Online ISSN : 2249-4626
Print ISSN : 0975-5896
DOI : 10.17406/GJSFR

Global Journal

of Science Frontier Research: A

Physics and Space Science

Highlights

- Forced Heat Exchange
- Separate Anions and Cations
- Quenching Silver Probe
- Mechanisms of the Threshold Space

Discovering Thoughts, Inventing Future

VOLUME 20 ISSUE 9 VERSION 1.0

Global Journal of Science Frontier Research: A
Physics & Space Science

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Volume 20 Issue 9 (Ver. 1.0)

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Global Journal of Science Frontier Research

Contents of the Issue

Global Journal of Science Frontier Research: a
Physics and Space Science
Volume 20 Issue 9 Version 1.0 Year 2020
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

The Concept of Access and the Mechanisms of the Threshold Space in Arab Traditional Built Environment: The Case of Najd, Saudi Arabia

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Abstract- Contemporary built environments experience a vast number of factors due to globalization, which effected and influenced how the built form is generated and used. The relationship between the urban and the building levels is a crucial aspect that needs a thorough investigation to understand how these two levels can integrate and complement the built environment's overall identity. This paper examines the concept of access and its location within the urban fabric and how an access influenced the formation of physical and nonphysical threshold spaces to overcome the number of socio-cultural issues. Space Syntax convex map and justified access graphs were used to understand the connectivity, density, and integration of the access and the threshold space in relation to the overall built form.

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GJSFR-A Classification: FOR Code: 249999

Strictly as per the compliance and regulations of:

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Mohammed Mashary Alnaim

Abstract- **Contemporary built environments experience a vast number of factors due to globalization, which effected and influenced how the built form is generated and used. The relationship between the urban and the building levels is a crucial aspect that needs a thorough investigation to understand how these two levels can integrate and complement the built environment's overall identity. This paper examines the concept of access and its location within the urban fabric and how an access influenced the formation of physical and nonphysical threshold spaces to overcome the number of socio-cultural issues. Space Syntax convex map and justified access graphs were used to understand the connectivity, density, and integration of the access and the threshold space in relation to the overall built form.**

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I. Introduction

The access (house entrance) in the traditional Najdi built environment influenced and shares some of the urban principles, which brings the argument that the hierarchical order of spaces found at the urban level continued inside the house. The objective here is to focus on understanding how the access to a building (house) is an element that increased the connectivity of and integration between the spatial and physical order and worked as a transitional element/space between the outside and inside spaces. Five settlements were chosen for this study Old Riyadh, Alkhabra, Ad-Diriya, Ushaiqer, and Sudus to examine how the concept of access influenced the generation of physical and nonphysical mechanisms in the inner threshold space of the traditional building [1].

In the traditional Najdi buildings, the access (entrance) has a transitional dual meaning (Alnaim, 2020). The perceived meanings are related and depend on how users approach the access itself either from the outside (external street) or from the inside domains (inside the house). The first meaning relates to how the family of the house perceives the entrance from the inside. They consider the access here as a semi-private element that provides access to the outside realm. The second meaning of the entrance is related to the access it provides from the outside where the community perceives it as a private element. By identifying these two transitional meanings in the traditional buildings, certain questions of concern to this study arise: to what degree does the entrance of the building form a relationship with its surrounding forces? How does this relationship affect the access' placement and the arrangement of the building's internal spaces? And how do multiple adjacent accesses in the same area relate to each other and influence one another?

Henri Lefebvre elaborates further on this notion when he argues that a group of places and their elements have a center. The center may be approached from any side and reached from any angle, hence, perceiving a place from a particular side or a particular angle means you occupy a place and discover everything that occurs within the place from that chosen vantage point (Lefebvre, 1991). The "center" in Lefebvre's argument is similar to the access element in this study, which means that the transitional dual meanings in the access are related to each other and those dual meanings are generated based on how people perceive the element from the spaces they occupy.

Therefore, the concept of access as a spatial order organizer is analyzed in two phases. The first phase is to identify the different types of entrances in relation to their street types in the traditional Najdi built environment. The second phase is to examine accesses and adjacent entries to understand how the access functions in the public and private domain. The intent of these two phases is to help identify how the access may generate transitional dual meanings and how the entrance as an element/space increases the organization of the spatial and physical order in the public and private domains so later we have the ability to understand how the threshold space is generated.

II. The Operational Aspects of the Access

The three street types (public, semi-public/private, and private) identified in the hierarchal

[1] The five cases gone through variant processes of filtration, such as availability of raw data, existing literature, were the case can be visited for site observation, etc.

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order of spaces control the formation of access at the building level according to three factors: street width, street location, and the kinds of activities conducted on the street. While these three factors influence the access form and location (in a building). The core concepts found in the hierarchal order of spaces and its street types still govern 'access' as an element. The process identified in the hierarchal order of spaces (Alnaim, 2020), is essential to ensure that *where* and *how* the access occurs is not interfering with the spatial order that the settlement established for itself. To better understand how the entrances of various buildings operate under different circumstances, a further analysis has been conducted to examine the different access types, keeping in mind the different street types and outside forces that affect access (Figure 1).

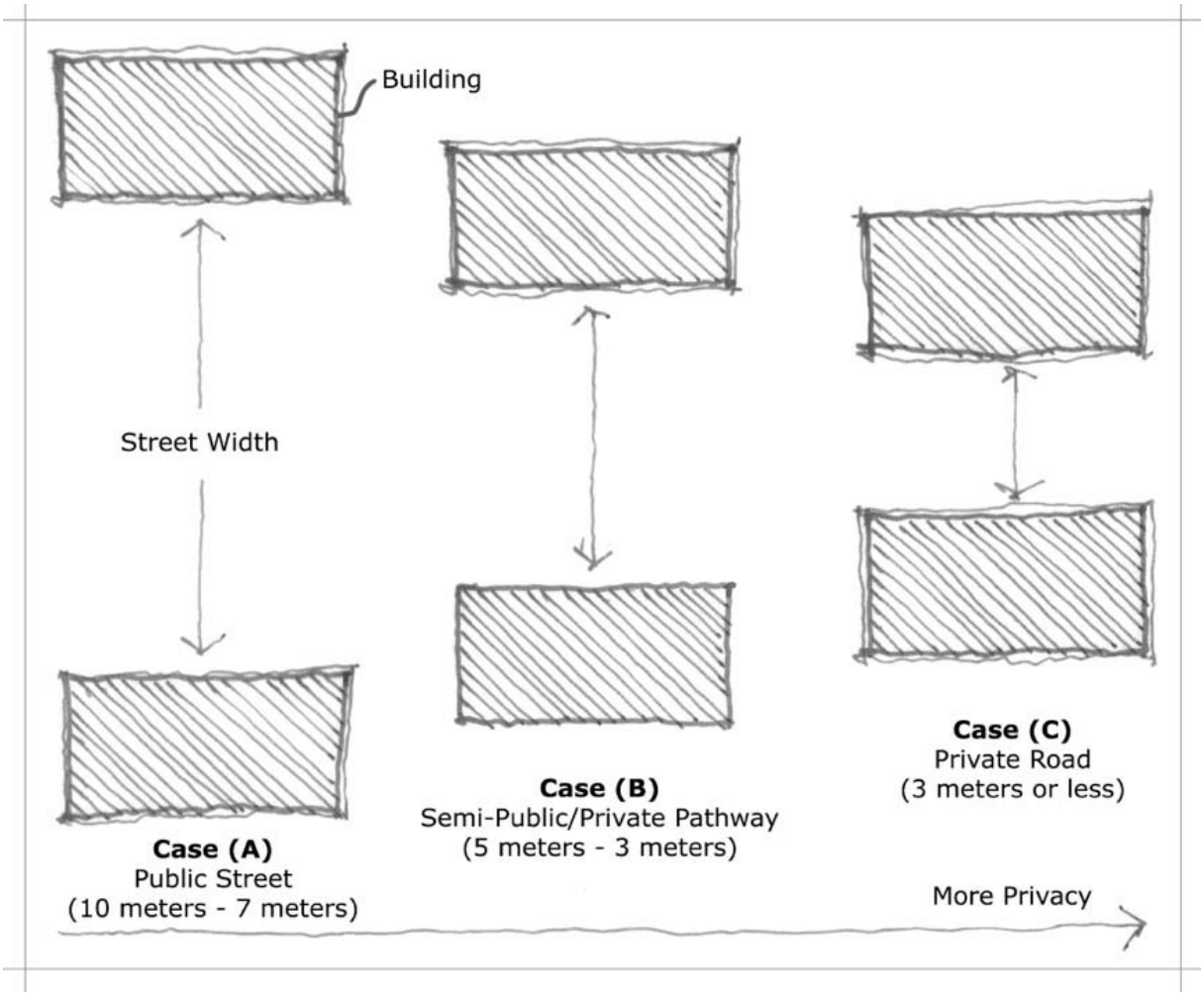

Figure 1: Street types and their classification in the traditional Najdi built environment. Source: Author

We identified three access types while examining how an access operates on different street types. The differences here are only related to how they open and close (related to doors for the family or the public), while their functionality is similar (Figure 2). In street type (A), the street is public and wide, which makes the access appear to have fewer restrictions on its placement and operation. This is because opposite buildings (houses) have enough distance between the buildings to disengage with each other. This makes direct visual access to internal spaces not much of a concern. Also, buildings located on this type of street usually have more than one entrance, a public entrance for a small shop or *majlis* space and another private entrance for the family.

In type (B), the street is semi-private, which makes the access appear more restricted in its placement and operation due to the proximity and compactness of buildings facing each other. In this street type, most of the buildings have only one access entrance and rarely is another access for a building found. The study discovered that the building access here has two regulatory mechanisms. The first mechanism is that two or more entrances should not face each other as this action interferes with the privacy of internal spaces of the different buildings. The second mechanism is the allowance that if the spatial order does not support the first mechanism, two entrances may face each other. However, in the second mechanism, setbacks and internal thresholds (*dehreez*)

were generated to overcome the privacy issue and these setbacks and internal thresholds were meant to decrease the direct visual access of the external domain to the internal private spaces. This action always depended on the agreement of the buildings' owners and most of the time the owners developed architectural solutions on site to overcome these circumstances(Akbar, 1981).

In type (C), the street is private, which makes the access appear highly restricted and have a similar regulatory process mechanism found in street type (B). However, the difference here is that the entrances in private pathways never face each other in any way. This is because the path in this street type is very narrow (less than 3 meters, around 9 ft) and buildings form one cluster of houses accessed by this street. This type of street is a private zone, and in many cases occupied by close families. Social agreement among neighbors is more present in this street type. Although most residents in this street type act as one big family, they still maintain a high level of privacy.

According to several interviews conducted between 2016 and 2018, access as an element seems to not only be used to separate public and private domains, but it is also used as a social gathering element and as a wayfinding [2]. Local people use the outside space in front of the house to meet and have a quick chat about their daily life. One conclusion that arose from interview discussions: this outdoor space is partially controlled by the house owner and is used as a social gathering space that does not require him to use the *majlis* (guest space) located inside the house [3]. Also, the setback of the entrances supported this social activity where several building owners in the same area can use their outside spaces near their access without worrying about affecting the privacy of their neighbors.

As a result of this key insight, the study found that the regulation of the locations of the dwelling entrances by inhabitants is significant for the spatial order as it established the relationship between the spatial aspect and the physical form. This core principle, in fact, developed to support the social structure of the community and serves mainly to support the middle social class(family related at the private neighborhood). Inhabitants developed these simple solutions to control the visual corridors between neighbors and was a result of the people's participation in the decision-making process to achieve social agreement.

[2] The way finding tool here is used an implicate meaning that changes depending on how inhabitants use the door and to whom it serves (men/guest door or private family door).

[3] Interviews with the local people of Alkhabra, Ushaiqer, and Sudus between 2016 and 2018.

