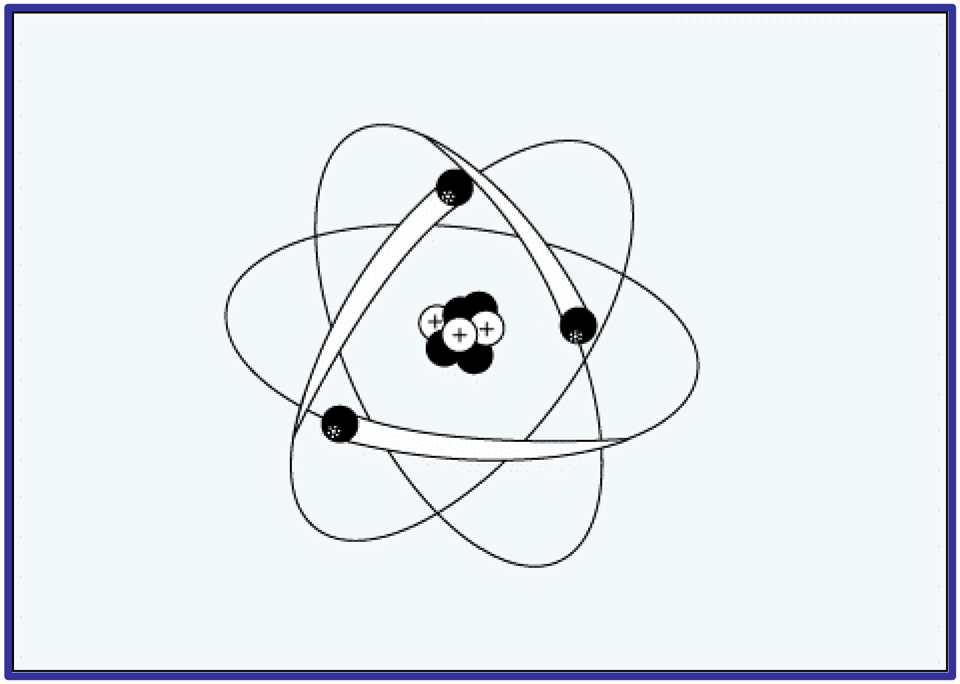
Scientists use models to study things like the center of the Earth, gravity, magnetism, and energy.

There are many types of models that are used in science.

The Sun and Solar Wind



A physical model of the sun, moon, and Earth illustrates the phases of the moon and eclipses, among other things.



The Bohr solar system model of the atom is often used by beginning chemistry students to help them to form a mental image of an atom.

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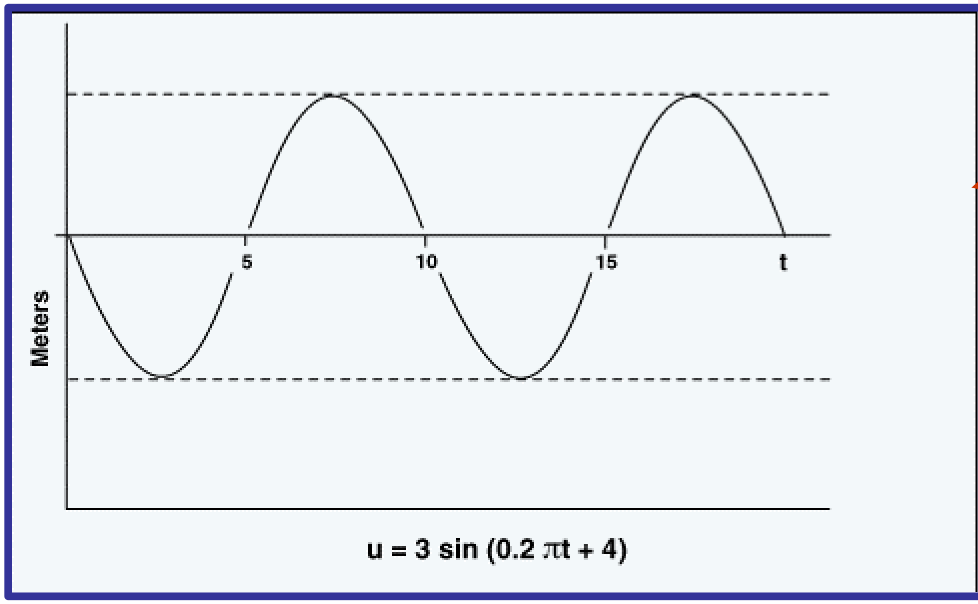

Mathematical model

How are models developed?

