



X-raying a Single Atom

Why in News?

Recently, scientists achieved a remarkable milestone by **identifying an element through [X-ray imaging of a single atom](#)**.

- X-rays, discovered by **Wilhelm Conrad Rontgen in 1895**, have become an integral part of various fields, including medicine and security.
- Previously, the **smallest amount of sample that can be X-rayed is an attogram**, (which is about **10,000 atoms or more**). Scientists have long wanted to be able to X-ray just one atom, which has now been made possible.

What is the new technique for X-raying a single atom?

- **Technique:**
 - Scientists have used a technique called **synchrotron X-ray scanning tunneling microscopy (SX-STM)** to detect the **X-ray signature of a single atom for the first time**.
 - SX-STM combines **synchrotron X-rays**, which are **high-energy X-rays** produced by accelerating electrons in a circular track, with **scanning tunneling microscopy**, which uses a **sharp metal tip to interact with the electrons of a sample at very close distances**.
 - The synchrotron X-rays excite the sample, and the metal tip collects the photoelectrons emitted by the atom, **revealing its identity and chemical state**.

Materials Science:

- Materials science, the study of the **properties of solid materials** and how those properties are determined by a material's composition and structure.
- **Importance for Material Science:**
 - It provides insights into the **atomic-scale properties and interactions of materials**.
 - Enables **precise understanding of molecular structures** and behaviors.
 - Facilitates the design and development of novel materials and devices.
 - Enhances **knowledge of catalytic activity, biomolecular interactions, and quantum phenomena**.

What is X-ray?

- It is a form of **[electromagnetic radiation](#)** with **higher energy, high frequency, and shorter wavelength than visible light**.
- It can pass through most objects, including the body, and **produce internal structure images**.
- Produced by **accelerating or decelerating charged particles** or exciting atoms.
- Widely used in science, medicine, industry, and security applications.
- Used for **detecting bone fractures, diagnosing diseases, identifying materials, and scanning luggage**.

UPSC Civil Services Examination, Previous Year Questions (PYQs)

Prelims

Q1. With reference to Visible Light Communication (VLC) technology, which of the following statements are correct? (2020)

1. VLC uses electromagnetic spectrum wavelengths 375 to 780 nm.
2. VLC is known as long-range optical wireless communication.
3. VLC can transmit large amounts of data faster than Bluetooth.
4. VLC has no electromagnetic interference.

Select the correct answer using the code given below:

- (a) 1, 2 and 3 only
(b) 1, 2 and 4 only
(c) 1, 3 and 4 only
(d) 2, 3 and 4 only

Ans: (c)

Exp:

- Visible Light Communication (VLC) systems employ visible light for communication that occupy the electromagnetic spectrum from 375 nm to 780 nm. **Hence, statement 1 is correct.**
- VLC is known as short-range optical wireless communication. Hence, statement 2 is not correct.
- Li-Fi, a kind of VLC, has a range of approximately 10 meters and it cannot pass through walls or any solid object.
- VLC can transmit large amounts of data faster than Bluetooth. The VLC uses visible light for communication to provide high speed internet up to 10 Gb/s while Bluetooth 4.0 promises speeds up to 25 Mb/s. **Hence, statement 3 is correct.**
- **VLC has no electromagnetic interference. The radio frequency (RF) based signals have the problem of interference** with other RF signals such as its interference with pilot navigational equipment signals in aircraft. Therefore, in the areas that are sensitive to electromagnetic radiation (such as aircrafts) VLC can be a better solution. **Hence, statement 4 is correct. Therefore, option (c) is the correct answer.**

Q2. Assertion (A): Radio waves bend in a magnetic field.

Reason (R): Radio waves are electromagnetic in nature. (2008)

Examine these two statements carefully and select the answers to these items using the code given below:

- (a) Both A and R are individually true and R is the correct explanation of A
(b) Both A and R are individually true but R is not the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Ans: (A)

- **The electromagnetic (EM) spectrum is the range of all types of EM radiation. Radiation is energy that travels and spreads out. The visible light that comes from a lamp in houses and the radio waves that come from a radio station are two types of electromagnetic radiation.** The other types of EM radiation that make up the electromagnetic spectrum are microwaves, infrared light, ultraviolet light, X-rays and gamma-rays.

- In 1873, Scottish physicist James Clerk Maxwell developed a unified theory of electromagnetism, which dealt with electrically charged particles interacting with each other and with magnetic fields. He proved that magnetic poles come in pairs that attract and repel each other, much like electric charges through his Maxwell equations.
- Electromagnetic waves are formed when an electric field is coupled with a magnetic field. Magnetic electric fields of an electromagnetic wave are perpendicular to each other and to the direction of the wave.
- Radio waves are at the lowest range of the EM spectrum, with frequencies of up to about 30 GHz, and wavelengths greater than about 10 millimetres (0.4 inches).
- Radio waves are waves of the electromagnetic spectrum (electromagnetic in nature), thus these waves bend in both magnetic and electric fields. **Hence, Assertion (A) is correct, and Reason (R) is correct explanation of Assertion (A). Therefore, option (a) is the correct answer.**

[Source: TH](#)

PDF Reference URL: <https://www.drishtiias.com/printpdf/x-raying-a-single-atom>