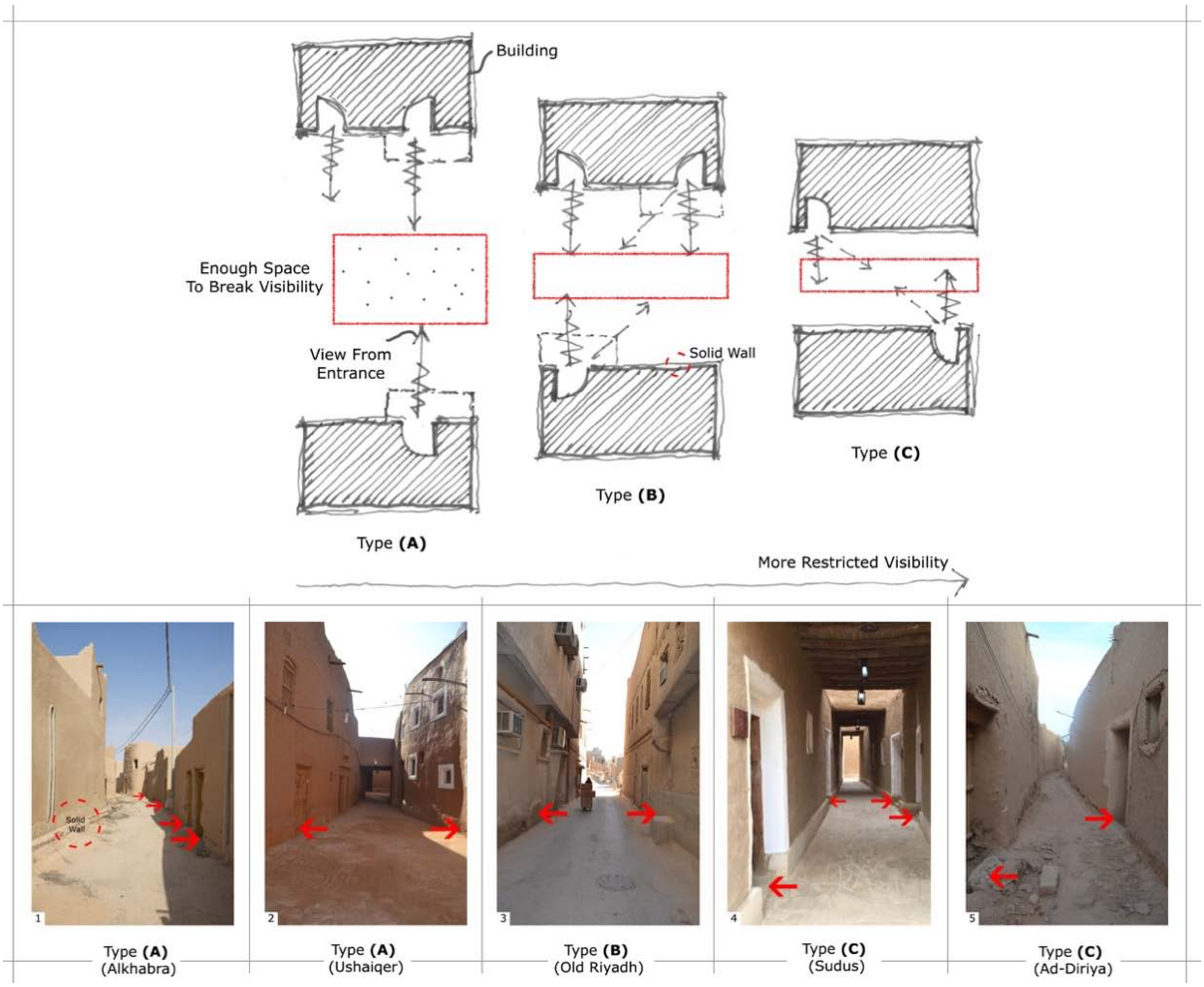

Figure 2: Different street spacing and how width controls openings in each street type. Source: Author

III. Phase One: The Location of the Access

To examine how inhabitants placed their entrances to control outside spaces, the possible locations of access in the five cases must be identified (Figure 3). The organization of the analysis is based on the type of street and at which settlement the street is located. The objective here is to identify the access' placement in the building, so later it is possible to understand how the entrance as a space/element increased the linkage and organization of the spatial and physical order in the public and private domains(Alnaim, 2020).

Referring to (Figure 3) the access placement in the traditional Najdi buildings supports the study's earlier analysis: that most entrances do not face each other unless they are on a street that has the appropriate width. In Sudus, for instance, one extended clan occupied the entire settlement. However, the access placements still seem not to face one another, even though the surrounding residents might be related family members (Figure 3(E)). The argument here is that the regulatory process mechanism of defining the access location does not consider the close relationship between neighbors. This is because the process itself limits the ability of individuals to interfere with it, which makes related social groups or individuals have the same process. This is important as it makes the operational aspect of access maintain the required privacy regardless of any familial relationship among the affected parties, which led to a shared and similar access generative process across the five cases.

In the case when the house has only one entrance, the entrance functions as a private family entrance and to accommodate guests (men). This type of use mostly appears in buildings that are small to medium in size and located in private areas (*hellas*) (Figure 3(A1, D1 & E1)). In an interview with the Ushaiqer local people in 2017, interview participants described how they accommodated guests[4]. They described that they mostly perceived the house entrance as a private element. However, to indicate when guests can use the private entrance, the owner

[4] Focus group interview with Ushaiqer local people on 1/7/2017

leaves the door open, signifying that guest are welcome. By keeping the doorway open, the owner nonverbally communicated with the community and granted them permission to access the house and directly enter the *majlis* (guest space) through the staggered entrance hallway. This act was essential and was understood by the local community to limit irrational behavior among neighbors to achieve the required privacy for the house (Figure 4). In this way, access is limited not only by the access' placement, but the access is also controlled by the socio-cultural needs that influenced its formation and its different usage.

Figure 3: Examining the entrance location in the traditional Najdi buildings. Source: Author

In the case when the house has two entrances, one of them is for the family (private) and functions as a service entrance, while the other entrance is for men (majlis or shop). The difference here is that the building location can form a secondary entrance dedicated for guest use. This is because houses of this type are usually located near local mosques, semi-public spaces, or may even be located near the center of the settlement (settlement core) (Figure 3 (A3, B2)). This house type, for the most part, is related to people with high social status or someone who is the eldest in an extended clan that has their *majlis* open all day for visitors[5]. This is why the secondary entrance is generated to support the high volume of social activity while also guarding the family's privacy.

[5] Interview with Ushaiqer local people on 1/7/2017 and Alkhabraon 1/1/2018

Figure 4: The entrance location within the traditional Najdi built environment. Source: (1,2 & 3) by ADA, Author

Al-Nowassair states that people that have more than one access usually leave the guest door open after prayer or when they are accepting visitors. He asserts that this type of behavior "Suggest[s] a spontaneous and informal action, where it signifies welcoming and generosity from the owner" (Al-Nowaiser, 1999). This kind of behavior also occurs in the Gulf regions and other regions of Saudi Arabia (see Abu-Ghazzeh, 1994; Al-Zubaidi, 2007; Alajmi, 2009; Jomah, 1992)[6]. This is similar to the Ushaiqer locals' interviews in 2017, were they described the same social behavior.

By leaving the door open, the owner of the house is using the door as an element to communicate "non-verbally/implicitly" with the community to invite them to visit. This social behavior usually occurs on a daily basis before and after the daily five prayers, family meetings, etc. Usually the visitor states the name of the owner loudly and then enters the guest space because they know from the open door that the family has taken steps to maintain its privacy. The owner usually answers *Hayak* (please come inside, you are welcome)[7].

This study argues that there are limits to this behavioral action when the family and guests share the same access. It is for this reason that settlement inhabitants perceive the second entrance as having a higher social status, enabling people with a second entrance to accommodate certain social obligations. That is not to say that buildings with one entry could not have this kind of behavioral action, but as discussed, it developed to accommodate normal daily social activities within the neighborhood, which already has other outdoor alternatives for social gatherings. This is why it is important that entrances not face each other in private zones in order to facilitate this limited behavior.

The difference between the two types of access is controlled by the location and the particular socio-cultural needs of different social groups. The fact that the second access is generated to accommodate the high volume of guests explains why the one entrance access type is the most repetitive pattern seen in the traditional Najdi built environment as the majority of local people do not accommodate guests on a daily basis. Instead, they gather in the outdoor spaces (e.g., *Al-Meshraq*) located in their neighborhoods [8]. This also encouraged people of high social status to live in houses near public streets to satisfy their economic and social activities while also maintaining the privacy of their families and adjacent neighbors.

IV. Phase Two: The Influence of the Access Location on the Spatial Order

The above-mentioned analysis highlights how socio-cultural needs might control certain access formations. By using the Space Syntax justified access graph technique, two graphs are developed to represent two different patterns generated by using the two types of access (Figure 5)[9]. This analysis aims to observe access placement, how the outside personal space formed, and the influence of adjacent access to understand the level of control that the access imposes on the street.

Pattern One, relies on building size and location which affect how the access operates. While this type of access is located within private zones, any secondary entrance intended to segregate public and private usage is more restricted. This is because the private pathway is already controlled by the surrounding residents who can identify any stranger in the area (Figure 5(A1)). Also, the people using the pathway are almost always the inhabitants of the neighborhood. The process of generating entrance setbacks is essential to preventing doors from facing each other under certain circumstances. This ensures that the outside personal space is not shared as it affects how each building access is used (Figure 5(A2))[10].

[6] Similar conclusion reached when the researcher interviewed local peoplethat experienced the traditional era across the five cases between 2016 and 2018.

[7] Interview with Ali Alshuabion 1/1/2018, Saleh Al-Hathloul 1/2/2018 and with local people from Ushaiqer on 2017.

[8] The *Al-Meshraq* is an outside bench, and inhabitants developed it to accommodate their socio-cultural needs within the traditional Najdi built environment.

[9] Usingjustified access graphing analysis enables the study to employ an analytical comparative approach to not only identify the similarities and differences of architectural elements, but also to understand the social behavior and meanings behind these different layouts.

[10] A conclusion reached by conducting a number of focus group interviews from the five cases between 2016 and 2018.

While this pattern mostly appears in narrow semi-private and private pathways and buildings are very compacted, increasing the number of access points for each building can affect the privacy and arrangement of the entrances in those buildings. This means sharing occurs between the outside personal space that each access creates for itself with other building accesses, which, in turn, affects the spatial order of the pathway. It could also affect the organization of internal spaces. Not that this action is unseen while examining this pattern, but it is not common, and if it did occur, there must have been an agreement among neighbors to find solutions to prevent any visual corridors. This is because the access in this pattern does not affect the building itself, but it does affect adjacent buildings which makes the arrangement of the entrances and how those entrances are used by the inhabitants critical to ensure that the spatial order of their shared pathway is preserved. We observed a level of flexibility in this pattern which gives a group of people the ability to interpret the regulatory process mechanism of access to fit and adjust to their specific conditions.

Pattern Two, relies on the street type and surrounding activities which affect how the access operates. The size of buildings in this type of street are usually medium to large in size, which makes secondary access a viable option, supported by the width of the street (Figure 5(B1))[11]. The study typically observed the generation of this pattern in public streets and semi-public passageways that may contain public buildings (e.g., mosque and market). This means that there is a possibility of travelers and strangers, along with local people from different areas passing through this type of street daily. The importance of implementing a secondary access here is that it is oriented for the family, and has a main access for guests (Figure 5 (B2)). This is because the building's owner here cannot control the street activity, which makes the generation of a secondary entrance a way to overcome the public activities that occur in the street. This is different from the other pattern, where people in their private areas control who accesses their space. In that sense, the importance of the secondary access in this street type is to increase the privacy level of the building that is located on a public street by dedicating one access for family use.

[11] Worth mentioning here is that wealthy people usually liveon public streets,so it makes sense to see medium to large sized buildings in these spaces. This social class generally wants to be near commercial spaces in the settlement. That is not to say that wealthy people do not live in private zones, but more individual wealthy figures are located near public zones to sustain their economic activities(see Al-Hussayen, 1996; Al-Nowaiser, 1999; Alajmi, 2009). Also, an interview conducted with the local community of Alkhabra, Ushaiqer in Saudi Arabia between 2016 and 2018 described the same phenomenon

Figure 5: The justified access graph identifies two patterns for two access types in the traditional Najdi buildings. Source: Author

This study identified three core concepts related to the regulatory process mechanism of access. First, the physical element (the main doorway) serves as a medium to implicitly communicate with the community about the owner's social status and how much privacy the door signifies to outsiders. Second, the access functions as an element to maintain an optimum distance between neighbors by developing the concept

of the door's setback. Third, the access controls the level of privacy and activity of the street. Therefore, it is not surprising to use gender segregation as a fundamental organizing device for the access. Although it is evident in the traditional settlements that the concept of access produces different patterns for different socio-economic classes and areas, the regulatory process mechanism of the access itself remained constant across the five cases (Figure 6). The hidden mechanism of the process that controls access maintains privacy for its owner and ensures that his outside space is preserved to practice quick social activities, as well as extending the hierarchical order of spaces seen at the urban level to the inner parts of the house.

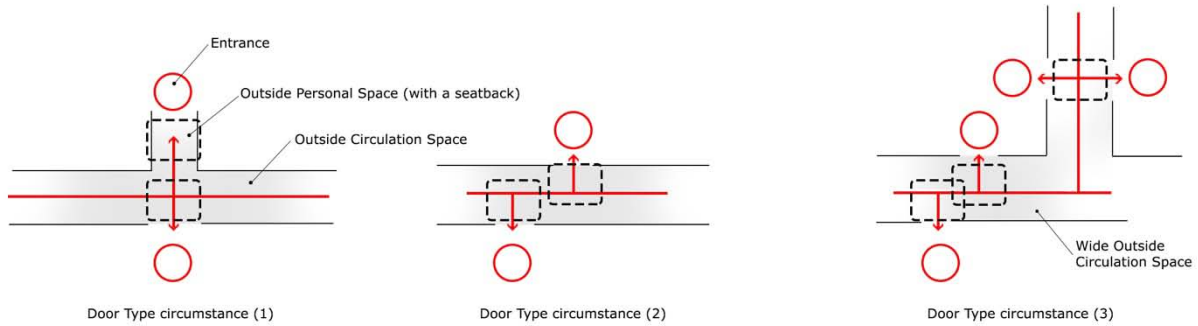

Figure 6: Different types of access formation found in traditional Najdi buildings. Source: Author

V. The Physical and Nonphysical Mechanisms of the Threshold

In Saudi Arabia and, specifically, in the traditional Najdi environment there is a complex relationship between the generosity and hospitality of families and each family's need for privacy. The need to balance between those two social necessities is a natural consideration seen already in previous studies relatedto the traditional Najdi built form(Al-Nowaiser, 1978; Hakim, 1986a, 1986b, 1990, 1997a; Al-Turabi, 1991; Al-Mohannadi, 2019). In this sense, this study sees the door access (the door as an element) as one of the most important architectural elements that strikes a balance between the owner's privacy, guests visiting, and outside surrounding activities. The entrance, as noted, can have different placements, can have different sizes, and can even have different quantities (typically one or two) to assure the privacy for its users while also supporting their social needs and obligations(Al-But'hie, 1996; Alnaim, 1998, 2015)

Observing the placement of the access (doorway), this study discovered two internal elements that appeared constantly near the building access. These elements are "staggered inner access," and "partitioning walls." Briefly, both elements are coexisting elements and depend on each other (Figure 7). This is because privacy is an important religious and social need in such a cultural context (Hakim, 1997b). The distinction between the desirable action and the actual level of privacy have influenced settlement inhabitants to develop and generate internal architectural elements that accommodate the different social engagements inside the house. This, in fact, goes along with an earlier study'sargument that the spatial organization of the house accommodates two domains simultaneously (Alnaim, 2020).

