REVIEW ARTICLE

"How Neutron Imaging Unfolds the Hidden Secrets of Fossils and Artifacts"

Arya K V*, F. Jasmin, Hiba* V A, Mary E V*, Shalina N K* Sana Backer**

*M.Sc Physics,**Assistant Professor,PG Department of Physics, Ansar Women's College, Perumpilavu, Thrissur-680519

Abstract

In many research fields neutron beam-based imaging techniques are rapidly developing and also it become versatile non-destructing analysing tool. Neutron differ strongly from electron, proton or X rays in terms of interaction with matter. Neutrons are perfectly suited probes for research on materials that are used for energy storage and conversion for example fuel cell, batteries, hydrogen storage etc. In bulk samples, their magnetic moment allows for resolving magnetic properties. Neutron images in three dimensional have been taken of rare archaeological artifacts here at ORNL for the first time. Many techniques are available for the neutron imaging such as non-invasive, non-destructive in order to provide more accurate information about fossils and artifacts. It also helps us to find their composition, inclusions, presence of alterations due to environmental conditions etc. Here we present an overview of the neutron imaging methods used in fossils which could pave a new way of light into the previous life.

Keywords: Neutron imaging Non- Destructive Non-invasive X-ray Archaeological artifacts

Introduction

In research fields neutron imaging using neutrons beams have become a versatile tool [1]. Their intrinsic properties differ from that of electrons and protons. Neutron imaging inspire future generation and also it advances our scientific knowledge. It helps to explore the wonders of the past and provide an exciting opportunity to develop a passion for science and history.

Neutrons are charge less particles but they have magnetic moment in them. They can interact with light objects strongly but cannot interact with metals strongly instead they interact weakly. Hence, they provide high sensitivity to light elements than the thick metals.

By the rapid development of neutron imaging in recent years it had paved a new way to the implementation of new techniques and contrast mechanisms in different fields. One such field is the field of the pale ontology. This development has enhanced a new way of imaging the fossils with neutrons. This can be possible with absorption mechanism based on neutron tomography and radiography to understand the materials in the related field of pale ontology.

The most important feature of neutron that is they can penetrate into light elements makes them perfectly suitable probes for the research fields. The magnetic moment property of neutron helps in the interaction of the neutrons with magnetic structures that can be used in the visualisations of two- and three- dimensional magnetic fields and domain distributions.

Theoretical review

Neutron imaging is a non - destructive imaging technique. It uses neutrons to penetrate the materials and can reveal hidden details by differentiating between various materials based on their neutron absorption characteristics in the context of fossils and artifacts. Neutron imaging are commonly used in medical imaging in this neutrons can penetrate dense and also heavy materials more effectively. It can unveil internal structures without causing any damage. Because of this reason, this method is particularly useful for studying fossils and artifacts. Also, in this method, it helps researchers to examine the composition, distribution of elements and density by providing insights into their composition, potential hidden details and preservation. When dealing with materials that are difficult to penetrate using other imaging techniques, this technique is especially valuable.

By utilising the unique properties of neutrons to reveal internal structures and details, it offers a non - invasive way to explore the hidden secrets of fossils and artifacts.

A technique that exploits the interaction of neutrons with matter is neutron radiography. Neutron imaging relies on the principle of this neutron radiography. Neutrons has the ability to penetrate materials depends on their energy and the properties of the materials they run in to, hence neutrons are neutral subatomic particles. When scientists began exploring the characteristics of neutrons, this technique can be traced back to the early 20 centuries.

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In industrial and military application, neutron have been used for imaging since after the discovery of neutron. Neutrons have no electric charge and as the name indicates it is a neutral subatomic particle.

From comparatively massive particle accelerators or from the by-products of nuclear reactors, neutrons that are suitable for tomography are produced. They relatively move slowly and have the energies one hundred millionth those of X rays in CT scanners. The slow-moving neutrons strongly interact with low density materials that X rays pass through blithely including hydrogen, boron and lithium.

Neutron imaging is an important technology due to its ability to glide through the dense material that blocks X rays. Hence this technology is used in the industrial testing of automobiles and planes

Neutron imaging have been predominantly used from early 20^{th} century onwards by Hartmut Kallmann and Ernst Kuhn after the discovery of neutron. Later these were followed by other scientists to new developments such as non-destructive technique that is used in neutron radiography. Further developments in neutron imaging embraced a new door to the imaging of many magnetic structures and became widely used in the fields of medical, pale ontology, archaeology etc.

Lately neutron imaging has been widely used in the discovering of fossils. It turns out to be more interesting and reliable technique since it could form three dimensional images. More of these fossils can provide a vast information about the previous life.

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Now neutron tomography is combined with computer tomography for finding the fossil structures and their information more accurately. This provides a new way to find out about the hidden secrets of fossils and artifacts such as that available at SANEAD facility of the SAFARI-1 nuclear research reactor in South Africa.

