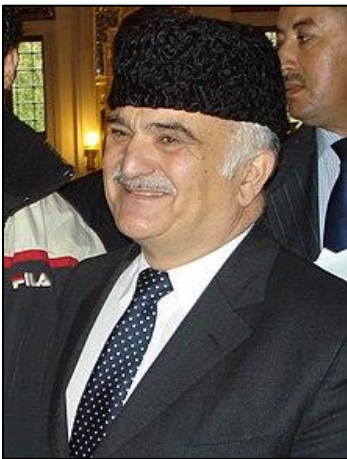


ADDRESS OF HIS ROYAL HIGHNESS PRINCE EL-HASSAN BIN TALAL
FOUNDING PATRON, IAS

at the 16th IAS Conference on Science, Technology and Innovation for Sustainable Development in the Islamic World: The Policies and Politics Rapprochement, held in, Kazan, Tatarstan



“In our interconnected world and with the need for all to share the planet resources, it is essential for us to realize that the solutions for our problems require a consensus on a global code of conduct and ethic of human cooperation. As a member of the Independent Commission for International Humanitarian Issues and with representatives from twenty-eight nationalities, we presented the United Nations General Assembly in 1983 with a document entitled “Winning the Human Race?”, in which emphasis was made on multilateralism as a means to strengthen hope for a better future for all.

I have addressed the United Nations General Assembly in the past with the aim of shifting focus from state security to human security. In an intra-independent world security issues such as population growth, poverty, food, resources, ecology, migration, energy, peace and cultural understanding need to be addressed not just through the public and private sectors, but through engaging a third sector as well, the Commons, a powerful countervailing force dedicated to ensuring human security, cooperation, and sustainability across borders. The responsibility for such transnational issues must be taken on by individuals, communities, and civil society as well as international organizations, regional systems, and networks, to develop a common global action plan. The third sector exists in the interconnectedness of Global Commons – in the intersection of society and nature, education and employment.

The Coalition for Global Commons was launched in March 2008 in Berlin with a vision of an intra-regional citizens’ conferencing so that conversations would not just be held between the intelligent few but rather be developed through collective knowledge and collective wisdom. In this context I would like to say that it is essential for us today to develop collective intelligence to enable our region, that is to say the West Asia region, and our neighbouring regions, South Asia and indeed Southeast Asia, to develop an Asian response to the systemic development of science and technology on the one hand, and research and development on the other.

Educating for life is an essential answer to educating for employment, and in this regard emphasis should be made on the importance of supra-national thinking, that is to say teaching by analogy – an approach of the Erasmus Mundus programme – where we place the rich in the shoes of the poor, and where we think of our neighbours' resources in the context of a regional call for a supra-national community of water and energy for the benefit of humanity. This is how Europe spoke of building bridges after two devastating world wars, with a community of Coal and Steel.

In an attempt to address environmental issues and climate change, in particular the ILO-initiated the “Green Jobs Initiative” to emphasise the importance of a green foundation. Important for that issue is Paul Volcker's emphasis on an asymmetric approach, that is, not only looking at investment per se as a yardstick of development, but looking at the importance of investment in human capital. Climate change is accelerating due to human activity, affecting all life on earth. It is with this in mind that I express my belief in the intersection of society and nature and the importance of speaking of global warming in the context of human warning as a form of exercising our responsibility towards the other, whether society or nature.

The human dignity deficit is widening by the day, and not least is the gap between the rich and poor. Yet when examining the impact of globalisation, it is not only good economic governance that is to be addressed, but the importance of making the law work for everyone as well, that is to say empowering the poor. It is important to say that legal empowerment is the eradication of legal illiteracy in order to protect the poor and enable them to advance their interests as citizens.

I do want to emphasise that we are seeking not science as a franchise from the rich to the poor, but science as a partnership in developing our own resources where we have failed and where we have succeeded. Only through this broad conversation, promoting the noble art of listening, can we overcome the fragile confrontation of cultures where we speak of Islam and the West or Islam and the rest.

In terms of our Islamic humanistic approach, it is essential to develop a democracy of doers and to move from the intelligent few to the intelligent many. In this context it is essential to develop collective intelligence in the many disciplines that are affecting us through attempting to close the human dignity deficit and emphasizing that economy means developing the grassroots capabilities of participation by future generations.

It is essential to create a basis for a culture of peace within a context of just law, and although some may say that law does not address the poor, it is essential to emphasise that the time has come to live up to international standards and international criteria of accreditation and of dissemination of knowledge in the context of an interconnected world. The time has come to interconnect our objectives in promoting science as a template for progress.

I shall not address science as a mere objective, conceptual image of reality divorced from its cultural context, but rather as the essence of this great cultural movement which we normally call modernity, which has by no means spent itself despite post-modernism.”

**LETTER FROM DR. ARIF ALVI
PRESIDENT OF THE ISLAMIC REPUBLIC OF PAKISTAN**

*On the occasion of the 24th IAS Conference on
Challenges to Promote Science and Technology for Socio-Economic Development in OIC Countries
that was held in Karachi, Pakistan, during 7-8 March 2023*

بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِیْمِ



PRESIDENT
Islamic Republic of Pakistan

23 May 2023

Excellency,

Kindly accept my profound appreciation on the successful conclusion of the twenty fourth scientific conference of the Islamic World Academy of Sciences (IWAS), which was held in Karachi, from 7-8 March 2023.

The smooth holding of this scientifically engaging and enriching conference speaks volumes of your leadership of the prestigious institution of IWAS. We are honoured to be part of this conference which reflects our common aspiration for sustainable development and inclusive growth. Pakistan has always played an instrumental role for the prosperity and progress of all OIC countries.

I avail myself of this opportunity to extend my sincere wishes for your personal well-being, and for the continued peace and prosperity of all the OIC countries.

Please accept, Excellency, the assurances of my highest consideration.

(Dr. Arif Alvi)

His Excellency Prof. Adnan ~~Bashir~~ Badran
President, Islamic World Academy of Sciences
Amman



Embassy of Pakistan

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No. Pol-8/2022

The Embassy of the Islamic Republic of Pakistan in Amman presents its compliments to the Islamic World Academy of Sciences in Amman and has the honour to enclose a letter, in original, by His Excellency Dr. Arif Alvi, President of the Islamic Republic of Pakistan addressed to His Excellency Prof. Adnan Badran, President, Islamic World Academy of Science, on the successful conclusion of the 24th Scientific Conference of the Islamic World Academy of Science, which was held in Karachi from 7-8 March, 2023.

The Embassy of the Islamic Republic of Pakistan in Amman avails itself of this opportunity to renew to the Islamic World Academy of Sciences in Amman the assurances of its highest consideration.

Encl: As above.

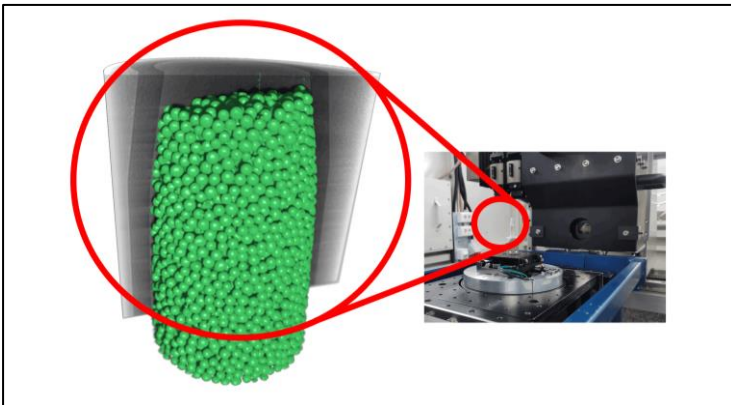
Amman, 25 June 2023

Islamic World Academy of Sciences,
Amman.

BEATS, SESAME'S FIFTH BEAMLINE SEES LIGHT AND EXPANDS THE CENTRE'S SCIENTIFIC CAPABILITY

SESAME is glad to announce that on Thursday, 11th May 2023, at 16:48, a group of its engineers and scientists successfully delivered the first X-ray photon beam to the experimental station of the BEATS (BEAMline for Tomography at SESAME) beamline. During the experiment, more than 1000 X-ray radiographic images of a rotating test sample were obtained in only 12 seconds by one of the beamline detectors. The data was collected and reconstructed by the high-performance computing facility specifically designed for the beamline and installed at SESAME in 2022, thus allowing the generation of a 3D image of the object.

The BEATS beamline will provide full-field X-ray radiography and tomography: two powerful and non-destructive techniques for 3D imaging and analysis of a large variety of objects and materials. With its non-destructive approach, this new beamline will deliver virtual volume images that are particularly important for the Cultural Heritage and Archaeological communities. The characterization of the 3D internal microstructure offered by tomography, is also of paramount importance for an exhaustive understanding of other materials, objects, and organisms. The BEATS beamline may be used in a large range of scientific and technological applications ranging from medicine, biology, engineering, and materials science to earth and planetary sciences, thus representing a key asset for researchers in the SESAME region.



© SESAME 2023: Phase contrast reconstruction generated by combining 1000 projections of 12 ms exposure time each (right) of a vial of glass spheres 300 μm in diameter positioned in front of the detector on the sample stage (left) for the first test of the BEATS beamline at SESAME.

The layout of the SESAME BEATS beamline was inspired by the tomography beamline at the Swiss Light Source (SLS) and is fully optimized for absorption and phase contrast

imaging. Particular attention was given to preserving the coherence of the X-rays. The X-ray source is a 3T 3-pole wiggler, which significantly increases the photon flux at X-ray energies up to 80 keV, necessary for the investigation of a broad variety of materials and samples.

“We were euphoric observing the first 3D images of BEATS only a few minutes after starting our tests [...]” said the BEATS beamline scientist, Gianluca Iori. *“It was the realization of four years of hard work, which made everyone at SESAME extremely proud.”*

The beamline was designed and built thanks to a European project that brought together leading research facilities in the Middle East (SESAME and The Cyprus Institute), and European synchrotron radiation facilities: ALBA-CELLS (Spain), DESY (Germany), Elettra (Italy), the ESRF (France), INFN (Italy), PSI (Switzerland) and SOLARIS (Poland). The initiative has been funded by the European Union's Horizon 2020 research and innovation programme. The project was coordinated by the ESRF.