The two type of access that this study identified in the previous discussion play an important role in *how* and *when* the entrance elements generate. As each access type has different functionalities under different circumstances, the elements here function in different ways to support those needs. The importance, however, is to assure the family that no visual contact from the outside to the inside exists and to create a layer of depth between internal private spaces and the actual access of the building. In this sense, the two elements influence the generation of an internal threshold (*dehreez*). This threshold is located between the building access and the internal private spaces, which makes these two elements only appear near the building access.

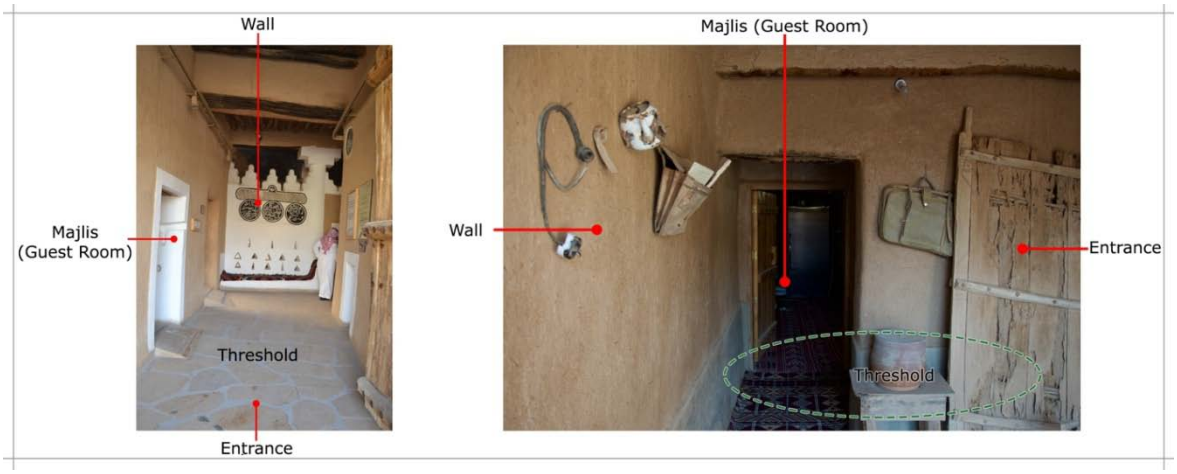

Figure 7: How physical barriers appear near the threshold space, (left) old Riyadh, (right) Alkhabra. Source: Author

The thresholds inside a building are agued and considered a continuous principle that maintains the hierarchical order of internal spaces and defines the level of privacy between the family and guest parts and among internal family spaces. The cultural settings that generated internal relationships among the spatial and physical forms supports this continuous process. A link to this idea is related to Habraken's view when he argues that the process of making of spatial and physical forms expresses two meanings that are understood through practice and collective forces (social production), and its material expression (construction know-how) (Habraken, 2000). In this sense, Najdi people understood their needs at the urban level and as a result formed the urban threshold. They then logically continued to apply the same principle to organize the internal spatial order of their buildings. This led inhabitants to adopt some of the same core concepts seen at the urban level within their buildings, albeit duly modified and reproduced to fit the settings of their buildings.

VI. The Formation of the Threshold Space

A threshold at the building level takes the shape of a transitional space located near the building's access to separate the semi-private space inside the house (*majlis*) and the most private spaces (family courtyard and rooms) (Figure 8). This space is mostly used as a buffer zone, essentially restricted from any uses other than facilitating a transition between two domains inside the house[12]. In this way, this transitional zone (threshold) is a space generated by the Najdi local people to separate their private internal spaces from their semi-private spaces (*majlis* space).

[12] In rare cases, it is found that the threshold space may have *"Dakka,"* which is an element similar to the function of *Al-Meshraq* in external spaces. *Dakka* in this situation is used as a bench near the door and inside the house to have a quick meeting that does not necessarily require the use of the *majlis*.

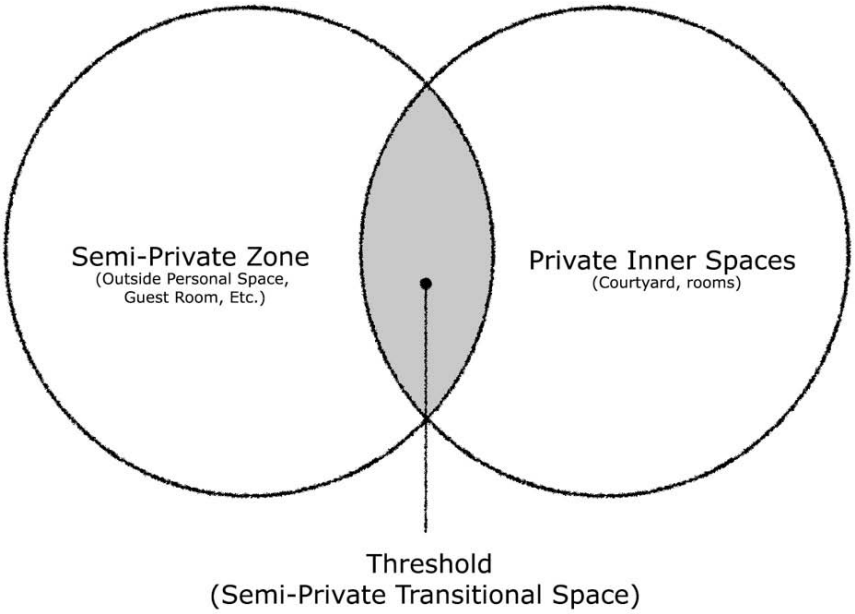

Figure 8: The nature of the threshold space in the traditional Najdi buildings. Developed from(Lawrence 1990: 89)

In fact, one may observe several cultures making use of some type of transitional device to maintain privacy. Ying-Keung Chan describes privacy in the Chinese culture as not an issue in Chinese society. In China, people prefer recognition from their follow clansmen and neighbors for their achievement, which makes them more exposed to the outside. However, he notes that privacy is still a concept that exists, but it is different from how other cultures view privacy. Chan argues that privacy within the context of his study is related to the regulation of personal information among individuals, which creates a number of private zones within a closed boundary (e.g., the house). He describes this behavior as performed "to regulate the permeability of interpersonal boundaries," or to regulate "the nature of the relationship between oneself and the other party in interaction" (Chan, 2000).

In a different context, Rodrick Lawrence examines the public collective and private spaces in the traditional urban housing of Switzerland. He notes that there is a connection between gender and an emphasis on privacy needs, which touches upon the physical boundaries of the concept. Lawrence argues that one may observe this phenomenon when a collective space is formed as a physical barrier for use as a transitional circulation space to "realign" and "redefine" the private realm from the public realm (Lawrence, 1990).

Accordingly, the generation of an internal threshold (transitional zone) within the cultural context of the traditional Najdi built environment creates a privacy balance between different internal spaces. Therefore, this threshold space occurred in two different ways: (1) by the establishment of physical barriers that explicitly limit public access to private spaces by using partitioning walls, and (2) by introducing staggered access to effectively create a threshold space to stop any visual contact to inner spaces of the house (Figure 9).

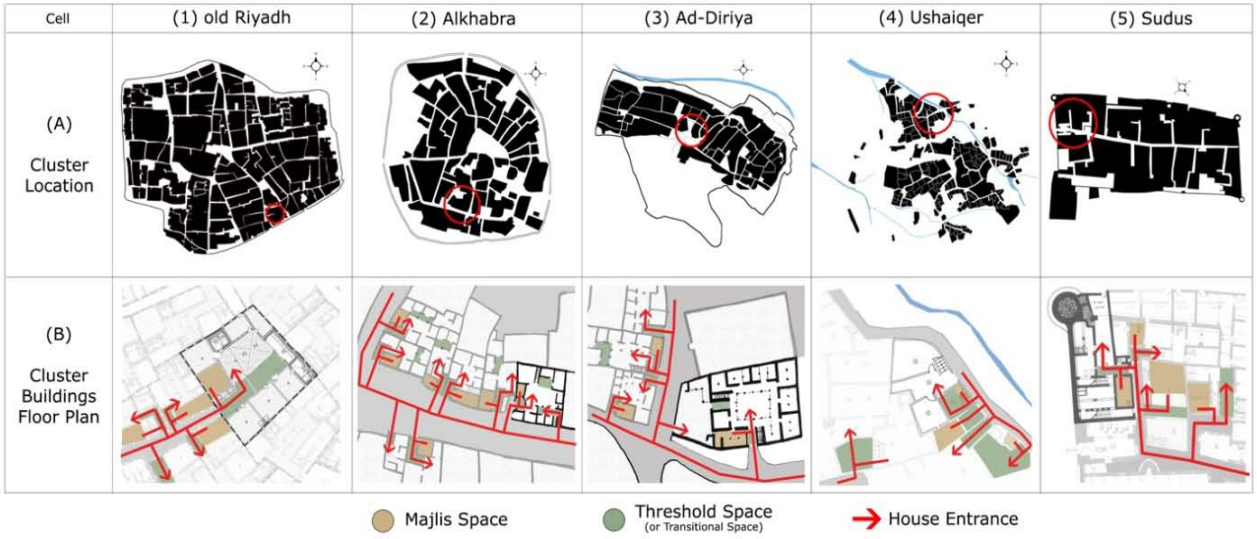

Figure 9: Threshold as a spatial organizer for house entry. Source: Author

There are more physical and non-physical internal thresholds found in the traditional Najdi houses that control the transition between different parts of the house. In some cases, there is a separation of the back of the house from the courtyard by another internal transitional space. It is less important than the main threshold (the *dehreez* near the access). Sometimes these spaces disappear, especially if the house is small and the back of the house shrinks to a small space underneath the staircase. In general, the existence of these thresholds is important in identifying the boundaries between the family and service spaces and it distinguishes between what inhabitants considered "clean" spaces from "dirty" spaces. In many cases the threshold is represented by a door or by an arch or beam to say to the user (usually a family member) "you are entering a different space" (Figure 10).

In fact, the deepest spaces in the spatial order of internal spaces are the family rooms, the main living space of the family. Doors directly connect the family rooms to the courtyard. Inhabitants considered the courtyard a transitional zone for family members and this transitional zone (courtyard) is protected from outside visual contact by the main entrance hallway (threshold). The relationship between the family rooms and the courtyard differ by day and night because family rooms served as multipurpose spaces. In the daytime the family opened the doors of the rooms, and they functioned as spatial defining zones, while in the nighttime the family closed the doors and the rooms functioned as restricted spaces because the rooms were used as private sleeping spaces by family members. Inhabitants achieved this dynamic use of space by developing hidden meanings for different thresholds, which enabled the local inhabitants to maximize the use of their domestic spaces.

