Nuclear Fusion

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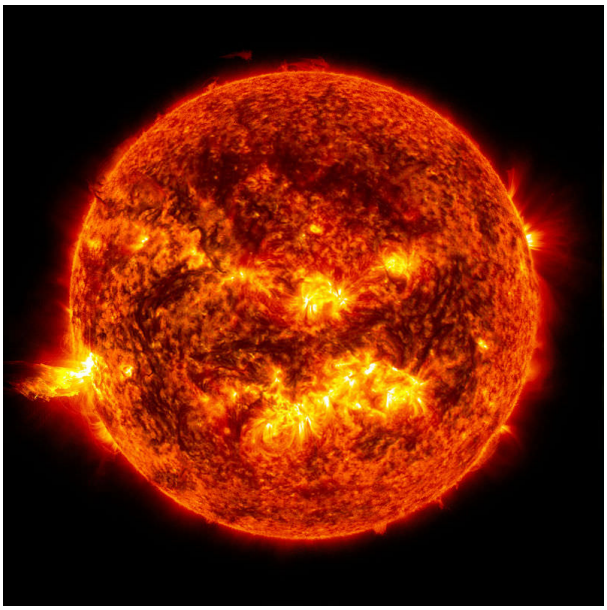
Nuclear Fusion

Energy can be produced by the fusion of small atomic nuclei.

Nuclear Fusion

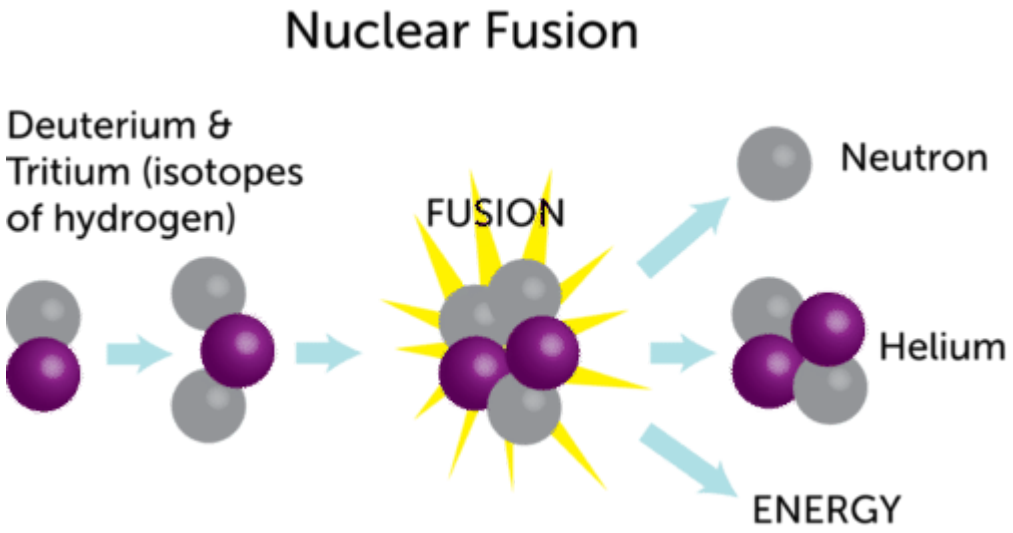


[Figure1]

What causes the sun to glow so brightly? The answer is **nuclear fusion**. Nuclear fusion is a type of nuclear reaction, and it releases a huge amount of energy.

What Is Nuclear Fusion?

In **nuclear fusion**, two or more small nuclei combine to form a single, larger nucleus. You can see an example in the **Figure** below. In this example, nuclei of two hydrogen isotope, tritium (${}_1^3H$) and deuterium (${}_1^2H$), fuse to form a helium nucleus (${}_2^4He$). A neutron and a tremendous amount of energy are also released.

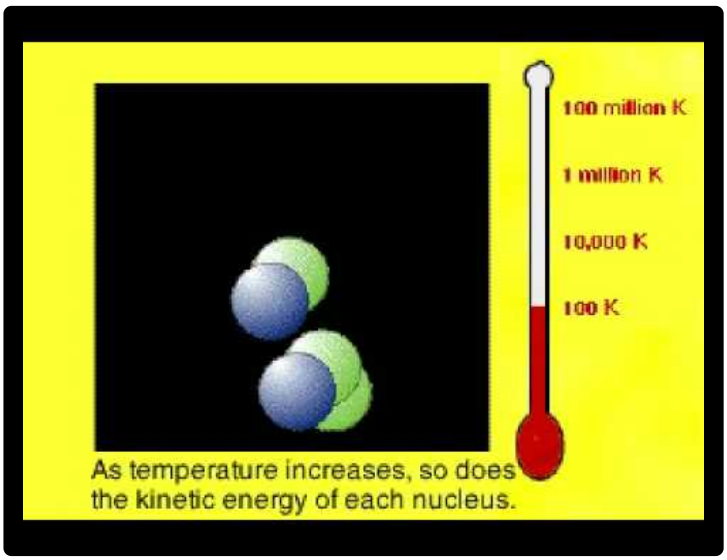


[Figure2]