© SESAME 2023: Members of the BEATS project team of SESAME in the experimental hutch of the beamline.

The first opportunity to submit a proposal to use the BEATS beamline will be in September 2023. BEATS project has received funding from the EU's H2020 framework programme for research and innovation under grant agreement n°822535.

* Source: <https://www.sesame.org.jo/news/beats-sesames-fifth-beamline-sees-light-and-expands-centres-scientific-capability>



THE EVOLUTION OF DIGITAL LEARNING

Joelle Mesmar¹, Adnan Badran² and Elias Baydoun³



According to UNESCO, “education is a global public good with the power to transform individual lives, communities and the planet for the better over generations”. It is an activity that aims to transmit knowledge, foster skills, and build character. Largely, it is the key to society’s growth and advancement. In fact, understanding the past is very important in enabling us to realize how we got here. Grasping the triumphs and failures, recognizing the good and the bad, and learning from past practices will help us move forward, plan where we are going next, and drive that change.

Education originated as a process of enculturation, which is the transmission of intangible cultural heritage from one generation to the next. It encompasses the norms and values of the people making-up a community and knowledge of their civilization for the purpose of perpetuation. It was simply based on transmitting knowledge from the mentor to the learner. In the earliest societies, storytelling was used to transmit information from one person to another and to be passed down for generations. As societies grew into complex structures, forming civilizations, the transmission of cultural values, knowledge and skills became more complex, and the outcome was formal education. Before the emergence of schools, education used to be carried out through community and faith-based groups. The earliest civilizations used religion as a means to exhibit social and cultural influences and disseminate knowledge. Particularly, formal education was controlled and carried out by priests for the purpose of training future priests and scribes. For example, in the highly developed ancient Egyptian and Mesopotamian civilizations, the “scribal mastery of writing and arithmetic provided access to high offices bringing power and social position”. It focused on religion, reading and writing, in

addition to some knowledge of mathematics, science, medicine, astrology, law, and architecture. In the Middle East, institutions of higher education were local religious schools known as “madrassa”, such as the Ez-Zitouna University in Tunisia, which is the first Islamic university in the world and is still operating today, the University of Al-Qarawiyyin in Morocco, and the Al-Azhar University in Egypt. In Europe, the spread of Christianity led to the establishment of monastic schools and cathedral schools as institutions of higher education to enhance spiritual learning. These also played an important role in the preservation and progress of science throughout the Middle Ages.

Largely during the course of civilizations, formal education gradually shifted from religious-based studies regulated by religious leaders and the elite to focus on skills, agricultural practices, and vocational training, while maintaining the conservation of values, and control of cultural deviances. Indeed, this knowledge fostered social progress and development up until the industrial revolution. Since then, massive efforts in education, science, and technology have been contributing to the development of knowledge, societies, and economies.

Intrinsically, the purpose of education is much more than simply acquiring, enhancing, and transmitting basic knowledge. Students have always been viewed as an investment that improves their own lives and also benefits their society, economy, and country. The knowledge they acquire through education is at the core of social and economic development. Accordingly, the functions of education are continuously changing to meet the needs of society. Since the industrial revolution, education has played a major role in the development of society and the country. In fact, with each industrial revolution there has been an educational revolution, causing inevitable transformations to higher education.

In modern history, an industrial revolution is a process that marked the shift from an agrarian and handicraft economy to a manufacturing economy.

Consequently, four revolutions have been identified, each powered by innovations and technologies that transform society and make an impact on people’s daily lives. The First Industrial Revolution (Industry 1.0 or 1IR), which began in the late 18th century, was about mechanical

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production driven by the use of steam and waterpower, or the shift from manual labor to machines and efficient forms of manufacturing, paving the way for mass production. The Second Industrial Revolution (Industry 2.0 or 2IR), known as the “Technological Revolution”, was based in the mid-19th century, and attributed to additional manufacturing technologies making use of electricity.

The first two industrial revolutions were marked first by a change in higher education followed by massive expansion of both public and private investment in order to meet the rapid expansion of the economy and manufacturing. As such, higher education became accessible to all and focused on scientific and technical education. This was accompanied by a commitment to research as shown by increased funding and investments for university scientists. The Third Industrial Revolution (Industry 3.0 or 3IR), referred to as the “Digital Revolution” was initiated in the late 20th century and was characterized by the development of computers, the internet, and interconnectivity. This was accompanied by an even greater access to higher education, showcasing greater diversity, enhanced academic research, the integration of ICT technologies into education, and the emergence of online courses. Finally, the Fourth Industrial Revolution (Industry 4.0 or 4IR) is a direct consequence of 3IR and is about automation and the integration of advanced technologies (artificial intelligence, the Internet of Things, robotics, nanotechnologies) resulting in the fusion of the physical, biological, and digital worlds. The basis of 4IR is a knowledge economy in which the individual is the major driver of economic growth. For a country to participate in a knowledge-based economy, the World Bank draws attention to four essential pillars, the first being “education and training”, which requires a skilled labor force that is educated and continuously learning skills to apply their knowledge efficiently and foster innovation. This places the human intellect at the center of economic growth and advancement. In parallel with knowledge, there is the technology element, which is the essence of the second pillar, an “information infrastructure” for the purpose of facilitating effective communication and interaction, as well as the processing of information and its dissemination. The remaining two pillars relate to innovation systems and the provision of favorable economic and institutional environments that promote a sustainable and open education system.

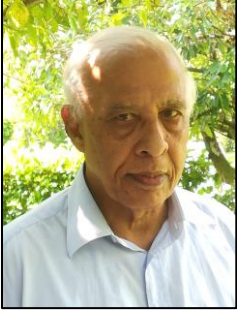
In fact, education has been going through its own revolutions, having evolved from Education 1.0 to Education 4.0, and having undergone reforms throughout to meet the needs of the industrial revolutions and equip students with the skills needed to enter the labor market. Concisely, Education 1.0 was a form of memorative learning that is teacher-centered with the student depicted as a passive recipient of information. Then technology began to infiltrate education at the beginning of the new millennium, marking the start of Education 2.0, and characterized by enhanced communication and collaboration. Education 3.0 has an even more connectivist approach and a richer interactive network thanks to the widespread adoption of the internet.

It recognizes the unique and personalized needs of the learners by networking and having access to wide range of knowledge and information resources that is no longer limited to communication between teacher and student. Education 4.0 is the current state of education that has emerged from the technological advancement of 4IR. It aims to transform education into a learning approach or technique that exploits the potential of digital technologies and produces a labor force that is proactive and innovative, characteristic of a knowledge society. These technologies, which include artificial intelligence, robotics, and smart systems, among others, have become an integral part of all industries. Moreover, in order to produce relevant and successful graduates, the learning process has to incorporate technology, and higher education must respond urgently in order to meet the advances of modern professions and produce graduates that are innovative, creative, and can take on challenges.

The pandemic has provided a window of opportunity to test some of the elements of Education 4.0 by adopting the use of technology in learning. It has also provided an opportunity to re-think and re-imagine a higher education system for the purpose of inducing the necessary change and focusing on job training as opposed to educating. The future of higher education is one that is based on connectedness and collaboration that is not limited to a typical classroom or a physical space and time. Learning can happen anywhere, anytime and in a way that encourages communication and teamwork with the help of technology. The role of the educator is to empower students and unleash their creativity and innovation. Higher education should ride the wave of the digital era and embrace digital learning.

PRODUCTION OF HEAVY ELEMENTS THROUGH THE R-PROCESS IN THE UNIVERSE

Muhammad Asghar* FLAS



Abstract: This text takes up the rapid neutron capture r-process to produce heavy elements, where the needed high free neutron density of around 10^{24} neutrons / cm^3 is provided by a two neutron stars merger leading to a black hole through the emission of

gravitational waves.

1. Processes of elemental production.

The elements up to Iron are produced through nuclear fusion in the stars. Beyond Iron, the energetics of the process does not allow the production of heavier elements. These heavier elements have to be produced through successive neutron captures starting with Iron, and the process which is responsible for the production of about half of the heavy elements, is called the rapid neutron capture process or the r-process of nucleosynthesis. The r-process is expected to happen in the presence of very high free neutron density of around 10^{24} neutrons / cm^3 (1) compared to about 10^{22} neutrons / cm^3 in a nuclear bomb explosion. Over the years, there have been different types of speculations on as to how and where, in the universe, this high neutron density may be produced, but without any substantial confirmation. Now, it seems that at least the merger of two neutron stars resulting in a black hole, does produce this high neutron density.

The evidence comes from the work on the detection of gravitational waves with the LIGO and Virgo interferometers installed in USA and Italy. On 17 August 2017, they detected the gravitational waves due to the merger of two neutron stars into a black hole and named it, the GW170817 event. At the same time, the astronomers with telescopes including the Very

Large Telescope in Chile observed the afterglow (light) of the *kilonova explosion* provoked by the merger of two neutron stars. This light was attributed to the radioactive decay of heavy elements produced through the r-process. In fact, the heavy element strontium has been identified through its spectral line present in the afterglow (2). It is certain that the neutron-star collisions produce the other r-process elements such as europium, silver, and gold. Furthermore, the authors of (3) claim that binary neutron mergers are the main source of elements in environments with low level of heavy elements such as the Milky Way halo, dwarf galaxies and the early universe. Moreover, they suggest that their contribution may be valid for all levels everywhere in the universe. As to the location of the r-process, it is believed to operate close to the neutron drip line and is fixed by the ratio of the beta-decay half-lives and the neutron capture rate (4).

2. Conclusions.

It is well established that the merger of two neutron stars produces a kilonova explosion that results in the production of a high neutron density needed to produce the heavy elements through the r-process. Moreover, this work confirms that neutron stars are, indeed, made of neutron-rich matter.

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ISLAMIC WORLD ACADEMY OF SCIENCES: ROLE IN HIGHER EDUCATION, SCIENCE & TECHNOLOGY

Zabta Shinwari
Vice President, Islamic World Academy of Sciences

The Academy of Sciences plays a crucial role in promoting critical thinking in higher education and advancing science and technology. As a prestigious and influential institution, it has the responsibility of setting high standards for research and education, promoting scientific inquiry, and advocating for evidence-based policies.