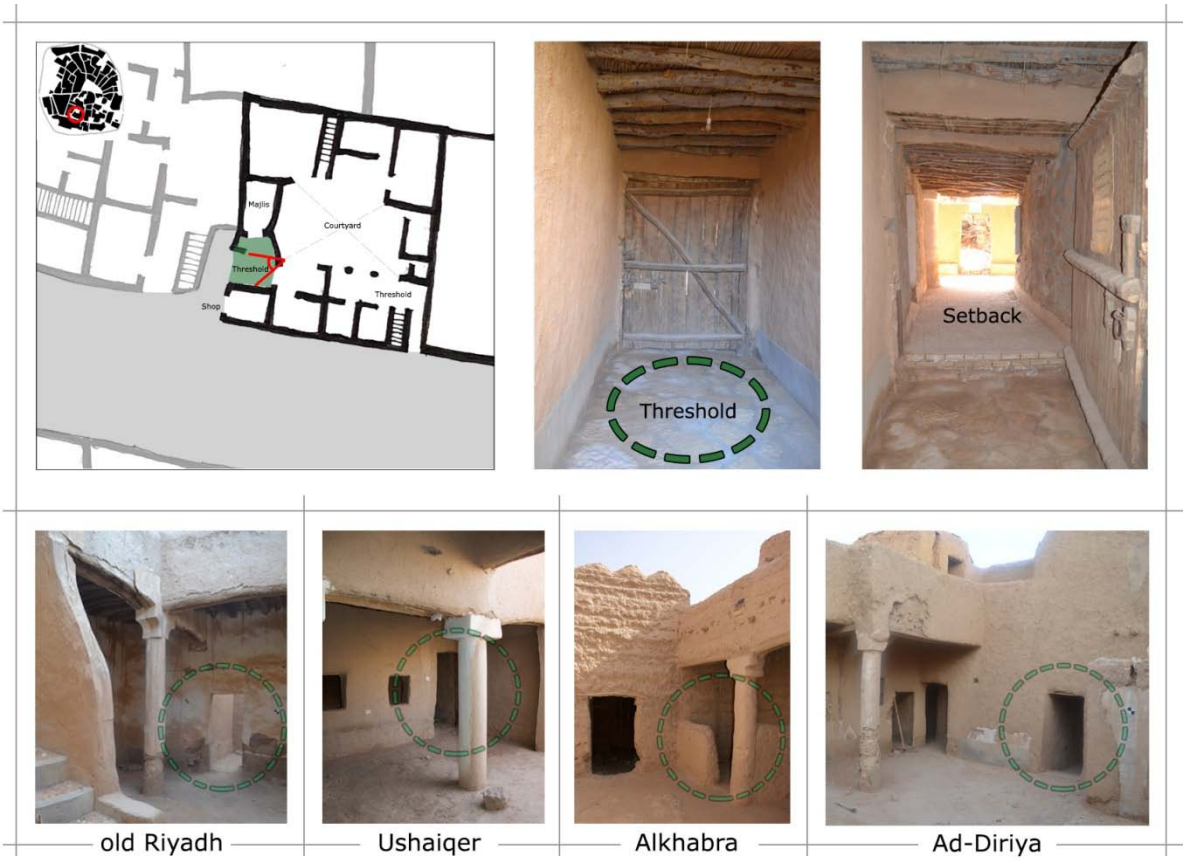

Figure 10: Threshold location inside the traditional Najdi buildings. Floor Plan from Alkhabra. Source: Author

The concept of the internal threshold stemmed from the holistic process of the integrative spatial and physical order which guided the local people to implement the same process at all levels in the built environment. We should view the concept of the threshold as a continuous process used by local inhabitants to create a homogenous built environment. In that sense, the integrative order evolves at each level (urban, building, and architectural element) to protect the main cultural principles in the Najdi built environment, helping the local people find ways to integrate the urban, building, and architectural element in the right places.

VII. The Location of the Internal Threshold Spaces

The researcher examined several buildings across the five cases to identify the location of the threshold spaces. In (Figure 11) the Space Syntax Convex map and justified Access Graph techniques are used to understand the following: the location of the two elements (staggered inner access and partitioning walls) in the house (Figure 11 (2)); the type of spaces in the threshold space as represented by a Convex map (Figure 11 (3)), and how the hierarchical order of internal spaces is organized by having the threshold space inside the house as shown by the Justified Access Graph (Figure 11 (4))[13].

By examining the threshold locations, the researcher discovered that the space appears in different shapes and forms. However, the difference is limited to the physical appearance as all the various formation aspects of the space are associated with how the access functioned, where it was placed and how it was accessed[14]. It is also possible to say that a threshold's formation is associated with how the internal spaces that are located near the threshold are placed and arranged.

The Location of the Guest Space and the Formation of the Threshold Space

Staggered access and partitioning walls are physical elements associated with building access and this study argues that they influence the organization of the spatial order of internal spaces and vice versa. They significantly influence the formation of the threshold

[13] A convex mapcontains a number of convex spaces, each space abstracted to a shape (node).The shapes are connected in order to abstractly represent the permeability of a convex map (Hillier et al., 1993). In a graph, a convex map is represented by a node and lines linking the different nodes represent permeability (Klarqvist, 1993).

[14] Double thresholds can be foundin Alkhabra in rare situations; this is related to how inner adjacent spaces are positioned and to what extent they have visibility to the private domain spaces which requiredan alternative approach.

space and what shape it takes. This is because internal spaces that are located near the threshold, as well as how people access these spaces, such as the *majlis* space, influence the location and formation of the threshold space inside the house.

Susan Kent identified three factors – gender, age, and function – which influence how social needs interact spatially in domestic spaces. These factors influence the formation of portioning spaces that take place differently in various cultures. She argues that each of these factors may play a role in shaping the organization of domestic space (Kent, 1991). To elaborate on Kent's argument, the discussion turns to an example from the Ushaiqer settlement. Referring to (Figure 11 (D)), while entering the house we are in the threshold space, and the *majlis* in this example is on the first floor. The guest space placement on the first floor led to placing the staircase near the door to prevent guests from going deep inside the house. Knowing that the semi-private space *majlis* (guest space) is in an isolated area on the first floor did not affect the placement of the threshold space. It also did not affect the existence of its associated two elements (staggered access and partitioning walls).

Guests, in this case, will not go deep inside the house; rather, they will go directly to the first floor. Even so, the two elements still appeared to ensure the preservation of a layer of depth between the semi-private spaces and the private spaces. This is similar to what Kent argues. In the Ushaiqer example, gender and functional factors played significant roles in the placement of the threshold space to accommodate the *majlis* space, which in turn, influenced the organization of the spatial order of internal spaces (e.g., staircase being next to the access).

If the *majlis* is placed on the ground floor (usually it is in most cases) and near the door access (Figure 11 (E)), the two physical elements constantly appeared in similar manners. The only difference found in those elements is the way they formed inside the house to prevent visibility and maintain the desired level of privacy while accommodating guests. This means that whichever interpretation process led to generate the threshold space's formation, the two physical elements are always present in the threshold space to separate the semi-private spaces from the private spaces.

The location of the *majlis* is usually on the ground floor. It is for this reason that the devices of the threshold space developed to protect the inner family spaces from any visual contact. However, when the settlements became crowded and the houses divided into smaller ones, inhabitants sometimes moved the *majlis* spaces to the upper floor while keeping the threshold devices as mentioned above. This study observed in the traditional settlements that guest spaces are more flexible and inhabitants sometimes modified and moved guest spaces to upper floors, but the devices (threshold spaces and their elements) govern and organize internal spaces, therefore their existence is constant. This is because they work as the main tools for the integrative spatial and physical order to generate a similar and understandable built environment.

The Type of Spaces Near the Threshold Space

The types of internal spaces located within or near the threshold space are examined using the Space Syntax Convex map technique. The goal here is to understand why specific spaces are located only in the threshold space and not in any other internal spaces inside the house. The Convex map helps to explain and identify how the threshold space and its associated physical elements function to link or segregate different internal spaces.

Referring to (Figure 11), the Convex maps have shown that internal spaces that are associated with the threshold are mostly semi-private spaces, while private spaces are deeper and separated from the threshold space by the courtyard element (Figure 11 (3)). This supports earlier arguments that the threshold space was mostly empty and functioned as a transitional space between the main access of the house and the most active private spaces. The threshold space, then, is meant to generate another layer of depth to reach the most private spaces. Justified access graphs in which the *majlis* is always located in the threshold space support this argument. In order to go deeper inside the house the threshold is the first space that must be accessed, then the courtyard is accessed, and only then, a private room may be reached (Figure 11 (4)). In this way, the importance of the threshold space is not limited to being a space that serves semi-private spaces inside the house and to accommodate two domains, but it also serves as a space that creates a layer of depth in the spatial order inside the building's internal spaces.

For example, hospitality in Saudi Arabia is essentially a religious and social norm which is also based on deeply shared social values[15]. The main door and entrance in the traditional house is highly important and is used as a communication tool, communicating ideas such as: how welcome the guests are, how private the home is, and the wealth of the home owner (Al-Hathloul, 2016). Therefore, how local people of Najd had their doors open during the daytime is mentioned earlier as a way to communicate that guests are welcome (Al-Soliman, 1991; Alnaim, 1998, 2006).The implicit mechanism that links how welcome the guests are with the privacy of the home is important to understand as it helps to better understand the

[15] Guest hospitality in Islam is a worthy practice for the sincere Muslim, and clear evidence of the strength of his faith, and these ideas have been pointed out by the teachings of the Prophet Mohammed (peace be upon him), who urges us to honor the guest(Al- Bukhari and Muslim, Book 1, Hadith 308).

organizational aspect of the spatial order of the internal spaces in the traditional Najdi house.

Having the main door open requires creative solutions by local people to control the privacy of the internal family spaces from external exposure. The staggered access and the partitioning walls are generative elements mainly developed to enable people to connect with the outside domain without exposing their private internal spaces. Therefore, inhabitants developed the threshold space (transitional zone) to accommodate different needs (e.g., the two domains inside the house), while at the same time isolate private spaces from outside visual contact. The researcher noticed a pattern across the settlements in how local inhabitants generated solutions to serve their main socio-cultural needs by utilizing similar devices and principles (threshold) at different levels (urban and building) to control different spaces' connectivity.

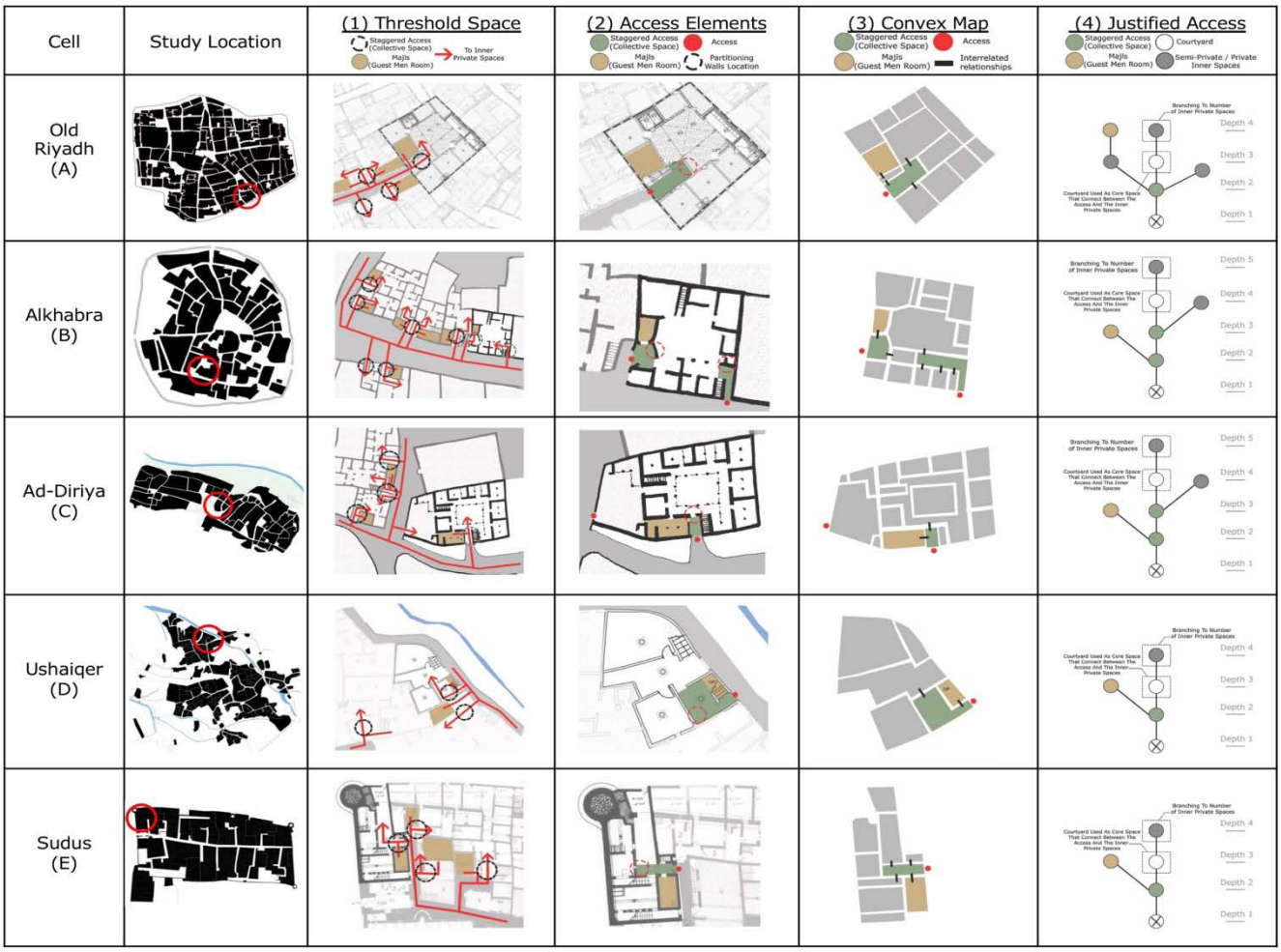

Figure 11: Examining the threshold space location in the traditional Najdi buildings. Source: Author

VIII. The Dynamic Mechanism of the Threshold Space

By combining the three phases of analysis – access elements, convex map space relationships, and the justified access graph analysis – now it is possible to say that the threshold space and its physical elements mostly control the semi-private spaces that are located inside the house and near the building access. This is because having the semi-private spaces near the door access is a religious and social obligation to accommodate guests. This obligation is honored by having the threshold's physical elements decrease the level of interference with private internal spaces while inhabitants make use of the semi-private spaces. Therefore, the local people of Najd found a way to support these two needs by generating the internal threshold space and supporting it with physical elements that control the territorial structure of different spaces inside the house, as well as using the threshold space's placement to create a layer of depth for the house's spatial order.