Nuclear Fusion

The Power of Stars

Nuclear fusion of hydrogen to form helium occurs naturally in the sun and other stars. It takes place only at extremely high temperatures. That's because a great deal of energy is needed to overcome the force of repulsion between the positively charged nuclei. The sun's energy comes from fusion in its core, shown in the **Figure** below. In the core, temperatures reach millions of degrees Kelvin.



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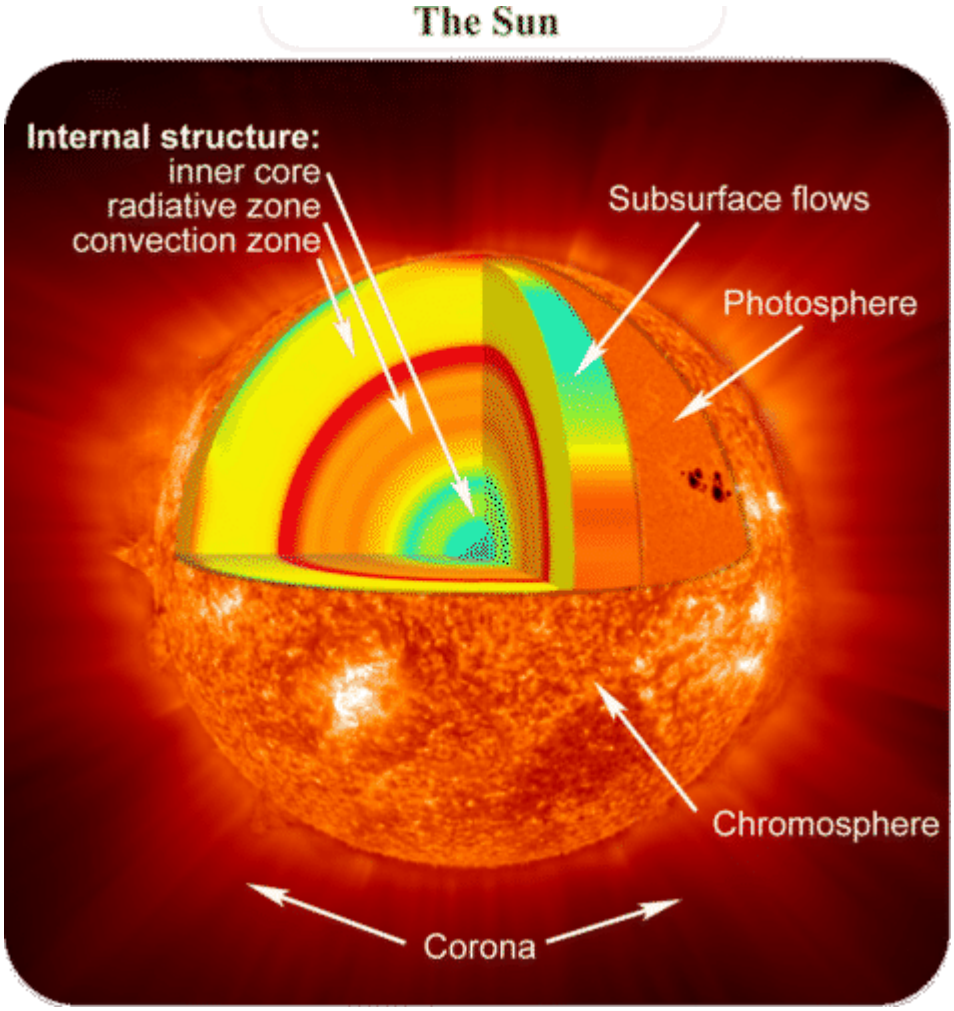


[Figure3]