In higher education, the Academy of Sciences serves as a leading authority in promoting critical thinking and scientific rigor. It provides guidance on best practices for teaching and learning, encourages interdisciplinary research collaborations, and fosters a culture of open-mindedness and intellectual curiosity. Through its academic publications, conferences, and other outreach activities, the Academy of Sciences helps to disseminate new scientific discoveries and ideas to a broad audience.

Moreover, the Academy of Sciences plays a significant role in advancing science and technology by providing funding for research, supporting innovation and technology transfer, and promoting science-based policy-making. By engaging with policymakers, industry leaders, and the public, the Academy of Sciences helps to ensure that scientific research is directed towards addressing the most pressing societal challenges, such as climate change, disease prevention, and economic development.

In summary, the Academy of Sciences is a critical institution in promoting critical thinking in higher education and advancing science and technology. Its role is vital in shaping the future of science and technology by supporting scientific inquiry, disseminating knowledge, and advocating for evidence-based policies.

The Islamic Academy of Sciences can contribute to producing critical thinkers by emphasizing the

importance of critical thinking skills in their educational programs. This can be achieved through the following measures:

1) Encouraging a culture of questioning: The Fellows of the Academy should encourage students in their respective spheres to ask questions and challenge assumptions. This can be done by providing opportunities for students to engage in debates, discussions, and critical analysis of texts and ideas.

2) Focusing on problem-solving skills: The fellows can focus on developing problem-solving skills in their students. This can be done by providing opportunities for students to work on real-world problems, engage in research projects, and develop solutions to complex issues.

3) Promoting interdisciplinary learning: The fellows from different countries can work together to promote interdisciplinary learning by exposing their students to a wide range of subjects and encouraging them to make connections between different fields of study. This can help students develop a broader perspective and critical thinking skills.

4) Encouraging independent thinking: The fellows of the academy can encourage independent thinking by providing students with the freedom to explore and express their ideas without fear of judgment. This can be done by creating a supportive environment where students feel safe to express their opinions and ideas.

5) Emphasizing the importance of ethics: The Academy can emphasize the importance of ethics in science and technology by providing students with a strong foundation in ethical principles and encouraging them to consider the ethical implications of their work. This can help students develop a critical perspective on the role of science and technology in society.

By incorporating these measures into their educational programs, the Islamic Academy of Sciences can help produce critical thinkers who are able to think independently, creatively, and critically, rather than just producing graduates who are skilled in specific fields like medicine and engineering.

**REPORT OF THE INTERNATIONAL
SCIENCE COUNCIL ASIA PACIFIC
MEMBERS MEETING (26th APRIL, 2023)**
Zabta Shinwari
*Vice President, Islamic World Academy of
Sciences*

Prof. Zabta Shinwari, Vice President, IAS had been nominated by Prof. Adnan Badran, President, IAS, to attend the inaugural **International Science Council Asia Pacific Members Meeting** to introduce the newly established ISC Regional Focal Point for the Asia Pacific (RFP-AP) on **Wednesday 26 April 2023** online on behalf of the Islamic World Academy of Sciences (IAS).

Below is the report submitted by Prof. Shinwari regarding the said meeting.

“There were 46 participants of different organizations, thanks to the President for nominating me to participate on behalf of IAS. The issues discussed were:

- Reflecting on the ISC [Global Commission on Science Missions for Sustainability](#), What do you feel are the critical science missions for the AP region (Food, Water, Health & Wellbeing, Urban Areas, Energy& Climate).
- What are the key capacity building needs to support these missions? (e.g., improved science systems, transdisciplinary research practice, science to policy translation, science communication, increasing gender and ethnic diversity).
- What do you feel is a critical role (what should we be doing) for the AP RFP to play in relation to promoting AP priorities and ensuring AP region benefits and is actively engaged in ISC global agenda/strategy building? (e.g., expand membership, gather expertise, engage in global sustainability efforts, promote regional expertise at global fora, hold regional meetings and workshops).

I had added and recommended a few new points to the discussions as follows:

The ISC [Global Commission on Science Missions for Sustainability](#):

- Climate modeling and prediction: Accurate climate modeling and prediction is critical for understanding the potential impacts of climate change and developing effective mitigation and adaptation strategies.
- Renewable energy research: Developing and improving renewable energy technologies is essential for transitioning away from fossil fuels and reducing greenhouse gas emissions.
- Sustainable agriculture: Developing sustainable agricultural practices and technologies is necessary for feeding a growing global population while minimizing environmental damage.
- Biodiversity conservation: Protecting and preserving biodiversity is essential for maintaining healthy ecosystems and ensuring the long-term sustainability of the planet.
- Circular economy: Moving towards a circular economy, where waste is minimized and resources are reused and recycled, is critical for reducing resource depletion and waste generation.
- These are just a few examples of the critical science missions for sustainability that are currently being pursued. There are many other areas of research and innovation that are also essential for achieving a sustainable future.

Key capacity building needs to support these missions? (e.g., improved science systems, transdisciplinary research practice, science to policy translation, science communication, increasing gender and ethnic diversity):

- Open Science and role of academies.
- Science Communication, infodemics and Academia.
- Assisting OIC countries to establish Science Academies.
- Science diplomacy; displaced and refugee scientists.

- SDGs: [Strengthening contributions from academia](#).
- On achieving Equality, Diversity and Inclusion (EDI): challenging Islamophobia across higher education.

What do you feel is a critical role (what should we be doing) for the AP RFP to play in relation to promoting AP priorities and ensuring AP region benefits and is actively engaged in ISC global agenda/strategy building? (e.g., expand membership, gather expertise, engage in global sustainability efforts, promote regional expertise at global fora, hold regional meetings and workshops). Here are some suggestions:

- Collaboration and networking: Collaboration and networking with other researchers and organizations, both locally and globally, is critical for staying up-to-date on the latest science priorities and strategies, and for ensuring that your region is engaged in relevant discussions.
- Advocacy and policy engagement: Advocating for science priorities and engaging with policymakers at the local, regional, and national levels can help ensure that science is seen as a priority and that funding and resources are allocated accordingly.
- Science communication and public engagement: Communicating the importance and relevance of science to the public can help build support for science priorities and ensure that the broader community is engaged in relevant discussions.
- Capacity building and training: Investing in science education, training, and capacity building can help ensure that the next generation of scientists and researchers are equipped with the skills and knowledge they need to contribute to the global science agenda.
- Implementation and evaluation: Finally, implementing and evaluating science strategies and initiatives can help ensure that they are effective and impactful, and can provide feedback and insights for future science priorities and strategies.”

ABIOTENESIS: SPONTANEOUS GENERATION OF LIFE FROM NON-LIVING MATTER

Muhammad Asghar FLAS

Abstract: This document treats the Oparin and Haldane Primordial Soup Theory (PST) and discusses the historic Miller –Urey experiment as an effort through the PST, to explore the development of abiogenesis phenomenon.

1. Introduction

The way life originated on the Earth has always been fundamental in different philosophical, cultural, religious, and mythical contexts. The abiogenesis theory postulates that organic life results from a spontaneous development from non-living inorganic matter without intelligence or design. Historically, the abiogenesis theory was supported by the ancient Egyptians and the Greek philosophers. The Egyptians believed that the mud of the river Nile gave rise to frogs, snakes and even crocodiles, when exposed to the warmth of the Sun. The abiogenesis model of Aristotle (384 – 322 BCE) proposed that flies formed directly from the decaying material and logs gave rise to crocodiles.

2. Scientific development

a. Primordial Soup theory

In the 1920’s and 1930’s Alexander Oparin (1) and J. B. S. Haldane (2) proposed a chemical-based theory for the evolution of life that started around 3.5 billion years back on the 4.5 billion years old Earth. They suggested that the Earth’s early atmosphere consisted mostly of water, hydrogen sulfide, carbon dioxide or carbon monoxide and phosphate, but little oxygen and ozone. This implies that chemically the atmosphere was reducing and capable of accepting electrons to form new molecules. Under these primitive conditions, the effect of energy sources such as lightning, ultraviolet radiation or even the shock from an impact could form

organic molecules such as amino acids. This suggestion is known as the Oparin and Haldane Primordial Soup Theory (PST). The PST proposes that these molecules may have concentrated in certain locations like the thermal vents in the ocean or shorelines, where they underwent further transformation led to more complex molecules eventually resulting in life.

b. Miller-Urey experiment (3).

In 1952, the chemists Harold Urey and Stanley Miller designed an experimental set up (**Fig. 1**) with a view to reproduce the atmospheric conditions on the Earth as proposed by Oparin and Haldane for their PST.

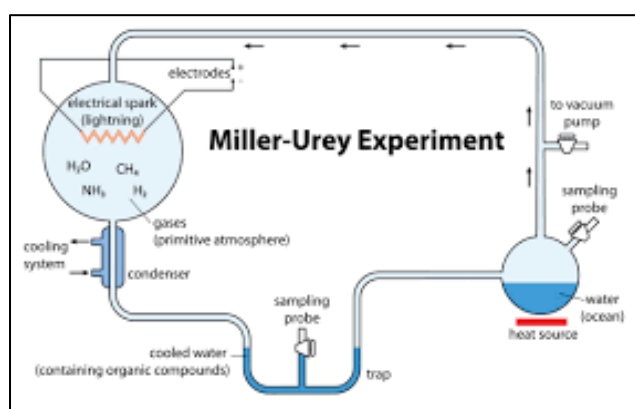


Fig. 1. Miller–Urey experimental set up for abiogenesis (Courtesy Wikipedia).

In this work, methane (CH_4), water (H_2O) ammonia (NH_3) and hydrogen were sealed together inside a sterile 5-liter glass flask connected to a 500 ml liter glass flask half full of water, Fig. 1. The water in the small flask was heated to induce evaporation and this water vapor was allowed to enter the large flask. A continuous electric spark was discharged between a pair of electrodes in the large flask. The spark passed through the mixture of *gases* and *water vapor* simulating lightning in the hypothesized primordial atmosphere of the Earth. Then, the apparatus was cooled to allow the water vapor to condense and trickle down to a U-shaped trap at the bottom. After the experiment, the needed treatment and analysis of the data led Miller to identify positively the formation of

5 amino acids, the building blocks of proteins and essential parts of any living organisms.

Miller died in 1907, and his preserved 1952 experiment samples were reanalyzed the following year using the latest chromatography methods revealing 25 compounds compared to 5 compounds that were reported in his original paper.