Although the physical rendering of the threshold may change from one house to another, the principle remained the same across the five cases. Also, the fact that there is a continuous pattern that links the urban fabric with buildings, suggests that the spatial and physical order work in parallel to increase the territorial

control between two different types of spaces: internal (building) and external (urban fabric) (Figure 12). This is achieved in two ways: first, the threshold space's existence influences to what degree the building is connected with outside spaces; second, the threshold's existence decreases the level of direct visual contact with the inside of the house which made the integration between the spatial areas (urban fabric) and the physical form possible. Having these two applications, the threshold space then has the necessary requirements to support a semi-private space *majlis* (guest space) inside the building and connect it with outside spaces by having the main door of the house open in the daytime.

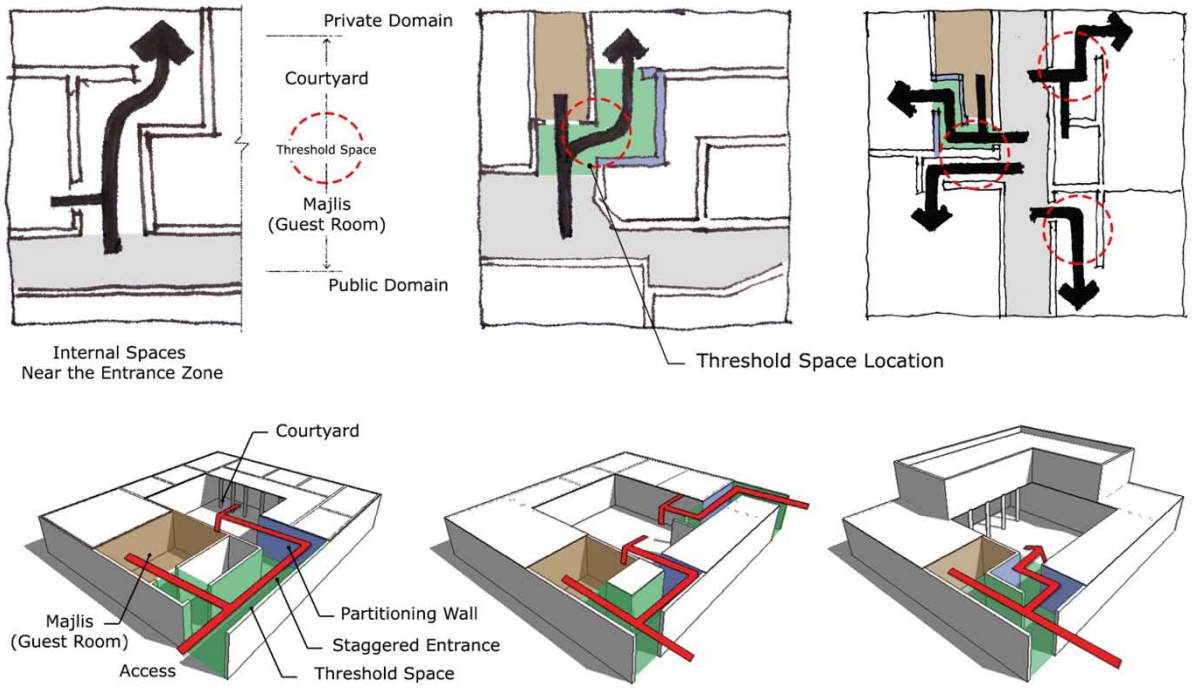

Figure 12: Different formations of the threshold space in the traditional Najdi building. Prototype house from old Riyad, Alkhabra, and Ushaiqer. Source: Author

IX. Conclusion and Recommendation

After understanding the regulatory process mechanism of access, and how two types of entrances were generated to support the social, political, and economic life of its inhabitants, several elements appeared in the internal spaces and near the building access. This study argues that the generation of these elements effectively increases the level of privacy among adjacent entrances. This enabled a deeper understanding of the access regulatory process mechanism, as well as the access' internal elements (e.g., threshold space) to understand how they influenced the organization of internal spaces in buildings in the Najd settlements to support the two domains inside the building.

The function of the access and its location within the settlement played a major role in *when* and *how* to apply the threshold space and its physical elements. The threshold space, however, is persistent in its existence even though some of the elements might not appear in some cases. No matter how big or small a house, a threshold space exists with different formations based on the placement of the elements and the access provided to other nearby internal spaces. The significance of such a space is to ensure the satisfaction of the socio-cultural needs of a household while also giving local people the ability to transit from one space to another without interfering with the privacy of others.

Examining the influence of the threshold space on the spatial order of internal spaces was critical to understanding the basic logic behind how inhabitants structured the circulation flow inside the traditional Najdi house. This helped to further examine the spatial order of internal spaces and how they relate to one another. In the following section, the focus is on how the traditional courtyard functioned as a space that connects different parts of the house and enhances the spatial order of internal spaces. The objective is to investigate the courtyard's explicit functional role as well as its implicit social roles and meanings.

Future studies can use this paper's findings and extend the concept of access and its relationship to the threshold space in the urban structure and the internal spaces of the building structure. We argue that the threshold is used as a controlling point to differentiate between the variety of spaces founded in the built environment and used to create a kind of hierarchy to

how users might experience those variable spaces in the public or private domain. This perspective, we believe, account expanding upon to truly discover the hidden meanings and the operational processes that the built environments established for themselves at the urban and building structure.

Acknowledgements

The authors would like to thank Saudi Arabia governmental entities, and all other individuals for their support and sharing the data, which improved the quality of the survey output.

Conflict of Interest

The authors declare no conflicts of interest.

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Global Journal of Science Frontier Research: a
Physics and Space Science
Volume 20 Issue 9 Version 1.0 Year 2020
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Charged Particle in a Flat Box with Static Electromagnetic field and Landau's Levels

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Keywords: *landau's levels, quantum hall effect.*

GJSFR-A Classification: *PACS: 03.65.-w, 03.65.Ca, 03.65.Ge*

Strictly as per the compliance and regulations of:

Charged Particle in a Flat Box with Static Electromagnetic field and Landau's Levels

Gustavo V. López [α] & Jorge A. Lizarraga [σ]

Abstract- We study the quantization of the motion of a charged particle without spin inside a flat box under a static electromagnetic field. Contrary to Landau's solution with constant magnetic field transverse to the box, we found a non separable variables solution for the wave function, and this fact remains when static electric field is added. However, the Landau's Levels appear in all cases.

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I. Introduction

Landau' solution [1] of a charged particle in a flat surface with magnetic field has become of great importance in understanding integer hall effect [2–6], fractional Hall effect [6–9], and topological insulators [10–16]. This last elements promise to become essential for future nanotechnology devices [17–19]. Due to this considerable application of the Landau's levels, it is worth to re-study this problem and its variations with an static electric field. In this paper, we show that there exists a non separable solution for this type of quantum problems, but having the same Landau's levels. In our cases, instead of having a flat surface, we consider to have a flat box with lengths L_x, L_y, and L_z such that $L_z \ll L_x, L_y$

II. Analytical Approach for the Case B = (0, 0, B)

Let us consider a charged particle "q" with mass "m" in a flat box with a constant magnetic field orthogonal to the flat surface, $\mathbf{B} = (0, 0, B)$, as shown in the next figure.

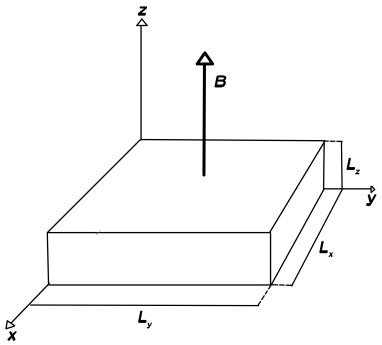

Figure 1: Electric charged in a at box with magnetic field

For a non relativistic charged particle, the Hamiltonian of the system (units CGS) is

$$H = \frac{(\mathbf{p} - q\mathbf{A}/c)^2}{2m}, \tag{1}$$

where $\mathbf{p}$ is the generalized linear momentum, $\mathbf{A}$ is the magnetic potential such that $\mathbf{B} = \nabla \times \mathbf{A}$, and "c" is the speed of light. We can choose the Landau's gauge to have the vector potential of the form $\mathbf{A} = (-By, 0, 0)$. Therefore, the Hamiltonian has the following form

$$H = \frac{(p_x + qBy/c)^2}{2m} + \frac{p_y^2}{2m} + \frac{p_z^2}{2m}. \tag{2}$$

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To quantize the system, we need to solve the Schrödinger's equation [20]

$$i\hbar\frac{\partial\Psi}{\partial t} = \left\{\frac{(\hat{p}_x + qBy/c)^2}{2m} + \frac{\hat{p}_y^2}{2m} + \frac{\hat{p}_z^2}{2m}\right\}\Psi. \tag{3}$$

where $\Psi = \Psi(\mathbf{x}, t)$ is the wave function, $\hbar$ is the Plank's constant divided by 2π, $\hat{p}_i$ are the momentum operators such that $[x_i, \hat{p}_j] = i\hbar\delta_{ij}$. Now, the argument used by Landau is that due to commutation relation $[\hat{p}_x, \hat{H}] = 0$, between the operators $\hat{p}_x$ and the Hamiltonian $\hat{H}$ (implying that $\hat{p}_x$ is a constant of motion), it is possible to replace this component of the momentum by $\hbar k_x$, having a solution for the eigenvalue problem of separable variable type, $f_1(t)f_2(x)f_3(y)f_4(z)$. However, we will see that this type of commutation does not imply necessarily separability of the solution. Since the Hamiltonian $\hat{H}$ does not depend explicitly on time, the proposition

$$\Psi(\mathbf{x}, t) = e^{-iEt/\hbar}\Phi(\mathbf{x}) \tag{4}$$

reduces the equation to an eigenvalue problem

$$\widehat{H}\Phi = E\Phi. \tag{5}$$

Then, this equation is written as

$$\left\{\frac{1}{2m}\left(\hat{p}_x^2 + \frac{2qB}{c}y\hat{p}_x + \frac{q^2B^2}{c^2}y^2\right) + \frac{\hat{p}_y^2}{2m} + \frac{\hat{p}_z^2}{2m}\right\}\Phi = E\Phi. \tag{6}$$

The variable "z" is separable through the proposition

$$\Phi(\mathbf{x}) = \phi(x, y)e^{-ik_z z}, \qquad k_z \in \Re, \tag{7}$$

resulting the following equation

$$\left\{\frac{1}{2m}\left(\hat{p}_x^2 + \frac{2qB}{c}y\hat{p}_x + \frac{q^2B^2}{c^2}y^2\right) + \frac{\hat{p}_y^2}{2m}\right\}\phi = E'\phi, \tag{8}$$

where E' is

$$E' = E - \frac{\hbar^2 k_x^2}{2m}. \tag{9}$$

That is, the resulting partial differential equation is of the form

$$\frac{1}{2m}\left\{-\hbar^2\frac{\partial^2\phi}{\partial x^2} - i\frac{2qB\hbar}{c}y\frac{\partial\phi}{\partial x} + \frac{q^2B2}{c^2}y^2\phi\right\} - \frac{\hbar^2}{2m}\frac{\partial^2\phi}{\partial y^2} = E'\phi. \tag{10}$$

This equation does not admit a separable variable solution ($\phi(x, y) = f(x)g(y)$) as Landau' solution is, but we can use Fourier transformation [21] on the variable "x",

$$\hat{\phi}(k, y) = \mathcal{F}[\phi] = \frac{1}{\sqrt{2\pi}}\int_{\Re} e^{ikx}\phi(x, y)dx, \tag{11}$$

to solve this equation. Applying Fourier transformation to this equation, knowing its property $\mathcal{F}[\partial\phi/\partial x] = (-ik)\hat{\phi}$, we get the ordinary differential equation

$$-\frac{\hbar^2}{2m}\frac{d^2\hat{\phi}}{dy^2} + \frac{m}{2}\omega_c^2(y - y_0)^2\hat{\phi} = E'\hat{\phi}, \tag{12}$$

where ω_c is the cyclotron frequency

$$\omega_c = \frac{qB}{mc} \tag{13a}$$

and y_0 is the displacement parameter

$$y_0 = \frac{\hbar c}{qB}k. \tag{13b}$$

This equation is just the quantum harmonic oscillator in the "y" direction displaced by a amount y_0. So, the solution is

$$\hat{\phi}_n(k,y) = \quad _n(\xi), \quad \xi = \sqrt{\frac{m\omega_c}{\hbar}}(y-y_0), \quad \psi_n(\xi) = A_n e^{-\xi^2} H_n(\xi), \tag{14}$$

being $H_n(\xi)$ the Hermit polynomials, and A_n is a constant of normalization, $An = (m\omega_c/\pi\hbar)^{1/4}/\sqrt{2^n n!}$. and

$$E'_n = \hbar\omega_c(n+1/2). \tag{15}$$

Now, the solution in the real space $\phi_n(x,y)$ is gotten by using the inverse Fourier transformation,

$$\phi_n(x,y) = \mathcal{F}^{-1}[\phi_n(k,y)] = \frac{1}{\sqrt{2\pi}}\int_{\Re} e^{-ikx}\psi_n\left(\sqrt{\frac{m\omega_c}{\hbar}}(y-\hbar ck/qB)\right)dk. \tag{16}$$

Making the change of variable $\sigma = \sqrt{m\omega_c/\hbar}(y-\hbar ck/qB)$, and knowing that the Fourier transformation of the harmonic oscillator solution is another harmonic oscillator solution, we get

$$\phi_n(x,y) = \frac{-qB}{\sqrt{mc^2\hbar\omega_c}} e^{-i\frac{qB}{\hbar c}xy}\psi_n\left(\frac{qB\ x}{\sqrt{mc^2\hbar\omega_c}}\right). \tag{17}$$