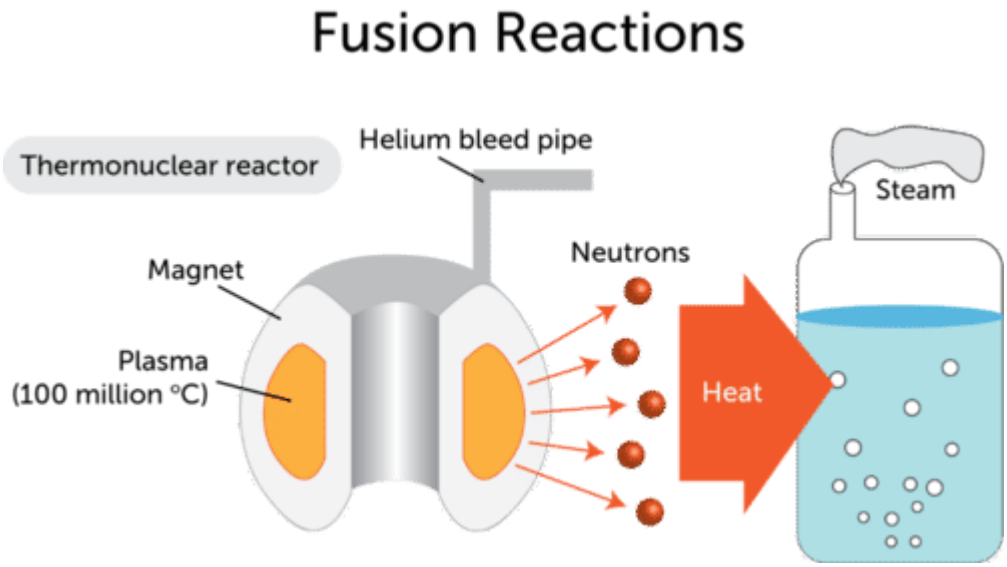
The Sun

Q: Why doesn't nuclear fusion occur naturally on Earth?

A: Nuclear fusion doesn't occur naturally on Earth because it requires temperatures far higher than Earth temperatures.

Using Nuclear Fusion

Scientists are searching for ways to create controlled nuclear fusion reactions on Earth. Their goal is develop nuclear fusion power plants, where the energy from fusion of hydrogen nuclei can be converted to electricity. You can see how this might work in the **Figure** below. In the thermonuclear reactor, radiation from fusion is used to heat water and produce steam. The steam can then be used to turn a turbine and generate electricity.



[Figure4]

The use of nuclear fusion for energy has several pros. Unlike nuclear fission, which involves radioactive elements which take hundreds of thousands of years to become safe, current research into nuclear fusion for electricity generation usually involves isotopes of hydrogen and helium. These elements are harmless. Hydrogen is also very plentiful. There is a huge amount of hydrogen in ocean water. Nuclear fusion is not without radioactive waste; the material that makes up the reactor does become radioactive but it becomes safe in under 100 years. The hydrogen in just a gallon of water could produce as much energy by nuclear fusion as burning 1,140 liters (300 gallons) of gasoline! The hydrogen in the oceans would generate enough energy to supply all the world's people for a very long time.

Using energy from nuclear fusion on a large scale is still far from being realized. Scientists have made recent progress in sustaining fusion reactions for over eight minutes at the Wendelstein 7-X fusion device - this is a huge step in the future of fusion reactors! Fusion is still challenging because raising temperatures high enough for fusion is energy intensive. Another problem is that matter this hot exists only in the plasma state. There are no known materials that can contain plasma, but magnetic fields are used to keep the plasma from touching the walls of the reactor in some research reactors. That's because plasma consists of ions and responds to magnetism.

Summary

- In nuclear fusion, two or more small nuclei combine to form a single larger nucleus, a neutron, and a tremendous amount of energy.

- Nuclear fusion of hydrogen to form helium occurs naturally in the sun and other stars. It takes place only at extremely high temperatures.
- Scientists are searching for ways to create controlled nuclear fusion reactions to produce safe nuclear power. Fusion involves mostly harmless, plentiful elements but requires extremely high temperatures.

Review

1. What is nuclear fusion?
2. Where does nuclear fusion occur naturally? Why does it occur only at extremely high temperatures?
3. Nuclear fusion results in a huge release of energy, yet it doesn't involve the use of dangerous radioactive elements. Why isn't it used to produce power?

Explore More

Watch the video about nuclear fusion and then answer the questions below.

1. On Earth, we use energy from the sun for several purposes. List three uses of solar energy.

2. The sun's energy comes from nuclear fusion. Explain why nuclear fusion releases energy.
3. In what form is the energy of nuclear fusion released? How does this energy reach Earth?

Vocabulary

Language: English

Term	Definition
nuclear fusion	a process in which low-mass nuclei (ex. H or He) combine to form a heavier and more stable nucleus, releasing an enormous amount of energy

1.0 REFERENCES

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