Miller had also performed additional experiments simulating conditions like those of a water-vapor-rich volcanic eruption, which involved spraying steam from a nozzle at the spark discharge. The original samples from those experiments were reanalyzed, too (**4**), and found this environment produced 22 amino acids, five amines, and several hydroxylated molecules. Hence, the original experiments were even more successful than Miller and Urey realized.

3. a. Conclusion

This text presents the Oparin and Haldane Primordial Soup Theory (PST) and treats the historic Miller – Urey experiment as an effort to explore through the PST, the development of abiogenesis phenomenon.

3. b. Point of caution

The amino acids need to combine to create more complex structures such as proteins and other compounds leading to the complex world of life. How, where and under which environmental conditions this should have happened leading to this organic life, is still mostly an unsolved problem (**5**).

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TOWARDS A NEW GENERATION OF COOLANTS & HEAT TRANSFER FLUIDS: NANOFLUIDS

Malik Maaşa^{1 2} FLAS



•In line with the current fast rising demand of our ICT driven society, and in search for more efficient coolants in nanoelectronics so to dissipate effectively the generated heat within as well as the heat

generated in the fast growing market of data storage centers, nanofluids are considered as a viable technology response [1-2]. Yet, initially investigated as a novel class of coolants for heat removal in nuclear reactors [3] and the automotive industry, nanofluids pioneered by Choi et al. [4] are being investigated extensively in addition to their potential applications in geothermal energy, biomedical sectors [5].

•In the automotive industry especially, and in the case of a standard car engine (Fig. 1), generally cooled by water, at each cycle, the cold water flowing from the radiator to the engine would remove a limited amount of heat from the hot engine. Because of the intrinsic low thermal conductivity of water, the usage of a nanofluid instead would remove a larger amount of heat at each cycle due to the nanofluid's enhanced thermal conductivity.

•As shown in Fig. 2(a), nanofluids are a form of molecular fluids consisting of a uniform dispersion of nanoparticles in a traditional coolant host fluid such as H₂O, oil or ethylene glycol (C₂H₆O₂) amongst others. Fig. 2(b) displays a comparison between the thermal conductivity of several organic materials, standard heat transfer fluids (water, ethylene glycol, mineral oil), metals and metal oxides. As one can notice, the thermal conductivity of standard heat transfer fluids is, inherently very weak; lower than $< 1 \text{ Wm}^{-1}\text{K}^{-1}$ at room temperature whilst that of metals and their corresponding oxides are 2–3 orders of magnitudes higher at least. Hence, the mixture of such metallic nanoparticles or their oxides in standard coolant host fluid in a form of a nano-suspension would induce a significant enhancement in the thermal conductivity of the nanofluid. While predicted and treated initially by Maxwell [6], such an enhancement has been theoretically quantified by Batchelor and O'Brien in 1977 [7] and Hamilton, Grosser et al., as early as 1962[8].

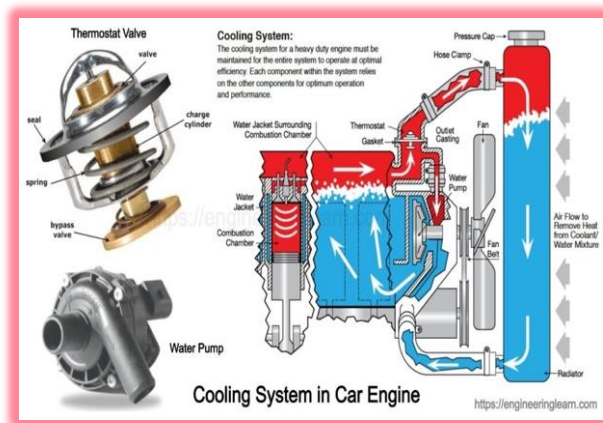


Fig. 1: Standard cooling system in car engine.

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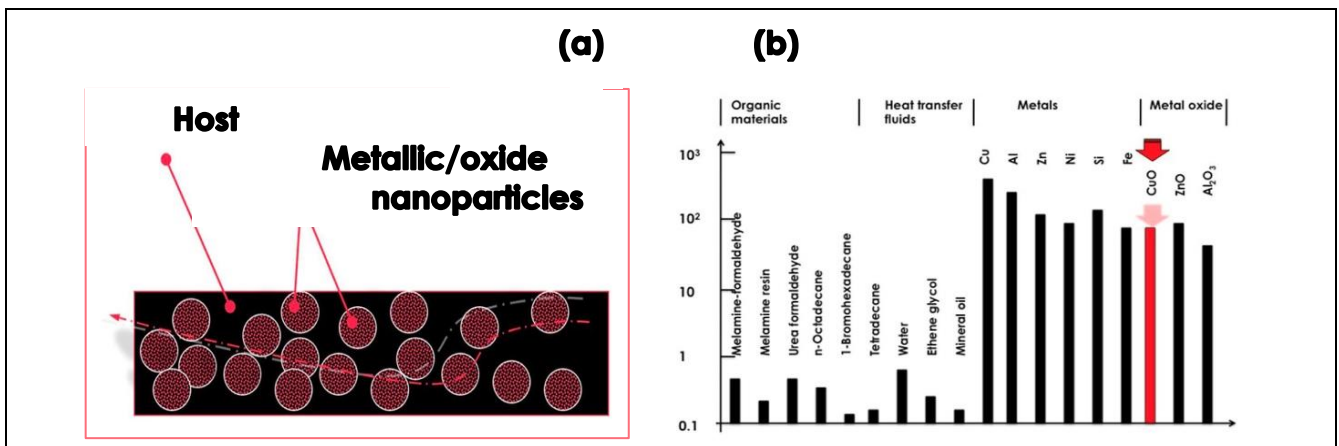


Fig. 2: (a) Nanofluid configuration, (b) Thermal conductivity of Organic materials, standard heat transfer fluids compared to that of metals & their oxides.

•Because the advances in nanosciences & nanotechnologies, such an enhancement of the thermal conductivity was confirmed experimentally in various nanofluids such as $\text{Al}_2\text{O}_3\text{-C}_2\text{H}_6\text{O}_2$, $\text{TiO}_2\text{-C}_2\text{H}_6\text{O}_2$, $\text{CNTs-C}_2\text{H}_6\text{O}_2$, $\text{CuO-H}_2\text{O}$, $\text{ZnO-H}_2\text{O}$, $\text{Ag-H}_2\text{O}$, $\text{CNTs-H}_2\text{O}$ [9]. This reproducible thermal conductivity enhancement was reported varying from 7 to 18% relatively to that of the host medium of $\text{C}_2\text{H}_6\text{O}_2$ or H_2O . Recently, 33% enhancement was reported in a multi-components nano-system of Ag or Au grafted Graphene/ $\text{C}_2\text{H}_6\text{O}_2$ based nanofluids [10-11].

•For the synthesis of stable nanofluids, two major approaches are followed so far; namely single and double steps approaches. While in the double steps approach, the nanoparticles are produced by various nanosynthesis physical or chemical methods and then dispersed in the host thermal host fluid with the possibly an additional surfactant molecular agent to minimize their agglomeration. Henceforth, preventing their Ostwald-ripening equivalent agglomeration. In the single step version, however, the nanoparticles are directly generated within the host fluid itself. The single step methodologies comprise the followings: (i) Evaporation, (ii) Microwave, (iii) Pulsed laser ablation in liquid solution, (iv) Electric arc-discharge, and (v) Sonochemistry.

Yet the subject of radiolysis is well established in radiochemistry and radiobiology, this contribution reports on & validates for the first time on the engineering of nanofluids using γ -radiolysis [12]. Fig. 3(a, b) summarizes the principle of such an approach in the case of a nanofluid of Ag nanoparticles in Ethylene Glycol (EG ; $\text{C}_2\text{H}_6\text{O}_2$).

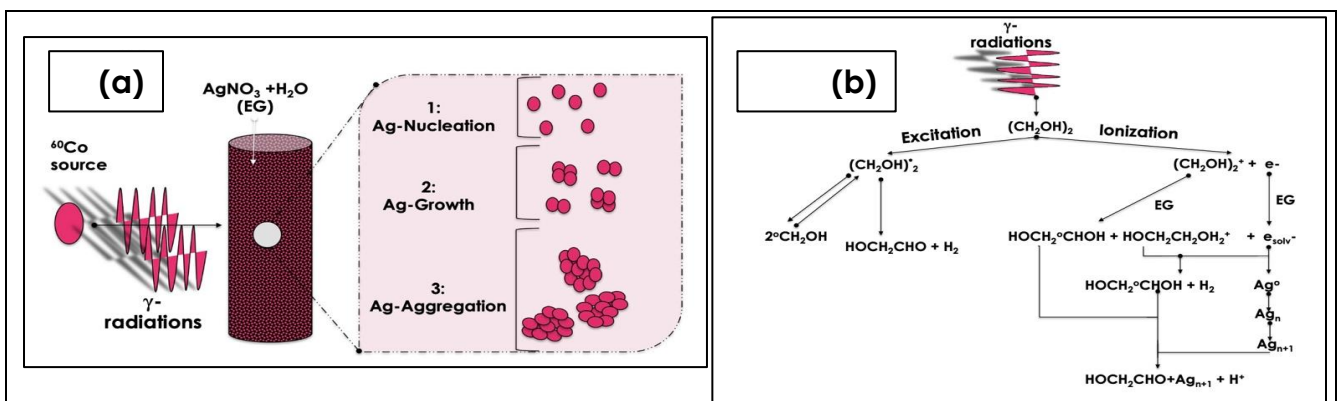


Fig. 3. (a) Principle of the formation of nanofluids with gamma radiolysis of Ag nanoparticles dispersed in $\text{C}_2\text{H}_6\text{O}_2$, (b) major scavenging intermediates species and chemical reactions involved in the mechanism of $\text{C}_2\text{H}_6\text{O}_2$ radiolysis and the formation of colloidal suspensions of nano-scaled Ag particles.