This is indeed the non separable solution of (8). Therefore, the normalized eigenfunctions of the eigenvalue problem (5) are (ignoring the sign)

$$\Phi_{n,k_z}(\mathbf{x},t) = \frac{\sqrt{qB}}{(mc^2\hbar\omega_c)^{1/4}} e^{-i(\frac{qB}{\hbar c}xy - k_z z)}\psi_n\left(\frac{qB\ x}{\sqrt{mc^2\hbar\omega_c}}\right). \tag{18a}$$

and

$$E_{n,k_z} = \hbar\omega_c(n+\frac{1}{2}) + \frac{\hbar^2 k_z^2}{2m}. \tag{18b}$$

These eigenvalues represent just the Landau's levels , but its solution (18a) is totally different to that given by Landau since it is of non separable type. Note that there is not displacement at all in the harmonic oscillation solution. Now, assuming a periodicity in the z-direction, $\Phi_{n,k_z}(\mathbf{x},t) = \Phi_{n,k_z}(x,y,z+L_z,t)$, the usual condition $k_z L_z = 2\pi n', \quad n' \in \mathcal{Z}$ makes the eigenvalues to be written as and the general solution of Schrödinger's equation (3) can be written as

$$E_{n,n'} = \hbar\omega_c(n+1/2) + \frac{\hbar^2 2\pi^2}{mL_z^2}n'^2. \tag{19}$$

We must observed that this quantum numbers correspond to the degree of freedom in the "y (n)" and "z(n')" directions. The quantization conditions of the magnetic flux appears rather naturally since by asking periodicity in the y direction $\Psi(\mathbf{x},t) = \Psi(x,y+L_y,z,t)$, this one must be satisfied for any $x \in [0,L_x]$. So, in particular for $x = L_x$. Thus, it follows from the phase term that

$$\frac{qBL_xL_y}{\hbar c} = 2\pi j, \qquad j \in \mathcal{Z}, \tag{20}$$

where BL_xL_y is the magnetic flux crossing the surface with area L_xL_y, and $\hbar c/q$ is the so called quantum flux [22]. Then, equation (18a) is

$$\Phi_{nn'j}(\mathbf{x},t) = \frac{\sqrt{qB}}{(mc^2\hbar\omega_c)^{1/4}} e^{-i(\frac{2\pi j}{L_xL_y}xy - \frac{2\pi n'}{L_z}z)}\psi_n\left(\frac{qB\ x}{\sqrt{mc^2\hbar\omega_c}}\right). \tag{21}$$

The degeneration of the eigenvalues (19) comes from the degree of freedom in "x" and can be obtained by making use the following quasi-classical argument: given the energy of the harmonic oscillator $E_o = \hbar\omega_c(n + 1/2)$, we know the the maximum displacement of the particle (classically) is given by $x_{max} = \pm\sqrt{2E_o/m\omega_c^2}$, and since the periodicity in the variable 'y" mentioned before is valid for any "x" value, we must have that the maximum value of the quantum number "j" must be

$$\Delta j = \frac{qBL_y}{\pi\hbar c} x_{max} = \frac{qBL_y}{\pi\hbar c}\sqrt{\frac{2\hbar(n+1/2)}{m\omega_c}}, \tag{22}$$

and this represents the degeneration, $D(n)$, we have in the system

$$D(n) = \left[\frac{qBL_y}{\pi\sqrt{mc^2\hbar\omega_c}}\sqrt{2n+1}\right]. \tag{23}$$

where $[\xi]$ means the integer part of the number ξ. Therefore, the general solution (absorbing the sign in the constants) is

$$\Psi(\mathbf{x},t) = \sum_{n,'n}\sum_{j=0}^{D(n)} C_{nn'j}\sqrt{\frac{2\pi j}{L_xL_y}}\left(\frac{\hbar}{m\omega_c}\right)^{1/4} e^{-i(\frac{2\pi j}{L_xL_y}xy - \frac{2\pi n'}{L_z}z)} e^{-i\frac{E_{n,n'}}{\hbar}t}\psi_n\left(\sqrt{\frac{\hbar}{m\omega_c}}\left(\frac{2\pi j}{L_xL_y}\right)x\right), \tag{24}$$

where the constants $C_{nn'j}$ must satisfy that $\sum_{n,n',j}|C_{nn'j}|^2 = 1$. The Landau's levels $E_{n,n'}$ are given by expression (19).

III. Analytical Approach for the Case B ⊥ E

This case is illustrated on the next figure,

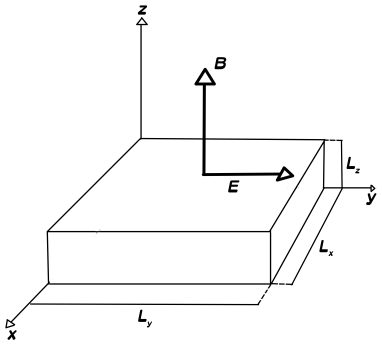

Figure 2: Electric charged in a flat box with magnetic and electric fields

where the magnetic and electric constant fields are given by $\mathbf{B} = (0,0,B)$ and $\mathbf{E} = (0,\mathcal{E},0)$. We select Landau's gauge for the magnetic field such that the vector and scalar potentials are $\mathbf{A} = (-By,0,0)$ and $\phi = -\mathcal{E}y$. Then, our Hamiltonian is [23–25]

$$\hat{H} = \frac{(\hat{\mathbf{p}} - \frac{q}{c}\mathbf{A})^2}{2m} + q\phi(\mathbf{x},) \tag{25}$$

and the Schrödinger's equation,

$$i\hbar\frac{\partial\Psi}{\partial t} = \hat{H}\Psi, \tag{26}$$

is written as

$$i\hbar\frac{\partial\Psi}{\partial t} = \left\{\frac{1}{2m}\left(\hat{p}_x + \frac{qB}{c}y\right)^2 + \frac{\hat{p}_y^2}{2m} + \frac{\hat{p}_z^2}{2m}\right\}\Psi - q\mathcal{E}y\Psi. \tag{27}$$

Using the definition $\hat{p}_j = -i\hbar\partial/\partial x_j$ and the commutation relation $[x_k, \hat{p}_j] = i\hbar\delta_j k$, the above expression is written as the following partial differential equation

$$i\hbar\frac{\partial\Psi}{\partial t} = -\frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial x^2} - i\frac{qB\hbar}{mc}\frac{\partial\Psi}{\partial x} + \frac{q^2B^2}{2mc^2}y^2\Psi - \frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial y^2} - \frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial z^2} - q\mathcal{E}y\Psi. \tag{28}$$

Taking the Fourier transformation with respect the x-variable, $\hat{\Psi}(k, y, z, t) = \mathcal{F}_x[\Psi(\mathbf{x}, t)]$, the resulting expression is

$$i\hbar\frac{\partial\hat{\Psi}}{\partial t} = \left[\frac{\hbar^2k^2}{2m} - \left(\frac{qB\hbar k}{mc} + q\mathcal{E}\right)y + \frac{q^2B^2}{2mc^2}y^2\right]\hat{\Psi} - \frac{\hbar^2}{2m}\frac{\partial^2\hat{\Psi}}{\partial y^2} - \frac{\hbar^2}{2m}\frac{\partial^2\hat{\Psi}}{\partial z^2}. \tag{29}$$

By proposing a solution of the form

$$\hat{\Psi}(k, yz, t) = e^{-iEt/\hbar + ik_z z}\Phi(k, y) \tag{30}$$

and after some rearrangements, the resulting equation for Φ is

$$-\frac{\hbar^2}{2m}\frac{d^2\Phi}{dy^2} + \frac{1}{2}m\omega_c^2(y - y_0)^2\Phi = E'\Phi, \tag{31}$$

where ω_c is the cyclotron frequency (13a), and we have made the definitions

$$y_0 = \frac{\hbar c}{qB}k + \frac{mc^2\mathcal{E}}{qB^2} \tag{32}$$

and

$$E' = E - \frac{\hbar^2k^2}{2m} - \frac{\hbar^2k_z^2}{2m} + \frac{1}{2m}(\hbar k + \frac{mc\mathcal{E}}{B})^2. \tag{33}$$

This equation is again the quantum harmonic oscillator on the variable "y" with a cyclotron frequency ω_c and displaced by a quantity y_0. Therefore, the solution (14) is

$$\Phi(k, y) = \psi_n\left(\sqrt{\frac{m\omega_c}{\hbar}}(y - y_0)\right) \tag{34}$$

and

$$E'_n = \hbar\omega_c(n + 1/2). \tag{35}$$

Thus, the solution in the Fourier space is

$$\hat{\Psi}(k, y, z, t) = e^{-iE_{n,k_z}t/\hbar + ik_z z}\ {}_n\left(\sqrt{\frac{m\omega_c}{\hbar}}(y - y_0)\right) \tag{36}$$

with the energies E_{n,k_z} given by

$$E_{n,k_z} = \hbar\omega_c(n + 1/2) + \frac{\hbar^2k_z^2}{2m} - \frac{mc^2\mathcal{E}^2}{2B^2} - \frac{c\mathcal{E}\hbar}{B}k. \tag{37}$$

The solution in the space-time is obtained by applying the inverse Fourier transformation,

$$\Psi_{n,k_z}(\mathbf{x}, t) = \mathcal{F}[\hat{\Psi}_{n,k_z}(k, y, z, t)] = \frac{1}{\sqrt{2\pi}}\int_{\Re} e^{-ixk}\hat{\Psi}_{n,k_z}(k, y, z, t)dk, \tag{38}$$

which after a proper change of variable and rearrangement, we get the normalized function (ignoring the sign)

$$\Psi_{n,k_z}(\mathbf{x}, t) = \frac{\sqrt{qB}}{(mc^2\hbar\omega_c)^{1/4}}e^{-i\phi_{n,k_z}(\mathbf{x},t)}\ {}_n\left(\frac{qB}{\sqrt{mc^2\hbar\omega_c}}(x - \frac{c\mathcal{E}t}{B})\right), \tag{39}$$

where the phase $\phi_{n,k_z}(\mathbf{x},t)$ has been defined as

$$\phi_{n,k_z}(\mathbf{x},t)=\left[\hbar\omega_c(n+1/2)+\frac{\hbar^2k_z^2}{2m}-\frac{mc^2\mathcal{E}^2}{2B^2}\right]\frac{t}{\hbar}-k_zz+\frac{qB}{\hbar c}\left(x-\frac{c\mathcal{E}t}{B}\right)\left(y-\frac{mc^2\mathcal{E}}{qB^2}\right). \tag{40}$$

asking for the periodicity with respect the variable "z", $\Psi_{n,k_z}(\mathbf{x},t)=\Psi_{n,k_z}(z,y,z+L_z,t)$, it follows that $k_zL_z=2\pi n'$ where n' is an integer number , and the above phase is now written as

$$\phi_{nn'}(\mathbf{x},t)=\left[\hbar\omega_c(n+1/2)+\frac{\hbar^2 2\pi^2n'^2}{mL_z^2}-\frac{mc^2\mathcal{E}^2}{2B^2}\right]\frac{t}{\hbar}-\frac{2\pi n'}{L_z}z+\frac{qB}{\hbar c}\left(x-\frac{c\mathcal{E}t}{B}\right)\left(y-\frac{mc^2\mathcal{E}}{qB^2}\right). \tag{41}$$

Note from this expression that the term $e^{-i\phi(\mathbf{x},t)}$ contains the element $e^{i\frac{qB}{\hbar c}xy}$, and by assuming the periodic condition $\Psi(\mathbf{x},t)=\Psi(x,y+L_y,z,t)$, will imply that $\Psi(\mathbf{x},t)$ will be periodic with respect the variable "y", for any "x" at any time "t." In particular, this will be true for $x=L_x$. This bring about the quantization of the magnetic flux of the form

$$\frac{qBL_xL_y}{\hbar c}=2\pi j,\quad J\in\mathcal{Z}\ , \tag{42}$$

obtaining the same expression as (20), and this phase is now depending of the quantum number "j"

$$\phi_{nn'j}(\mathbf{x},t)=e_{nn'}t/\hbar-\frac{2\pi n'}{L_z}z+\frac{2\pi j}{L_xL_y}xy-\frac{2\pi j}{L_xL_y}\left[\frac{mc^2\mathcal{E}}{qB^2}x+\frac{c\mathcal{E}}{B}ty\right]. \tag{43}$$

where $e_{nn'}$ is the energy associated to the system,

$$e_{n,n'}=\hbar\omega_c(n+1/2)+\frac{2\pi^2\hbar^2}{mL_z^2}n'^2+\frac{mc^2\mathcal{E}^2}{2B^2}. \tag{44}$$

In this way, from these relations and the expression (39) we have a family of solutions $\{\Psi_{nn'j}(\mathbf{x},t)\}_{n,n',j\in\mathcal{Z}}$ of the Schrödinger equation (27),

$$\Psi_{nn'j}(\mathbf{x},t)=\sqrt{\frac{2\pi j}{L_xL_y}}\left(\frac{\hbar}{m\omega_c}\right)^{1/4}e^{-i\phi_{nn'j}(\mathbf{x},t)}\ {}_n\left(\sqrt{\frac{\hbar}{m\omega_c}}\left(\frac{2\pi j}{L_xL_y}\right)(x-\frac{c\mathcal{E}t}{B})\right), \tag{45}$$

Now, by the same arguments we did in the previous case, the degeneration of the systems would be given by (23), and the general solution would be of the form

$$\Psi(\mathbf{x},t)=\sum_{n,n'}\sum_{j=0}^{D(n)}\widetilde{C}_{nn'j}\Psi_{nn'j}(\mathbf{x},t). \tag{46}$$

IV. Analytical Approach for the Case B || E

The following figure shows this case.