By making physical observations on a system of interest to establish facts. Rays of light can be modeled on a mathematical model as shown above.

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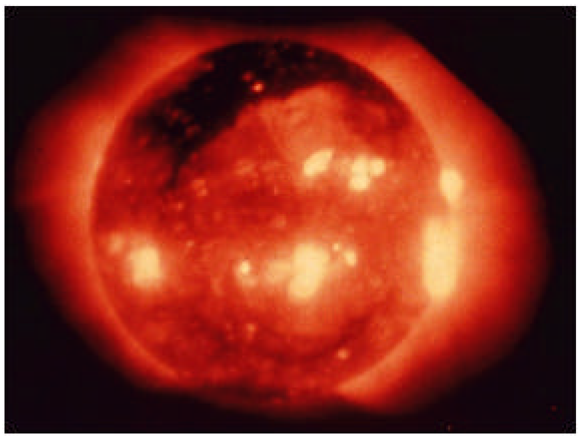
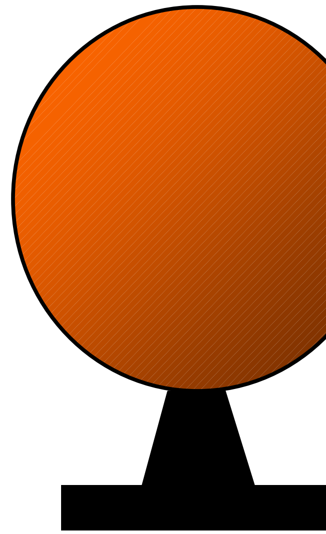
The Sun and Solar Wind

Image courtesy of NASA





The distant sun is enormous in diameter, hot, and gaseous. It is unlikely to be visited up close by humans in the near future and must be modeled.

The result is the need for what has been widely accepted as the Standard Solar Model, a mathematical model that offers these major scientific principles and assumptions:

- **The sun originated from a primordial cloud of (mostly) hydrogen and some helium gas. The fraction of helium has increased steadily over the life of the sun.**
- **The sun is in a steady state, meaning that it is neither expanding nor contracting.**

The Sun and Solar Wind

- There is a core where hydrogen is undergoing nuclear fusion to make helium and this is the primary source of the sun's energy.

- Energy produced in the core is transferred outward by radiation until it gets to the opaque convection zone, where energy transfer is more efficient by convection.

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Armed with information gleaned from experiments conducted here on Earth (like studies of nuclear fusion), trained specialists are able to calculate and update the Standard Solar Model in an effort to obtain good numerical agreement between the model and the observed sun.