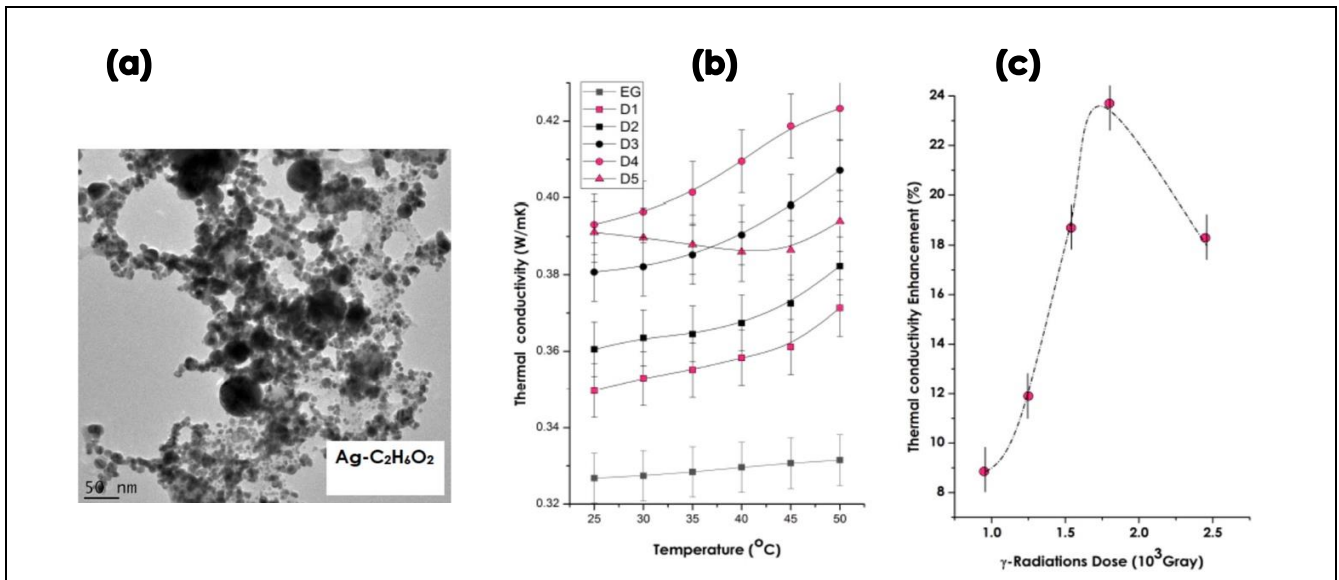


Fig. 4: (a) Transmission Electron Microscopy of a typical $\text{Ag-C}_2\text{H}_6\text{O}_2$ nanofluids by radiolysis, (b) Thermal conductivity of the various $\text{Ag-C}_2\text{H}_6\text{O}_2$ nanofluids radiolyzed at $D_1 = 0.95 \times 10^3$, $D_2 = 1.25 \times 10^3$, $D_3 = 1.54 \times 10^3$, $D_4 = 1.80 \times 10^3$ and $D_5 = 2.45 \times 10^3$ Gray, (c) average thermal conductivity (measured within the 25–50 °C range versus the γ -radiations dose).

Fig. 4.a, displays a typical Transmission Electron microscopy of an $\text{Ag-C}_2\text{H}_6\text{O}_2$ nanofluid by radiolysis. Fig. 7.b reports the thermal conductivity of the various $\text{Ag-C}_2\text{H}_6\text{O}_2$ nanofluids synthesized at various doses as well as the thermal conductivity of pure $\text{C}_2\text{H}_6\text{O}_2$ (as a reference) in the standard temperature range of 25 - 50°C. In general, and relatively to pure $\text{C}_2\text{H}_6\text{O}_2$, there is a net enhancement of the thermal conductivity of the various nanofluids relatively to pure $\text{C}_2\text{H}_6\text{O}_2$.

The average thermal conductivity within such a temperature range is 0.3581, 0.3684, 0.3906, 0.4071 and 0.3892 W/m K for the nanofluids radiolyzed at $D_1 = 0.95 \times 10^3$ Gray, $D_2 = 1.2 \times 10^3$ Gray, $D_3 = 1.54 \times 10^3$ Gray, $D_4 = 1.80 \times 10^3$ Gray and $D_5 = 2.45 \times 10^3$ Gray respectively. The measured average thermal conductivity of the host fluid i.e. $\text{C}_2\text{H}_6\text{O}_2$ is 0.3290 W/m K. Likewise, and excluding the $\text{Ag-C}_2\text{H}_6\text{O}_2$ nanofluid synthesized at the highest dose ($D_5 = 2.45 \times 10^3$ Gray), the thermal conductivity increases regularly with temperature in the considered limited temperature range of 25–50 °C. As summarized in Fig. 4.c, this translates into an increase of the relative average thermal conductivity η from 8.89%, 11.54%, 18.69%, 23.57% and 18.45% for $D_1 = 0.95 \times 10^3$ Gray, $D_2 = 1.2 \times 10^3$ Gray, $D_3 = 1.54 \times 10^3$ Gray, $D_4 = 1.80 \times 10^3$ Gray and $D_5 = 2.45 \times 10^3$ Gray respectively.

As a pre-conclusion, yet not optimized, the registered maximum of the enhancement of the thermal conductivity was as high as 23.57%. Hence, one can safely confirm that \square -radiolysis could be used to engineer nanofluids. The advantages of such a radiations based technology are various among which, (i) its cost effectiveness, (ii) fitting with mass production and hence upscaling, (iii) and for being a single step approach, [12]. With such a set of advantages, nanofluids by \square -radiolysis would respond to the expected demand as new generation of coolants of several industrial sectors including but not limited to (i) Heat transfer, heat removal and cooling applications, (ii) Automotive applications, (iv) Biomedical technologies, (v) Detergents, (vi) Ultra deep drilling, and (vii) Geothermal applications as well as (iii) Electronic applications and cooling of data storage centres. In this sector especially, it is expected that nanofluids would play a pivotal role. If one considers the US data centres' consumption in 2014-2016, the end use electricity usage consumption was 43% (Cooling & power provision systems), 43% (Servers), 11% (storage drives) & 3% (networks). Consequentially, several national policies are targeting to use the heat generated by data centers as a potential energy source for smart cities through a generalized usage of nanofluids as effective heat removal carriers as heat waste recovery. As per Fig. 5, some data centers use more electricity than entire countries.

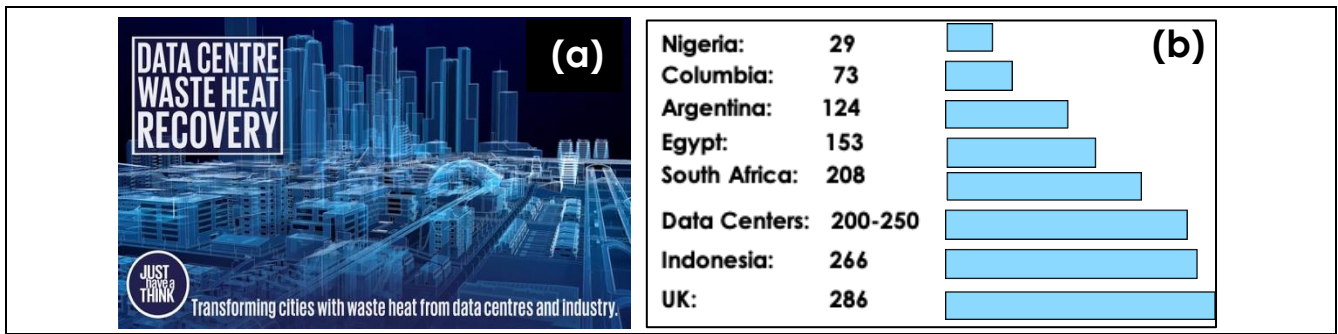
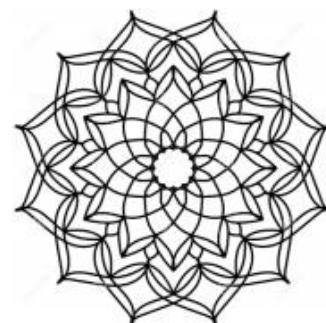


Fig. 5: (a) Potential recovery of heat generated by datacenters as a potential energy source for smart cities through a generalized usage of nanofluids, (b) Domestic electricity consumption of selected countries versus data centres in 2020 in TWb.

Conclusion: This contribution validated the possibility of engineering Ag-C₂H₆O₂ based nanofluids by γ -radiolysis. Such nanofluids exhibited a significant enhancement of their thermal conductivity which was found to be dose dependent. More precisely, In the case of Ag-C₂H₆O₂ nanofluids, the highest relative enhancement in the temperature range of 25 - 50°C was found to be ~23.57%.

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BLOCH'S THEOREM FOR PERIODIC SYSTEMS

Muhammad Asghar FLAS

Abstract: The document presents the Bloch's theorem for periodic systems and analyses its role in dealing with different types of periodic systems such as gapless conductors, semiconductors, and insulators with forbidden energy gaps, along with showing the equivalence between Laue's diffraction conditions and Bragg's law.

1. Bloch's theorem.

When treating the problems of structure in the condensed matter physics, the Bloch's theorem (1) is the solution of Schrodinger equation in a periodic potential is represented by a travelling plane wave $e^{ik \cdot r}$ modulated by a periodic function $u(r)$:

$$\psi(r) = e^{ik \cdot r} u(r), \quad (1)$$

where r is the position vector, the ψ , the wave function called the Bloch function or Bloch state, with the same period as the periodic medium such as a crystal, the wave vector $k = 2\pi / \lambda$, in the plain wave is the medium momentum vector.

