SNS COLLEGE OF TECHNOLOGY

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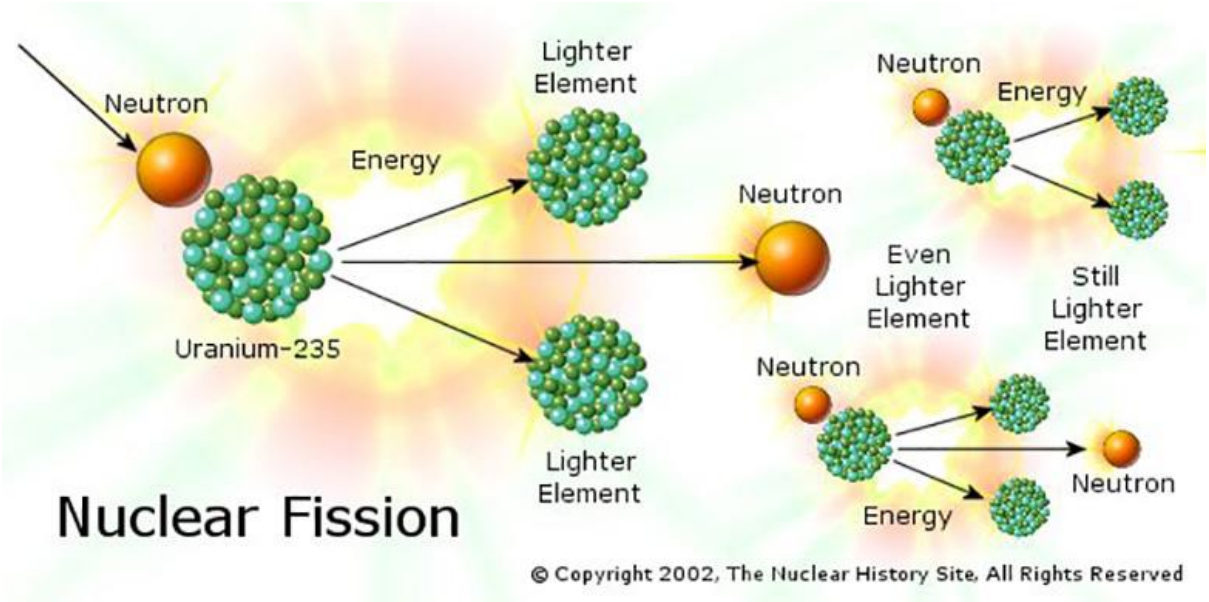
NUCLEAR ENERGY

Introduction to Nuclear Fission

- **Definition**: Nuclear fission is the process in which a heavy atomic nucleus splits into two or more smaller nuclei, along with the release of energy, neutrons, and gamma radiation.
- **Discovery**: Fission was discovered in 1938 by Otto Hahn and Fritz Strassmann and further explained by Lise Meitner and Otto Frisch.

Basic Principles of Nuclear Fission

1. **Fissile Materials**: Materials capable of sustaining a fission chain reaction, such as:
   - Uranium-235 (235U^{235}\text{U}235U)
   - Plutonium-239 (239Pu^{239}\text{Pu}239Pu)
2. **Chain Reaction**:
   - When a fissile nucleus absorbs a neutron, it becomes unstable and splits into smaller nuclei (fission products), releasing additional neutrons.
   - These released neutrons can initiate further fission reactions, leading to a self-sustaining chain reaction.
3. **Critical Mass**:
   - The minimum amount of fissile material needed to maintain a chain reaction. Below this mass, the reaction will fizzle out; above it, the reaction can sustain itself.



Types of Nuclear Fission

1. **Fast Fission**:
    - Occurs when a nucleus absorbs a fast-moving neutron. Generally requires fast neutrons (higher energy).
2. **Thermal Fission**:
    - Occurs when a nucleus absorbs a slow-moving (thermal) neutron. Most common in nuclear reactors using enriched uranium or plutonium.

Fission Products and Energy Release

- **Fission Products**: The smaller nuclei produced, which are often radioactive and can include isotopes of krypton, barium, and others.
- **Energy Release**: The fission of one nucleus releases approximately 200 MeV (million electron volts) of energy, primarily in the form of kinetic energy of the fission products and neutrons.

Components of a Nuclear Reactor

1. **Reactor Core**: Contains the fuel (e.g., uranium), where fission takes place.
2. **Control Rods**: Made of materials (e.g., boron, cadmium) that absorb neutrons and help regulate the fission process.
3. **Coolant**: A substance (often water) that transfers heat away from the reactor core, often used to produce steam to drive turbines for electricity generation.
4. **Containment Structure**: A strong structure designed to contain radiation and prevent the release of radioactive materials in case of an accident.

Advantages of Nuclear Fission

- **High Energy Density**: Fission releases a vast amount of energy from a small amount of fuel compared to fossil fuels.
- **Low Greenhouse Gas Emissions**: During operation, nuclear power plants produce minimal carbon emissions.
- **Reliable Energy Source**: Capable of providing a continuous and stable energy supply, unlike some renewable sources.

Challenges and Risks

1. **Radioactive Waste**: Management and disposal of long-lived radioactive waste pose significant challenges.
2. **Accident Risks**: Potential for catastrophic accidents (e.g., Chernobyl, Fukushima) due to reactor malfunctions, natural disasters, or human error.
3. **Nuclear Proliferation**: The spread of nuclear technology and materials raises concerns about their potential use in nuclear weapons.

Current Status and Future of Nuclear Fission

- **Global Use**: Approximately 10% of the world's electricity is generated from nuclear fission, with over 400 reactors operating worldwide.
- **Advancements**: Research is ongoing into advanced reactor designs (e.g., Generation IV reactors) and small modular reactors (SMRs) aimed at enhancing safety and efficiency.
- **Public Perception**: Nuclear energy often faces opposition due to safety concerns and the legacy of past accidents.