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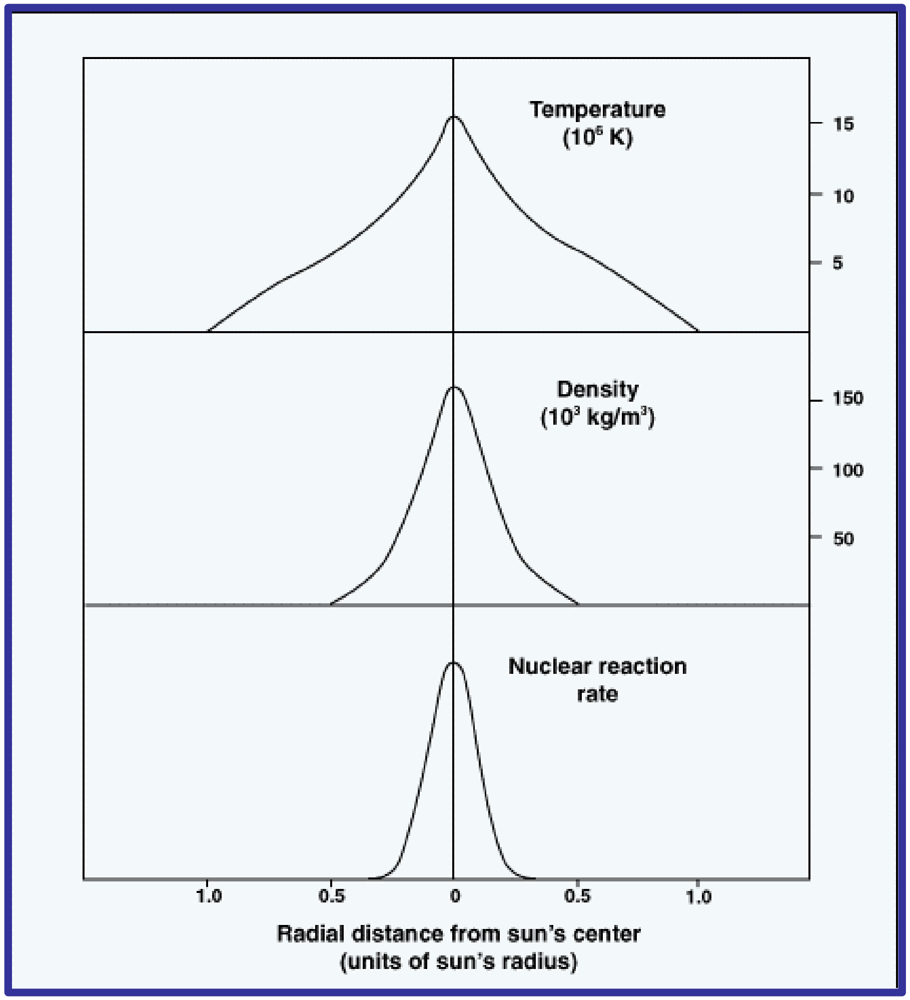

A recent calculation by astrophysicist John Bahcall predicts the temperature and density at the center of the sun's core.

Models are beneficial for testing.

Enter: The Neutrino

Mysterious particles called neutrinos are produced by nuclear fusion. They have no charge, little mass, and are difficult to observe. According to the Standard Solar Model, neutrinos should be bombarding the Earth at the rate of 6×10^{14} neutrinos per second for every square meter of surface.

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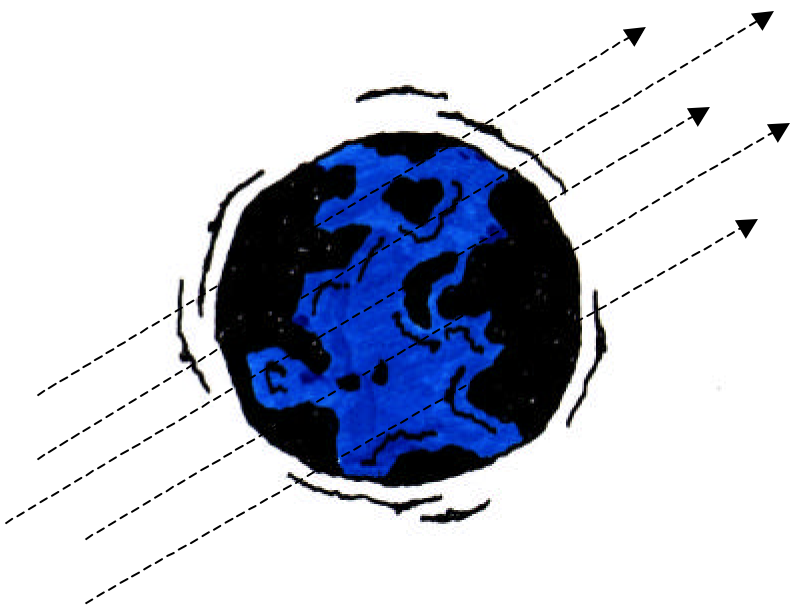
✷Detecting these neutrinos experimentally with an instrument would provide a good check of the correctness of one of the assumptions of the Standard solar Model.