2. Proof of the Bloch function, (2).

We consider a one-dimensional case of a periodic potential:

$V(x) = V(x+a)$ with a as the lattice's periodic constant,

and argue that the probability of finding the ψ of an electron at x as $|\psi(x)|^2$

must be the same at any indistinguishable position:

$$|\psi(x)|^2 = |\psi(x+a)|^2$$

This implies that

$$|\psi(x+a)| = C \cdot |\psi(x)|$$

Where C is a complex quantity such that $|C|^2 = 1$, which can be expressed as

$$C = \exp(i k \cdot a) \quad (2),$$

ensuring that $C^2 = \exp(i k \cdot a) \cdot \exp(-i k \cdot a) = 1$. The C 's real part is represented by "cosine" and the imaginary one by "sine"

Thus, we have

$$|\psi(x+a)| = \exp(i k \cdot a) |\psi(x)| \quad (3a)$$

Or

$$|\psi(x)| = \exp(-i k \cdot a) |\psi(x+a)| \quad (3b)$$

This relation is already a general form of Bloch's theorem, and we can get from it the form represented by relation (1):

Multiply the relation (3b) with $\exp(-i k \cdot x)$:

$$\exp(-i k \cdot x) |\psi(x)| = \exp(-i k \cdot x) \exp(-i k \cdot a) |\psi(x+a)| = \exp(-i k \cdot [x+a]) |\psi(x+a)|$$

This clearly shows that:

$$|\psi(x)| \cdot \exp(-i k \cdot x) = u(x),$$

where the $u(x)$ is a periodic function with the period of the lattice of the material leading to the Bloch's function (1) in one dimension:

$$|\psi(x)| = e^{ik \cdot x} u(x). \quad (4)$$

These Bloch states are written with the subscripts as ψ_{nk} , where n is a discrete index called the **band index** which is present because there are many different wavefunctions with the same k , but each of which has a different periodic function $u(x)$. Within a band for a fixed n , the ψ_{nk} varies continuously with $k = 2\pi / \lambda$, as the energy goes up. If one restricts the k to the first Brillouin zone, the Bloch state has a unique k . The first Brillouin zone is often used to depict all the Bloch states without redundancy for example in the band structure.

In physics, the reciprocal lattice represents the Fourier transform of the direct lattice which exists in real space as physical lattice such as the lattice of a crystal. The reciprocal lattice exists in the reciprocal space known as the momentum space or K -space, due to the relationship between the Pontryagin conjugate duals of momentum and position. Here the first Brillouin zone is a uniquely defined primitive cell in the reciprocal space. The Fig. 1a, shows the first Brillouin zones for the reciprocal lattices (dots) for a square lattice and a hexagonal lattice. Fig.1b, shows a two-dimensional crystal and its reciprocal lattice with the reciprocal vectors g_1 , g_2 and g_3 . The Brillouin zones are analyzed in terms of the Bloch states.

The real space and the reciprocal space are of the same dimensions but differ in units of length: for a real space of L units of length, the reciprocal space will have units of one divided by L , hence, L^{-1} (reciprocal length). If Δv is the volume in the real space and $\Delta^* v$, in the reciprocal space, then, $\Delta v \times \Delta^* v = 1$

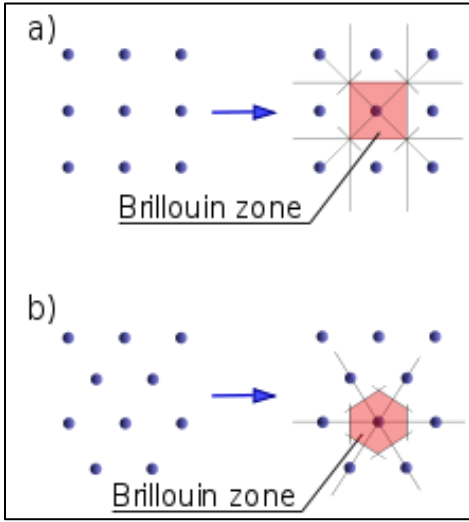


Fig. 1a, The reciprocal lattices (dots) and the

corresponding first Brillouin zones (a) of a square lattice and (b) of a hexagonal reciprocal lattice (3).

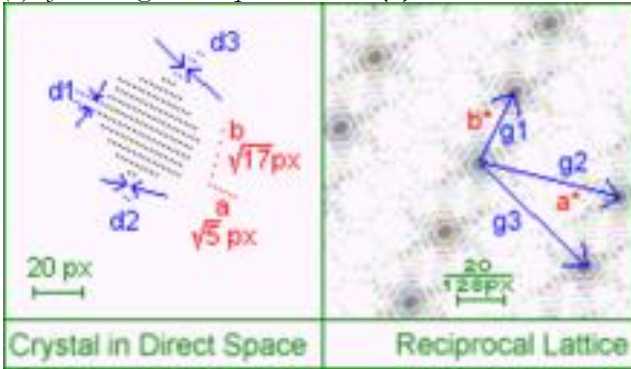


Fig. 1b, A two-dimensional crystal and its reciprocal lattice (3).

Fig. 2, Presents the Bloch functions $\psi(x)$ and their components separately for two values of k_1 and k_2 .

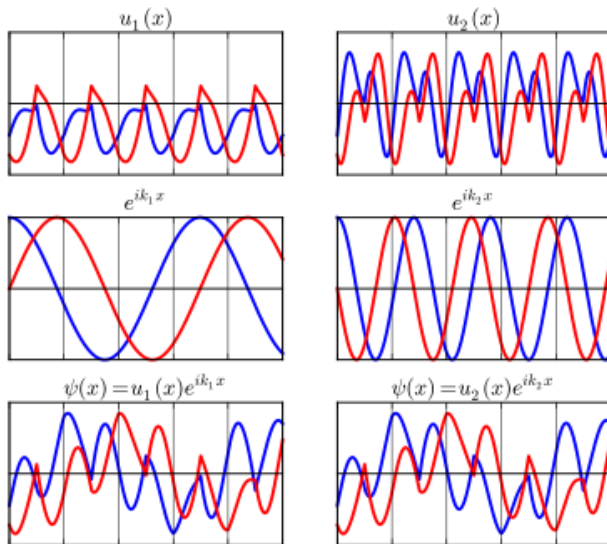


Fig. 2, A Bloch wave function $\psi(x)$ (bottom) can be broken up into the product of a periodic function (top) and a plane-wave (center). The left side and right side represent the same Bloch state broken up in two different ways, involving the

wavevector k_1 (left) or k_2 (right). The difference $\Delta k = (k_2 - k_1) = G$ is a [reciprocal lattice](#) vector. Moreover, two vectors that differ only by reciprocal lattice vector G along with their respective $u(x)$ functions, represent the same Bloch state as seen in the lowest fig. above. In all plots, blue is real part (cosine term) and red is the imaginary part (sine term), (3)

The experimental diffraction (elastic scattering) work on the physical periodic systems such as crystals carried out using x-rays and neutrons results in momentum-based reciprocal lattice structure through the **Laue conditions** for diffraction by a crystal lattice:

$$k_{\text{out}} - k_{\text{in}} = \Delta k = G \quad (5),$$

where the k_{in} are the incoming wavevector to the crystal lattice; k_{out} , the outgoing wavevector from the crystal lattice, and G , the reciprocal lattice wavevector for the crystal. Moreover, because of elastic scattering, $(k_{\text{out}})^2 = (k_{\text{in}})^2$ and the k_{in} and k_{out} wavevectors are in phase at the lattice scattering point. If the scattering satisfies this equation, all the crystal lattice points scatter the incoming wave towards the scattering direction along the k_{out} .

The experimental work done with diffractometers leads to the reciprocal lattice of the real crystal lattice. One transforms the reciprocal lattice structure into the physical lattice structure (the atomic arrangement) of the periodic system through a Fourier transform.

3. Relation between direct lattice and reciprocal lattice parameters.

1. The vector R of an atom at a lattice point in a direct lattice in terms of its primitive vectors a , b and c can be expressed as:

$$R = p a + q b + r c \quad (6),$$

where p , q and r , are integers.

Similarly, for the reciprocal lattice with the a' , b' , c' primitive vectors, the reciprocal vector G can be expressed as

$$G = p' a' + q' b' + r' c' \quad (7),$$

where p' , q' and r' are integers.

The primitive vectors of the direct lattice and the reciprocal lattice are related as:

$$\mathbf{a} \cdot \mathbf{a}' = \mathbf{b} \cdot \mathbf{b}' = \mathbf{c} \cdot \mathbf{c}' = 1 \quad (8),$$

because the primitive vectors \mathbf{a} and \mathbf{a}' , the \mathbf{b} and \mathbf{b}' and the \mathbf{c} and \mathbf{c}' are parallel to each other and their respective length units are proportional to L and $1/L$,

and

$$\mathbf{a} \cdot \mathbf{b}' = \mathbf{a} \cdot \mathbf{c}' = \mathbf{b} \cdot \mathbf{a}' = \mathbf{b} \cdot \mathbf{c}' = \mathbf{c} \cdot \mathbf{a}' = \mathbf{c} \cdot \mathbf{b}' = 0 \quad (9),$$

because the primitive vectors \mathbf{a} and \mathbf{b}' , ..., are perpendicular to each other.

Furthermore, the reciprocal lattice primitive vectors \mathbf{a}' , \mathbf{b}' , \mathbf{c}' are related to the direct lattice primitive vectors as:

$$\mathbf{a}' = \mathbf{b} \times \mathbf{c} / \mathbf{a} \cdot \mathbf{b} \times \mathbf{c}; \quad \mathbf{b}' = \mathbf{c} \times \mathbf{a} / \mathbf{a} \cdot \mathbf{b} \times \mathbf{c}; \quad \mathbf{c}' = \mathbf{a} \times \mathbf{b} / \mathbf{a} \cdot \mathbf{b} \times \mathbf{c}, \quad (10)$$

where the factor $(\mathbf{a} \cdot \mathbf{b} \times \mathbf{c})$ and its different permutations, represent the volume of the lattice. The relations (8) and (9) directly result from relation (10).

2. Mathematical description.

For a three-dimensional direct lattice (Bravais lattice), the vector \mathbf{R}_n can be expressed as:

$$\mathbf{R}_n = n_1 \mathbf{a} + n_2 \mathbf{b} + n_3 \mathbf{c} \quad (11)$$

Take a function $f(\mathbf{r})$, where \mathbf{r} is the position vector from $\mathbf{R}_n = 0$ to any position. If $f(\mathbf{r})$ follows the periodicity of the lattice, one can write $f(\mathbf{r})$ as a multidimensional Fourier series:

$$\sum_m f_m e^{i \mathbf{G}_m \cdot \mathbf{r}} = f(\mathbf{r}) \quad (12),$$

where \mathbf{G}_m is the reciprocal lattice vector and $m = (m_1, m_2, m_3)$ is the triple sum. As $f(\mathbf{r})$ follows the periodicity of the lattice, translating the vector \mathbf{r} by the lattice vector \mathbf{R}_n , one gets the same value, thus,

$$f(\mathbf{r} + \mathbf{R}_n) = f(\mathbf{r}). \quad (13)$$

Expressing this in terms of Fourier Series, one gets:

$$\sum_m f_m e^{i \mathbf{G}_m \cdot (\mathbf{r} + \mathbf{R}_n)} = \sum_m f_m e^{i \mathbf{G}_m \cdot \mathbf{R}_n} e^{i \mathbf{G}_m \cdot \mathbf{r}} = f(\mathbf{r}). \quad (14)$$

The equality of the two Fourier Series (12) and (14), implies the equality of their coefficients leading to:

$$e^{i \mathbf{G}_m \cdot \mathbf{R}_n} = 1 \quad (15)$$

or

$$\mathbf{G}_m \cdot \mathbf{R}_n = 2 \pi n \quad (16),$$

where n is an integer.