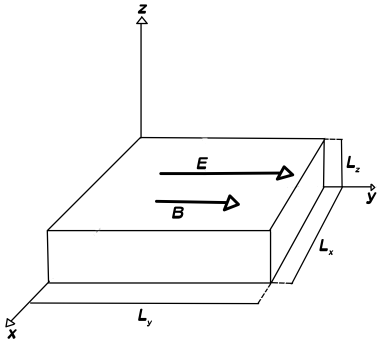

Figure 3: Electric charged in a flat box with parallel electric and magnetic fields

The fields are of the form $\mathbf{B} = (0, B, 0)$ and $\mathbf{E} = (0, \mathcal{E}, 0)$. The scalar and vector potentials are chosen as $\mathbf{A} = (Bz, 0, 0)$ and $\phi = -\mathcal{E}y$. The Shrödinger equation is for this case as

$$i\hbar\frac{\partial\Psi}{\partial t} = \left\{\frac{(\hat{p}_x - qBz/c)^2}{2m} + \frac{\hat{p}_y^2}{2m} + \frac{\hat{p}_z^2}{2m} - q\mathcal{E}y\right\}\Psi, \tag{47}$$

which defines the following partial differential equation

$$i\hbar\frac{\partial\Psi}{\partial t} = -\frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial x^2} + i\frac{qB\hbar z}{mc}\frac{\partial\Psi}{\partial x} + \frac{q^2B^2}{2mc^2}z^2\Psi - \frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial y^2} - \frac{\hbar^2}{2m}\frac{\partial^2\Psi}{\partial z^2} - q\mathcal{E}y\Psi. \tag{48}$$

Proposing a solution of the form $\Psi(\mathbf{x}, t) = e^{-iEt/\hbar}\Phi(\mathbf{x})$, we get the following eigenvalue problem

$$E\Phi = -\frac{\hbar^2}{2m}\frac{\partial^2\Phi}{\partial x^2} + i\frac{qB\hbar z}{mc}\frac{\partial\Phi}{\partial x} + \frac{q^2B^2}{2mc^2}z^2\Phi - \frac{\hbar^2}{2m}\frac{\partial^2\Phi}{\partial y^2} - \frac{\hbar^2}{2m}\frac{\partial^2\Phi}{\partial z^2} - q\mathcal{E}y\Phi. \tag{49}$$

Applying the Fourier transformation over the x-variable, $\hat{\Phi}(k, y, z) = \mathcal{F}_x[\Phi(\mathbf{x})]$, the following equation arises after some rearrangements

$$E\hat{\Phi} = \frac{(\hbar k + qBz/c)^2}{2m}\hat{\Phi} - \frac{\hbar^2}{2m}\frac{\partial^2\hat{\phi}}{\partial z^2} - \frac{\hbar^2}{2m}\frac{\partial^2\hat{\Phi}}{\partial y^2} - q\mathcal{E}y\hat{\Phi}, \tag{50}$$

which can be written as

$$-\frac{\hbar^2}{2m}\frac{\partial^2\hat{\Phi}}{\partial z^2} + \frac{1}{2}m\omega_c(z + z_0)^2\hat{\Phi} - \frac{\hbar^2}{2m}\frac{\partial^2\hat{\Phi}}{\partial y^2} - q\mathcal{E}y\hat{\Phi}, \tag{51a}$$

where ω_c is the cyclotron frequency (13a), and z_0 has been defined as

$$z_0 = \frac{\hbar c}{qB}k. \tag{51b}$$

This equation admits a variable separable approach since by the proposition $\hat{\Phi}(k, y, z) = f(k, z)g(y)$, the following equations are bringing about

$$-\frac{\hbar^2}{2m}\frac{d^2f}{dz^2} + \frac{1}{2}m\omega_c^2(z + z_0)^2 = E^{(1)}f \tag{52a}$$

and

$$-\frac{\hbar^2}{2m}\frac{d^2g}{dy^2} - g\mathcal{E}yg = E^{(2)}g, \tag{52b}$$

where $E = E^{(1)} + E^{(2)}$. The solutions of these equations are, of course, the quantum harmonic oscillator and the quantum bouncer, which are given by

$$f_n(k, z) = A_n e^{-\xi^2/2}H_n(\xi), \qquad \xi = \sqrt{\frac{m\omega_c}{\hbar}}(z + z_0), \qquad E_n^{(1)} = \hbar\omega_c(n + 1/2). \tag{53a}$$

and

$$g_{n'}(y) = \frac{Ai(\tilde{\xi} - \tilde{\xi}_{n'})}{|Ai'(-\tilde{\xi}_{n'})|}, \qquad \tilde{\xi} = y/l, \qquad E_n^{(2)} = -q\mathcal{E}l\tilde{\xi}_{n'}, \tag{53b}$$

where $A_n = (m\omega_c/\pi\hbar)^{1/4}/\sqrt{2^n n!}$, $l = (\hbar^2/(-2mq\mathcal{E}))^{1/3}$, $Ai(-\tilde{\xi}_{n'}) = 0$, and $Ai'(\xi)$ is the differentiation of the Airy function. In this way, we have

$$\hat{\Phi}_{n,n'}(k, y, z) = a_{n'}\ {}_n\left(\sqrt{\frac{m\omega_c}{\hbar}}(z + z_0)\right)Ai(l^{-1}(y - y_{n'})), \qquad E_{n,n'} = \hbar\omega_c(n + 1/2) - q\mathcal{E}y_{n'}, \tag{54}$$

where we have defined $a_{n'}$ as $a_{n'} = 1/|Ai'(-l^{-1}y_{n'})|$. Now, the inverse Fourier transformation will affect only the quantum harmonic oscillator function ψ_n through the k-dependence on the parameter z_0, and the resulting expression is

$$\Phi_{n,n'}(\mathbf{x}) = \frac{a_{n'}qB}{\sqrt{mc^2\hbar\omega_c}} e^{i\frac{qB}{\hbar c}xz}\psi_n\left(\frac{qBx}{\sqrt{mc^2\hbar\omega_c}}\right)Ai\big(l^{-1}(y-y_{n'})\big). \tag{55}$$

Now, asking for the periodicity condition of the above solution with respect the z-variable, $\Psi(\mathbf{x},t) = \Psi(x,y,z+L_z,t)$, the periodicity must satisfy for any x-values, and in particular for $x = L_x$. Thus it follows the quantization expression for the magnetic flux

$$\frac{qBL_xL_z}{\hbar c} = 2\pi j, \qquad j \in \mathcal{Z}. \tag{56}$$

Using the same arguments shown above for the degeneration of the system, we have the same expression (23) for the degeneration of the system and the function (55) is given by (normalized)

$$\Phi_{nn'j}(\mathbf{x}) = a_{n'}\sqrt{\frac{2\pi j}{L_xL_y}}\left(\frac{\hbar}{m\omega_c}\right)^{1/4} e^{i\frac{2\pi j}{L_xL_z}xz}\psi_n\left(\sqrt{\frac{\hbar}{m\omega_c}}\left(\frac{2\pi j}{L_xL_y}\right)x\right)Ai\big(l^{-1}(y-y_{n'})\big). \tag{57}$$

Then, we have obtained a family of solution of the Schrödinger equation (48),

$$\Psi_{n,n'}(\mathbf{x},t) = e^{-iE_{n,n'}t/\hbar}\Phi_{nn'j}(\mathbf{x}), \tag{58}$$

where the energies $E_{n,n'}$ are given by the expression (54). The general solution of (48) can be written as

$$\Psi(\mathbf{x},t) = \sum_{n,n'}\sum_{j=0}^{D(n)} C^*_{n,n'}e^{-iE_{n,n'}t/\hbar}e^{i\frac{2\pi j}{L_xL_z}xz}\tilde{u}_{n,n'}(x,y), \tag{59}$$

with the condition $\sum_{n,n'}|C^*_{n,n'}|^2 = 1$, and where it has been defined the functions $\tilde{u}_{n,n'}$ as

$$\tilde{u}_{n,n'}(x,y) = a_{n'}\sqrt{\frac{2\pi j}{L_xL_y}}\left(\frac{\hbar}{m\omega_c}\right)^{1/4}\psi_n\left(\sqrt{\frac{\hbar}{m\omega_c}}\left(\frac{2\pi j}{L_xL_y}\right)x\right)Ai\big(l^{-1}(y-y_{n'})\big). \tag{60}$$

a) Same system but with new magnetic gauge

Let us consider the magnetic gauge given such that the vector potential is of the form $\mathbf{A} = (0,0,-Bx)$, and the potential is the same $\phi = -\mathcal{E}y$. Passing directly to the eigenvalue problem for the Schrödinger equation when we select the wave function of the form $\Psi(\mathbf{x},t) = e^{-iEt/\hbar}\Phi(\mathbf{x})$, the resulting equation is

$$-\frac{\hbar^2}{2m}\frac{\partial^2\Phi}{\partial x^2} - \frac{\hbar^2}{2m}\frac{\partial^2\Phi}{\partial y^2} - \frac{\hbar^2}{2m}\frac{\partial^2\Phi}{\partial z^2} - i\frac{qB\hbar}{mc}x\frac{\partial\Phi}{\partial z} + \frac{q^2B^2}{2mc^2}x^2\Phi - q\mathcal{E}y\Phi = E\Phi. \tag{61}$$

Taking the Fourier transformation with respect the z-variable, $\hat{\Phi}(x,y,k) = \mathcal{F}_z[\Phi(\mathbf{x})]$, and making some rearrangements, it follows that

$$-\frac{\hbar^2}{2m}\frac{\partial^2\hat{\Phi}}{\partial x^2} + \frac{1}{2m}\big(\hbar k - \frac{qB}{c}x\big)^2\hat{\Phi} - \frac{\hbar^2}{2m}\frac{\partial^2\hat{\Phi}}{\partial y^2} - q\mathcal{E}y\hat{\Phi} = E\hat{\Phi}. \tag{62}$$

This equation admits a variable separable solution of the form $\hat{\Phi}(x,y,k) = \phi_1(k,x)\phi_2(y)$, where the functions ϕ_1 and ϕ_2 satisfy the equations

$$-\frac{\hbar^2}{2m}\frac{d^2\phi_1}{dx^2} + \frac{(\hbar k - \frac{qB}{c}x)^2}{2m}\phi_1 = E^{(1)}\phi_1 \tag{63}$$

and

$$-\frac{\hbar^2}{2m}\frac{\partial^2\phi_2}{\partial y^2} - q\mathcal{E}y\phi_2 = E^{(2)}\phi_2, \tag{64}$$

where $E = E^{(1)} + E^{(2)}$. The solution of these equations are

$$\phi_{1n}(k,x) = \quad _n(\xi) = A_n e^{-\xi^2/2} H_n(\xi), \quad \xi = \sqrt{\frac{m\omega_c}{\hbar}}(x - x_0), \qquad E_n^{(1)} = \hbar\omega_c(n + 1/2) \tag{65}$$

and

$$\phi_{2n'}(y) = a_{n'} Ai(l^{-1}(y - y_{n'})), \quad l = \left(\frac{\hbar^2}{-2mq\mathcal{E}}\right)^{1/3}, \qquad E_{n'}^{(2)} = -q\mathcal{E}y_{n'}, \tag{66}$$

where ω_c is the cyclotron frequency (13a), x_0 is the displacement $x_0 = \hbar ck/qB$, $a_{n'} = 1/|Ai'(l^{-1}y_{n'})|$ is a constant, and A_n the constant associated to the quantum harmonic oscillator solution. The inverse Fourier transformation affect only the function ϕ_1, and we have

$$\phi_{1n}(z,x) = \mathcal{F}^{-1}[\phi_{1n}(k,x)] = \frac{-qB}{\sqrt{mc^2\hbar\omega_c}} e^{-i\frac{qB}{\hbar c}xz} \psi_n\left(\frac{qBz}{\sqrt{mc^2\hbar\omega_c}}\right). \tag{67}$$

The periodic condition on the variable "x", $\Psi(\mathbf{x},t) = \Psi(x + L_x, y, z, t)$, for any value of the other variables, implies that this will happen in particular for the value of $z = L_z$. So, we get the quantization of the magnetic flux (BL_xL_y),

$$\frac{qBL_xL_z}{\hbar c} = 2\pi j, \qquad j \in \mathcal{Z}. \tag{68}$$

Thus, we have a family of solutions $\{\Psi_{nn'j}(\mathbf{x},t)\}$ of the Shcrödinger equation of the form

$$\Psi_{nn'j}(\mathbf{x},t) = e^{-iE_{n,n'}t/\hbar}\Phi_{nn'j}(\mathbf{x}), \tag{69}$$

or (normalized and ignoring the sign)

$$\Psi_{nn'j}(\mathbf{x},t) = a_{n'}\sqrt{\frac{2\pi j}{L_xL_y}}\left(\frac{\hbar}{m\omega_c}\right)^{1/4} e^{-i(E_{n,n'}\frac{t}{\hbar} + \frac{2\pi j}{L_xL_z}xz)} \psi_n\left(\sqrt{\frac{\hbar}{m\omega_c}}\left(\frac{2\pi j}{L_xL_y}\right)z\right) Ai(l^{-1}(y - y_{n'})). \tag{70}$$

By the same arguments about the degenerationn of the systems, the general solution is just a combination of all of these,

$$\Psi(\mathbf{x},t) = \sum_{n,n'} A_{nn'j} e^{-i(E_{n,n'}\frac{t}{\hbar} + \frac{2\pi j}{L_xL_z}xz)} v_{nn'j}(y,z), \tag{71}$$

where the condition $\sum_{n,n'} |A_{nn'j}|^2 = 1$ must be satisfied, and the function $v_{nn'j}$ is given by

$$v_{nn'j}(y,z) = a_{n'}\sqrt{\frac{2\pi j}{L_xL_y}}\left(\frac{\hbar}{m\omega_c}\right)^{1/4} \psi_n \quad \sqrt{\frac{\hbar}{m\omega_c}}\left(\frac{2\pi j}{L_xL_y}\right)z\Big) Ai\big(l^{-1}(y - y_{n'})\big). \tag{72}$$

V. Conclusions and Comments

We have studied the quantization of a charged particle in a flat box and under constants magnetic and electric fields for several cases and have shown that a full separation of variable solution is not admitted in these cases (contrary to Landau's solution in one of these cases). This situation arises since the commutation of a component of the generalized linear momentum operator with the Hamiltonian of the system does not imply necessarily that a variable separation of its associated variable must exist in the Schrödinger equation. However, using the Fourier transformation, we were be able to find the full solution of the problems. As expected, Landau's level appears in all these cases, and a characteristic phase which help us to find the quantization of the magnetic flux in a natural way. We consider that the approach given here maybe very useful to understand quantum Hall effect and related phenomena.