Neutrinos

Neutrinos, they are very small.
They have no charge and have no mass
And do not interact at all.
The Earth is just a silly ball
To them, through which they simply pass,
Like dust maids down a drafty hall.

J. Updike: Cosmic Gall. Originally published in : The New Yorker, 17 December 1960, p. 36. Reproduced in J. Updike: Telephone Poles and Other Poems, Alfred A. Knopf, New York 1979, p. 5 and in J. Updike: Collected poems 1953-1993, Alfred A. Knopf, New York 1993, p 315.

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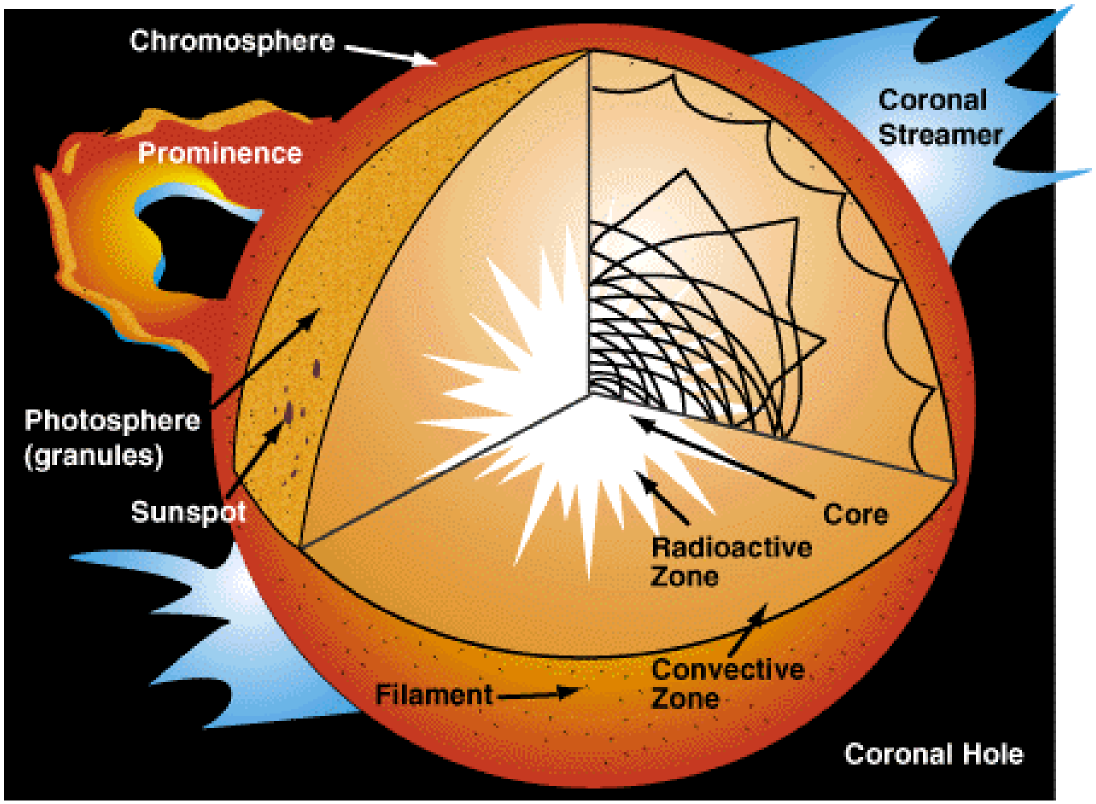

Since the Standard Solar Model provides estimates of the temperature profile of the sun, it is possible to calculate the expected speed of sound waves traversing the interior.

The Sun and Solar Wind

At this point you should be totally convinced of the importance of the necessity for models in science. It would be impossible to begin to understand our immense solar system without the construction of models.

The Sun and Solar Wind

- To learn more about the sun and solar wind, visit the Genesis Web site at:

http://genesismission.jpl.nasa.gov