In this context, the relation $e^{i \mathbf{k} \cdot \mathbf{x}} = 1$, with $\mathbf{k} \cdot \mathbf{x} = 2 \pi n$

where like the relation (15), the \mathbf{k} is the reciprocal lattice vector and \mathbf{x} , the spatial lattice vector.

Also, $e^{i \mathbf{G} \cdot \mathbf{d}} = 1$

or $\mathbf{G} \cdot \mathbf{d} = 2 \pi n$,

where \mathbf{d} is the space between the planes of the periodic system.

4. Laue's reciprocal lattice and Bragg's law of diffraction (3)

Laue's diffraction conditions are equivalent to Bragg's law of diffraction. This can be shown through the relation (5) subject to the conditions:

$$\begin{aligned} |k_{out}| - |k_{in}| &= |G| \text{ and } |k_{in}|^2 = |k_{out}|^2; \\ |k_{in}| &= |k_{out}| - |G|, \\ |k_{in}|^2 &= (|k_{out}| - |G|)^2 = |k_{out}|^2 + |G|^2 - 2 |k_{out}| \cdot |G|, \\ 2 |k_{out}| \cdot |G| &= |G|^2. \end{aligned} \quad (17)$$

The relation (5) represents a plane wave parallel to the crystal plane called the Bragg's plane. Moreover, since the reciprocal lattice vector $|G|$ is normal to the crystal plane and the $|k_{out}|$ wavevector makes an outgoing angle θ with the crystal plane, the angle between $|G|$ and $|k_{out}|$ is $(\pi/2 - \theta)$ leading to $|k_{out}| |G| \sin\theta$. With $|k_{out}| = 2\pi/\lambda$, and $|G| = (2\pi n/d)$ from the relation $e^{i \mathbf{G} \cdot \mathbf{d}} = 1$ for a periodic system, where d is the distance between the crystal planes, and n , an integer, one gets the desired Bragg's law:

$$\begin{aligned} 2 |k_{out}| \cdot |G| &= |G|^2 \\ 2 |k_{out}| |G| \sin\theta &= |G|^2 \\ 2 (2\pi/\lambda) (2\pi n/d) \sin\theta &= (2\pi n/d)^2 \\ n\lambda &= 2 d \sin\theta \dots \text{Bragg's Law of diffraction} \end{aligned} \quad (18)$$

5. Forbidden energy gaps in periodic systems.

In nature there are different types of periodic systems: insulators with forbidden-energy gap of several eVs between the valence band and the conduction band, semiconductors with an eV or less gap and the conductors without any gap. In fact, the behavior of these different periodic systems is controlled by the different locations of their Fermi energy relative to the conduction

band: in the case of a conductor, the valence band with the Fermi energy level is present in the conduction band and there is no energy gap, while for a semiconductor and an insulator, the valence band with the Fermi energy is lower than the conduction band leading to a forbidden energy gap without the presence of any level for both of them. These gaps can be reproduced through the Bloch's function, for example, with the Kronig-Penney's model, (4), whose analysis leads to the relation:

$$\cos(k a) = \cos(\alpha a) + (mA/\hbar^2 \alpha) \sin(\alpha a) \quad (19),$$

with $\alpha^2 = 2m E_k / (\hbar^2)$, where the \hbar is Planck's reduced constant = $\hbar/2\pi$; E_k , the energy and a , the lattice constant.

This formula gives a relation between the wave number k and the energy E_k through α . Since the left-hand side of equation (6) can vary only from -1 to +1, there are limits on the values that α , hence, E_k , can take, and for some values of E_k , there is no solution to this equation and the system will not have those energies and the corresponding levels, leading to energy gaps between the valence band and the conduction band called band gaps, in semiconductors and insulators.

6. Conclusions.

This document presents the Bloch's theorem for periodic systems and discusses its role, when dealing with different types of periodic systems such as gapless conductors, semiconductors, and insulators with forbidden energy gaps, along with showing the equivalence of Laue conditions for diffraction and Bragg's law of diffraction.

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REPORT OF CAPITALIZING ON SYNERGIES IN SCIENCE 2023 MID-TERM MEETING OF ISC MEMBERS

10 - 12 MAY 2023, PARIS, FRANCE

Zabta Shinwari

*Vice President, Islamic World Academy of
Sciences*

Prof. Zabta Shinwari, Vice President, IAS had been nominated by Prof. Adnan Badran, President, IAS, to represent the IAS in the 2023 Mid-Term Meeting of ISC Members, herewith is his report of the meeting:



Part I:

Participated as a panelist in ISC-UNESCO Joint Event on Scientific Freedom on 9 May, 3 - 6 pm, Room IV, UNESCO. It was a well-attended meeting and has given exposure to the activities of IAS and a positive image of the academy in general.

Presented the following data:

1) The elements of scientific freedom:

- Scientific freedom refers to the ability of scientists to pursue their research and communicate their findings without undue interference from external forces. The right of scientists to share their findings with others and engage in open debate about their research. (ensuring the integrity of scientific research and for allowing others to replicate and build upon scientific discoveries).

- **Creating an enabling environment for scientific freedom:**

- Independent funding: free from political and ideological influence, promoting transparency
- Protection of researchers: Researchers & whistleblowers must be protected from harassment, intimidation,
- Open communication:
 - Ethical guidelines: Research is conducted with integrity and respect for human rights.
- Education and public awareness: teaching critical thinking skills and encouraging public engagement with science.
- International collaboration: break down barriers and promote a more collaborative and inclusive scientific community

2) The benefits of scientific freedom:

- a. The benefits of scientific freedom for society, such as innovation, progress, and advancements in science and technology
- b. Scientific freedom has led to significant discoveries and advancements in various fields

3) Challenges to scientific freedom:

- a. Censorship, political influence, and conflicts of interest and discrimination.

4) Solutions for promoting scientific freedom:

- a. Increased public engagement, advocacy for independent funding, and the creation of international networks and collaborations
- b. Provide examples of how these solutions have been successful in promoting scientific freedom in various contexts

5) Freedom with responsibility:

- Misleading reporting.
- Conflicts of interest.
- Lack of transparency.
- Gender Gap: editorial boards 14% for editors and 8% for editors-in-chief.
- Self-Publication.
- Multimillion-dollar trade in paper authorships.
- Predatory journals continue to be indexed by the likes of the Web of Science and Scopus – and some have [high impact factors](#).
- Global innovation and digital ethics

- ethical implications of technology and its impact on individuals, society, and the environment.

- Misrepresentation of research.
- Academic dishonesty.
- Pressure to publish:
 - Consequences of Breaching Publication Integrity.
 - Harm to public trust in science.

By promoting ethical research practices and holding those who engage in fraudulent practices accountable, the scientific community can maintain the integrity of the research process and build public trust in science.

6) Solutions to Ensure Responsibility:

- Develop and follow clear guidelines and standards for publication integrity.
- Encourage transparency in research and reporting.
- Create consequences for breaches of publication integrity.
- By promoting responsible innovation and ethical considerations in the development and use of technology, we can ensure that these innovations serve the common good and contribute to a better world for all.
- Strengthen regulations.
- Raise awareness:
- Collaboration.
- Quality assessment.
- Measuring societal impact: how to go beyond standard publication metrics.

The Bottom Lines:

- Science – our best bet to achieve the SDGs?
- Science and inequality: On achieving equality, diversity and inclusion (EDI): challenging phobia across higher education, S & T.
- The relevance of modern education, reallocation of sources, changing channels of communication, and the roles of ethics in academia.
- Bottom line: Let's resolve to encourage to take action to support scientific freedom

in our communities and beyond with integrity and responsibility.

Part II:

Promotion of IAS on Screen throughout the meeting with following messages:

Islamic World Academy of Sciences (IAS) Seeking collaboration with Members regarding:

- Capacity building young Researchers; Webinars on Current Issues; Grants for scientific research projects and Networking.

Priorities/Main areas of work:

- Science diplomacy (to address issues of Refugee scientists in Muslim world).
- Vaccine manufacturing capacity In Islamic world.
- Science Communication, infodemics and Academia.
- Assisting OIC countries to establish Science Academies.
- On achieving equality, diversity and inclusion (EDI): challenging Islamophobia across higher education.

Current opportunities for collaboration:

- The academy will encourage collaboration in producing a) Joint vaccine; Renewable Energy; Health and Medicine; Agriculture and Food Security; Artificial Intelligence.

Opportunities (call for prizes, nominations, events, etc.):

- The Academy is willing to offer prizes to recognize outstanding scientific achievements by its members.
- Events: The Academy could organize conferences, workshops, and other events to bring together its members and other scientists from around the world.
- Research Collaboration Opportunities: The Academy is open for joint research initiatives, exchange programs, and international partnerships.

Day 1: May 10, 2023:

Participated in discussions on:

- a) The present and future of ISC.

b) The evolution of Science in Global contest.

c) Science diplomacy and Science in time of crises (Emphasized on help to refugee scientists especially in Afghanistan, Rohingya, Palestine, and middle East).

Day 2: May 11, 2023:

i) Increasing Global impact of Science in for societal transformation towards sustainability.

ii) Training next generation of Scientists and empowering their voice in international Science.

iii) Constitutional revision of ISC towards Governance and election.

Day 3: May 12, 2023:

➤ The ISC and its affiliated bodies.

➤ The ISC fellowship program.



Side Meetings Opportunities with the Governing Board members to strengthen ties between IAS and ISC:

- Peter Gluckman, President (ISC); Motoko Kotani, Vice-President for Science and Society; Sawako Shirahase, Vice-President for Finance; Anne Husebekk, Vice-President for Freedom and Responsibility in Science; Salim Abdool Karim, Vice-President for Outreach and Engagement, ISC.