Neutron tomography techniques were also performed in Neutron Radiography Facility at HANARO, KAERI for the investigation of the dinosaur embroyo to understand the physical features of Dinosaurs living in that period

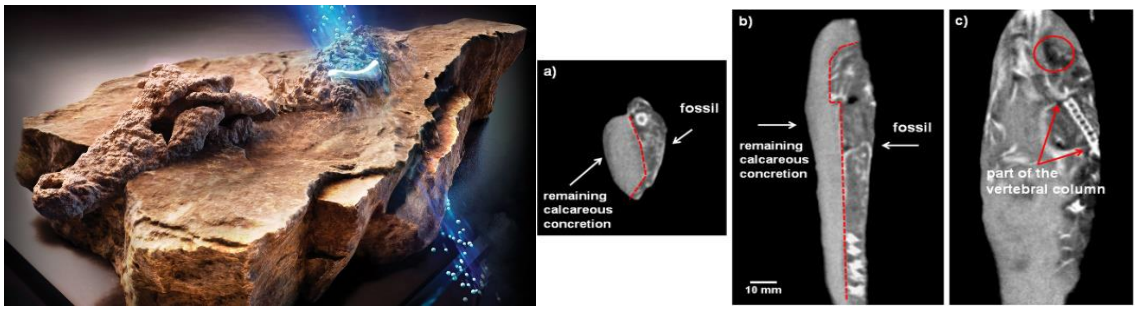
Penetration, scattering properties of neutrons, images of matters in two or three dimensions +neutrons, unobtainable information can reveal using other probes of image of matter in 2 or 3 dimensions. The different aspects of modern geosciences need several neutron imaging techniques despite the limitation in brilliance of neutron.

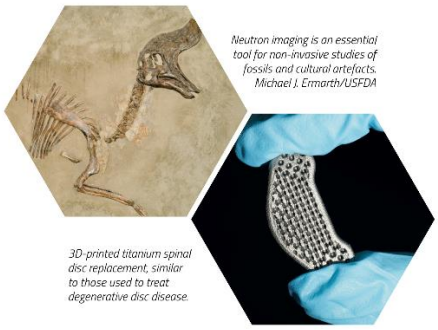
The evaluation of porosity in sediment mud rocks and the mapping of light elements in solids, in porous of fluids, organic inorganic composites and living organisms.

In heterogeneous media simultaneous neutron and x-ray tomography, imaging of Bragg edge and the possibility of porosity from dark field imaging.

X ray and neutron imaging can be simultaneously done by using the Neutron and X ray tomography or NeXT facility which is led by LaManna at NIST. It gives distinct yet complementary information in the case of things that contain combination of materials such as hydrogen fuel cell, building materials and soil samples.

Without damaging the internal structures of fossils and artifacts, neutron imaging allows researchers to examine them. It gives unprecedented details such as anatomy and lifestyle of ancient creatures. And also, this technology provides the valuable information into the past. In the field of pale ontology and archaeology this technology is very helpful.





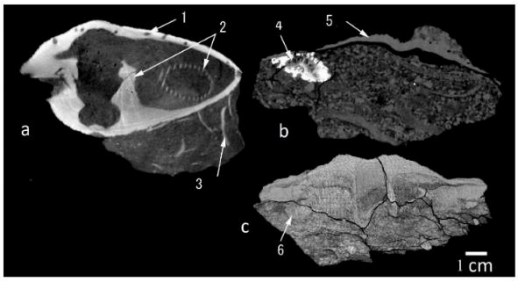
Conclusion

Neutrons interact through scattering and absorption with matter. Neutrons are charge less and are less likely to be deflected. Because of this reason neutron can penetrate materials more effectively than X-rays.

Neutron imaging inspire future generation and also it advances our scientific knowledge. It helps to explore the wonders of the past and provide an exciting opportunity to develop a passion for science and history.

Neutron imaging is now belonged to the important non-destructive investigation methods. Neutron imaging is often performed with polychromatic, for obtaining the highest flux.

The imaging techniques based on neutron are complementary to those based on other types of radiation because free neutrons interact differently with matter than electrons, protons and X rays.



In the recent times neutron imaging allows to real time imaging using an intensive neutron beam. This technique allows to follow a dynamic process in real time. Neutron imaging can provide more accurate information when chosen a selective neutron. Because of the magnetic moment property, they are used to find the magnetic structures.

The future of neutron imaging is widely spread in vast areas. They can be more competitive to other techniques available nowadays. They can be easily interpreted and could be carried out more easily. It can create two- and three- dimensional images compared to x rays.

In general, the neutron imaging paved a new way for the modern science and research a new way to interpret and identify the materials more easily. In case of fossils the three -dimensional images formed by neutron imaging could provide more information about the fossil not only by determining their age but also by knowing their habitat and other physical and biological reasons. This can provide us with a vast and more accurate information about the extinct ones and earn more knowledge from them.

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