- Committee for Outreach and Engagement (COE): Jahnvi Phalkey.

- Committee for Freedom and Responsibility in Science (CFRS): Sayaka Oki.

- Regional Focal Point for Asia and the Pacific: Petra Lundgren.

IAS AND BUILDING BRIDGES SOCIETY SIGN A MEMORANDUM OF UNDERSTANDING

On behalf of the Islamic World Academy of Sciences (IAS), Dr. Adnan Badran, IAS President signed a Memorandum of Understanding (MOU) with the Building Bridges Society in Amman. The MOU is concerned with promoting continuous education and training courses to enhance capacity building of human resources in academic fields in the Islamic world and empowering women in all economic and developmental aspects throughout Jordan. The purpose of the Memorandum of Understanding is joint cooperation in establishing joint national action and unifying the efforts exerted to build capacities and economic and developmental empowerment of institutions in the public and private sectors and civil society in particular.



PROF. ZABTA SHINWARI FIAS SELECTED AS A MEMBER OF THE MULTIDISCIPLINARY AD HOC TECHNICAL EXPERT GROUP ON SYNTHETIC BIOLOGY (AHTEG)



The IAS is proud to announce that Prof. Zabta Shinwari FIAS has been selected as a member of the Multidisciplinary Ad Hoc Technical Expert Group on Synthetic Biology (AHTEG) established by the UN-CBD Conference of the Parties, a significant and critical initiative.

The selection committee and the organizers have recognized Prof. Shinwari's expertise and granted him the opportunity to be a part of the AHTEG and collaborate with esteemed professionals in the field of synthetic biology.

This platform provides a unique avenue to address the complex challenges and opportunities associated with synthetic biology and its implications for biodiversity.

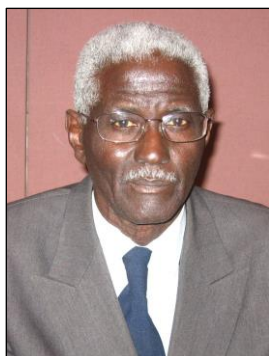
As a member of the AHTEG, Prof. Shinwari is committed to fulfilling his responsibilities diligently and actively participating in the group's activities.

Prof. Zabta said: *"I firmly believe that our collective efforts and expertise will help shape policies, guidelines, and recommendations that promote the sustainable development and responsible use of synthetic biology technologies.*

I am confident that this engagement will not only expand my knowledge, but also enable me to contribute significantly to the field. I look forward to engaging in meaningful discussions, sharing insights, and working together towards achieving the objectives outlined by the UN-CBD Conference of the Parties."

FELLOWS NO LONGER WITH US

THE LATE PROF. OUSSAYNOU FALL DIA (SENEGAL)



(1935 - 2020)

It is with a sense of sadness and sorrow that the President of the Islamic World Academy of Sciences (IAS) announces the passing away of the eminent scientist and IAS Fellow; **Prof. Oussaynou Fall Dia (Senegal)**, who was a renowned Geologist. He was the former Director of the Institute of Earth Sciences (IST), of the Ecole Polytechnique de Thiès (EPT), of Higher Education, former Head of the Geology Department of UCAD and member of the National Academy of Sciences and Technology of Senegal.



THE LATE PROF. ELДАР SALAYEV (AZERBAIJAN)



(1933 - 2022)

The IAS also announces the passing away of **Prof. Eldar Salayev (Azerbaijan)**, former President of the Azerbaijan National Academy of Sciences. Prof. Eldar Salayev was born in Nakhichevan, Azerbaijan in 1933.

He was awarded his Doctor of Physical and Mathematical Sciences degree from the Azerbaijan State University.

Prof. Salayev became the President of the Azerbaijan Academy of Sciences in 1983, and in 1997 became the Director of the Institute of Photo-electronics in Baku, Azerbaijan.

He was a noted scientist and specialist in the field of Experimental Physics, Physics and Techniques of Semiconductors, Quantum Electronics and non-linear optics. Prof. Salayev was one of the founders of a new scientific branch in physics and techniques of Semiconductors-Physics of limiting Anisotropic Crystals.

In appreciation of his remarkable contribution to scientific instrument making, he was awarded State Prize in 1972 and the Vavilov Prize for his achievements in the sphere of Physics of Semiconductors in 1982. He has made a valuable contribution in training highly skilled specialists and has supervised more than 40 doctors' theses. He has also trained a great number of scientists, working in many different countries of the world.

Prof. Salayev had more than 200 scientific works and has 86 inventions to his credit.

Prof. Salayev was elected to the Fellowship of the Islamic World Academy of Sciences in 1993.

ABU HAMID AL-GHAZALI* (1058-1111 AD)



Abu Hamid Ibn Muhammad Ibn Muhammad al-Tusi al-Shafi'i al-Ghazali was born in 1058 A.D. in Khorasan, Iran. His father died while he was still very young but he had the opportunity of getting education in the prevalent curriculum at Nishapur and Baghdad. Soon he acquired a high standard of scholarship in religion and philosophy and was honoured by his appointment as a Professor at the Nizamiyah University of Baghdad, which was recognised as one of the most reputed institutions of learning in the golden era of Muslim history.

After a few years, however, he gave up his academic pursuits and worldly interests and became a wandering ascetic. This was a process (period) of mystical transformation. Later, he resumed his teaching duties, but again left these. An era of solitary life, devoted to contemplation and writing then ensued, which led to the authorship of a number of everlasting books. He died in 1111 A.D. at Tus.

Ghazali's major contribution lies in religion, philosophy and sufism. A number of Muslim philosophers had been following and developing several viewpoints of Greek philosophy, including the Neoplatonic philosophy, and this was leading to conflict with several Islamic teachings. On the other hand, the movement of Sufism was assuming such excessive proportions as to avoid observance of obligatory prayers and duties of Islam. Based on his unquestionable scholarship and personal mystical experience, Ghazali sought to rectify these trends, both in philosophy and Sufism.

In philosophy, Ghazali upheld the approach of mathematics and exact sciences as essentially correct. However, he adopted the techniques of Aristotelian logic and the Neoplatonic procedures and employed these very tools to lay bare the flaws and lacunas of the then prevalent Neoplatonic philosophy and to diminish the negative influences of Aristotelianism and excessive rationalism. In contrast to some of the Muslim philosophers, e.g., Farabi, he portrayed the inability of reason to comprehend *the absolute* and *the infinite*. Reason could not transcend the finite and was limited to the observation of the relative. Also, several Muslim philosophers had held that the universe was finite in space but infinite in time. Ghazali argued that an infinite time was related to an infinite space. With his clarity of thought and force of argument, he was able to create a balance between religion and reason, and identified their respective spheres as being the infinite and the finite, respectively.

In religion, particularly mysticism, he cleansed the approach of Sufism of its excesses and reestablished the authority of the orthodox religion. Yet, he stressed the importance of genuine Sufism, which he maintained was the path to attain the absolute truth.

He was a prolific writer. His immortal books include *Tuhafut al-Falasifa* (The Incoherence of the Philosophers), *Ihya al-'Ulum al-Islamia* (The Revival of the Religious Sciences), "The Beginning of Guidance" and his "Autobiography", "Deliverance from Error." Some of his works were translated into European languages in the Middle Ages. He also wrote a summary of astronomy.

Ghazali's influence was deep and everlasting. He is one of the greatest theologians of Islam. His theological doctrines penetrated Europe, influenced Jewish and Christian Scholasticism and several of his arguments seem to have been adopted by St. Thomas Aquinas in order to similarly reestablish the authority of orthodox Christian religion in the West. So forceful was his argument in favour of religion that he was accused of damaging the cause of philosophy and, in Muslim Spain, Ibn Rushd (Averros) wrote a rejoinder to his *Tuhafut*.

* Source: *Personalities Noble*, 2nd Edition, 2000, Edited by Hakim Mohammed Said, Published by LAS with permission of Hamdard Foundation Pakistan.

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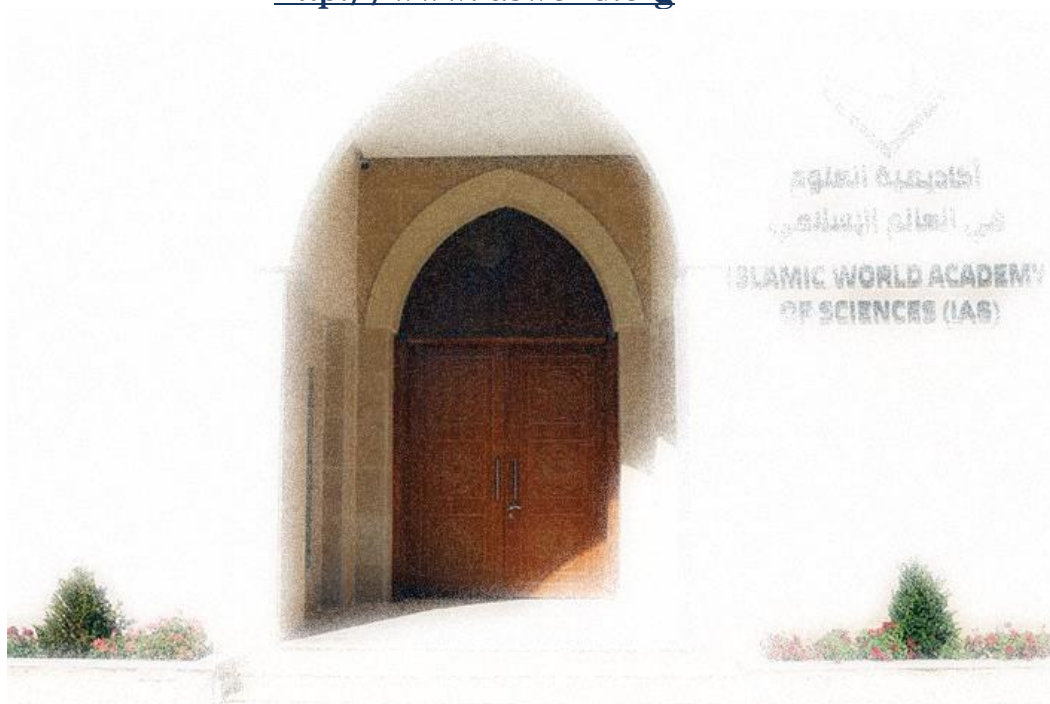
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