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Global Journal of Science Frontier Research: a
Physics and Space Science
Volume 20 Issue 9 Version 1.0 Year 2020
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Unusual Phenomenon of Forced Heat Exchange taking Place during Quenching Silver Probe in Cold Electrolyte

By Nikolai I. Kobasko

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GJSFR-A Classification: FOR Code: 020304

Strictly as per the compliance and regulations of:

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I. Introduction

The author of the paper was dealing a long time with testing of different kinds of water salts solutions using spherical silver probe 20 mm in diameter. The silver probe was used to evaluate critical heat flux densities of water at different temperatures [1]. However, it was impossible to evaluate critical heat flux densities of water salt solution (electrolytes) using standard silver probe 20 mm in diameter because developed film boiling during quenching was completely absent. Nobody could explain such strange behavior of silver probe during its quenching in cold electrolytes. The matter is that thermal conductivity of silver at 100°C is equal to 392 W/mK while thermal conductivity of steel is equal to 17.5 W/mK. It means that silver probe, according to law of Fourier, can generate during quenching 22 times larger heat flux density as compared with the steel. In this case developed film boiling must be presented. It was not present at all during testing of silver probe in cold electrolytes. Later scientists switched from silver standard probes to Inconel 600 probe 12.5 mm in diameter [2 - 5] and started to use Liscic probe 50 mm in diameter [6, 7] for testing liquid media. A huge amount of experiments were carried out with water salt solutions using standard cylindrical probe 12.5 mm and Liscic probe 50 mm in diameter. Typical temperature cooling curves versus time for cylindrical probe 50 mm in diameter are illustrated in Fig. 1 [8]. As seen from Fig. 1, surface temperature of probe drops quickly almost to boiling point of a liquid that coincides very well with the accurate experiments of French [9]. After that surface temperature of probe maintains relatively a long time at the level of saturation temperature of a liquid until nucleate boiling is finished. Such behavior of surface temperature is called self – regulated thermal process [10, 11]. There is an equation for its duration evaluation. According to authors [12], the heat transfer coefficient (HTC) decreases with decreasing core temperature of the probe during nucleate boiling process. These two main characteristics of the transient nucleate boiling process were taken into account when considering quenching silver probes in water salt solutions of the same concentration. Transient nucleate boiling analysis, observed during cooling steel probes and silver probes of different sizes, allows understanding the nature of forced heat transfer exchange during quenching silver probes in different kinds of electrolytes.

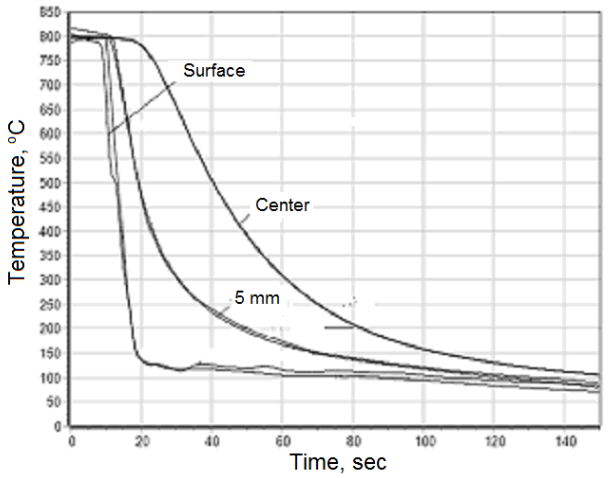

Fig. 1: Temperature curves versus time during quenching 50 mm in diameter cylindrical stainless probe in 14 % water solution of NaCl at 23°C received by experiment [8]

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However, the problem concerning unusual behavior of silver probe during its quenching in electrolytes is not easy to solve. Currently, the Inconel 600 probe is used to get core cooling curves and core cooling rates during quenching of the probe. It has only one thermocouple located at its center. Authors [13] criticized the Inconel 600 probe and recommended using Liscic probe 50 mm in diameter with accurately instrumented through probe section three thermocouples. To solve the mentioned problem on unusual behavior of silver spherical probe during quenching in electrolytes, the author of the paper analyzes accurate experimental data obtained during testing electrolytes by silver spherical probe 20 mm, steel cylindrical probe 12 mm, and cylindrical probe 50 mm in diameter. Based on analyzing experimental data, one can came to conclusion that unusual behavior of silver probe during quenching in cold electrolytes is explained by periodical changing of film boiling by shock boiling that replace each other with the high frequency. Also, in the paper the contemporary theory on nucleate boiling process is considered to formulate ones again the boundary condition used for temperature field calculation during quenching when transient nucleate boiling takes place.

II. Heat Transfer Coefficients Evaluation

The standard probe for evaluating the cooling capacity of quenchants is discussed in [2]. Test methods based on ASTM Standards D6200-01, D6482-99, and D6649-00 for determining the cooling characteristics of quenchants are widely used in practice [2, 3]. The chemical composition of Inconel 600 is: 72 % nickel; 14–17 % chromium; 6–10 % iron; 0.15 % carbon; 0.5 % copper; and 0.5 % silicon. The diameter of the probe is 12.5 mm and its length is 60 mm. Probe details and its general assembly is provided in Ref.. [2].

Fig. 2 illustrates the spherical silver probe used for study unstable film boiling process [14]. The 20-mm-diameter spherical silver probe was prepared by casting the probe from the molten silver with a type K chromel-alumel thermocouple inserted through a 1.5-mm stainless steel sheath, with the thermocouple tip precisely located at the geometric center before casting. After casting, the silver surface was properly ground. The spherical shape of the probe was selected to ensure a uniform heat transfer.

To evaluate heat transfer coefficients and the heat flux density via solving inverse problem, the Liscic probe may be used [6, 7]. This is the most accurate commercially available probe, obtaining the most accurate experimental data. Some experimental results are provided in [13].

The Liscic probe is an excellent tool for investigation of the self-regulated thermal process reported in Ref. [6, 7].

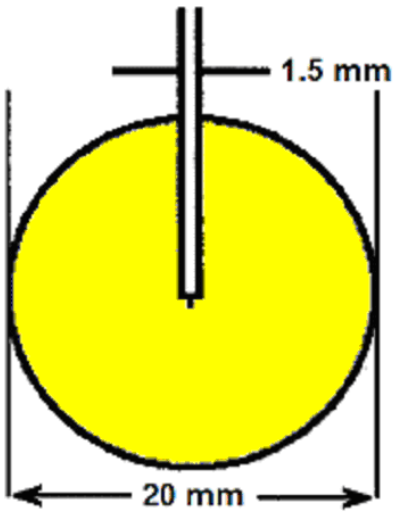

Fig. 2: The spherical silver probe used for testing of quenchants [14].

It was accepted by heat treating community that during quenching of silver probe in liquid media core temperature of the spherical probe always is equal to its surface temperature because thermal conductivity of silver is 400 W/mK and effective heat transfer coefficient (HTC) is not too high that all together always provides Bi < 0.2. However, the condition Bi < 0.2 is not satisfied if consider real heat transfer coefficients (HTCs) instead of effective HTCs [12]. During quenching of silver probe essential temperature difference appears between core and surface temperatures. If so, the problem appears during solving inverse problem in evaluating correct values of HTCs. Probably, CFD modeling could help here. Currently, such computations are performed using CFD (computational fluid dynamics) methods mostly for plain convection, but unfortunately, it cannot be applied effectively yet to boiling processes, which are the main modes of heat transfer during quenching. That is why the regular thermal condition theory of Kondrat'ev was used for approximate evaluation of HTCs during boiling [14]. Also, accurate experimental data of author [15] were used which are shown in Fig. 3. Based on these data and thermal properties of silver and AISI 304 steel (see Table 1 – Tasble 3), HTCs were evaluated which are provided in Table 4.

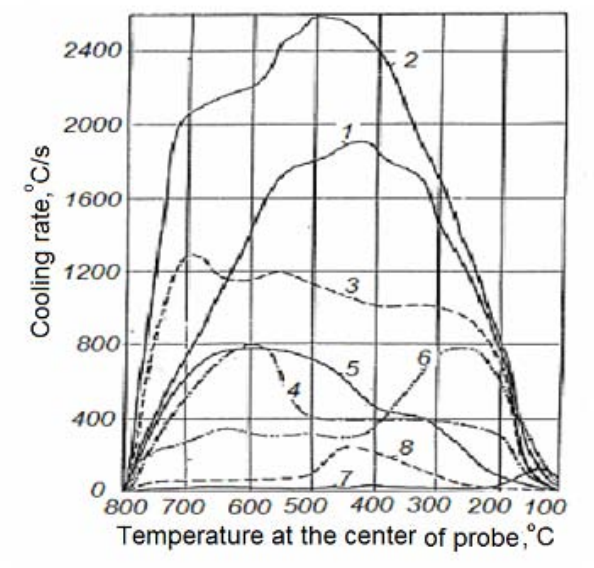

Fig. 3: Cooling rate curves at the center of spherical probe 20 mm diameter obtained during testing different quenchants [15]: 1, 2, 3 are water solutions of NaCl with concentration 5%, 15%, 20% at a temperature 20°C; 4 is 20% water solution NaCl at a temperature 60°C; 5 is 50% water solution of HNO_3 at a temperature (96°C); 6, 7 is water at temperatures 20°C and 98°C; 8 is industrial oil at a temperature 50°C.

Table 1: Thermal conductivity of austenitre versus temperature

T. °C	100	200	300	400	500	600	700	800	900
$\lambda, \frac{W}{mK}$	17.5	18	19.6	21	23	24.8	26.3	27.8	29.3
$\bar{\lambda}, \frac{W}{mK}$	17.5	17.75	18.55	19.25	20.25	21.15	21.90	22.65	23.4

Note $\bar{\lambda}$ *is the mean value for the range between 100°C and the stated temperature.*

Table 2: Thermal conductivity of copper and silver versus temperature

Temperature. °C	0	100	200	400	600	800	900
Copper $\lambda, \frac{W}{mK}$	393.1	384.9	380	365	353.5	340.8	333
Silver, $\lambda, \frac{W}{mK}$	410.5	392	372	362	374.5	-	-

Table 3: Thermal diffusivity of austenitre versus temperature

T. °C	100	200	300	400	500	600	700	800	900
$a \cdot 10^6, m^2/s$	4.55	4.63	4.70	4.95	5.34	5.65	5.83	6.19	6.55
$\bar{a} \cdot 10^6, m^2/s$	4.55	4.59	4.625	4.75	4.95	5.10	5.19	5.37	5.55

Note $\bar{a}$ *is the mean value for the range between 100°C and the stated temperature.*

According to regular thermal conditions theory, cooling rate is directly proportional to Kondrat'ev number Kn (see Eq. (1)) [14]:

$$Kn = \frac{vK}{a(T - T_s)} \quad (1)$$

Knowing Kondrat'ev number Kn, the generalized Biot number Bi_V was found using Eq. (2).

$$Kn = \frac{Bi_V}{\left(Bi_V{}^2 + 1.437 Bi_V + 1\right)^{0.5}} \quad (2)$$

Since the generalized Biot number is designed as

$$Bi_V = \frac{\alpha}{\lambda} K \frac{S}{V} \quad (3)$$

the heat transfer coefficient was evaluated using Eq. (4)

$$\alpha = \frac{\lambda Bi_V V}{KS} \quad (4)$$

Results of calculations are provided in Table 4.

Table 4: Heat transfer coefficients taking place during quenching of silver and steel probes in water salt solutions

Material	Probe , concentration and temperature	HTC at 600°C	HTC at 500°C	HTC at 400°C	HTC at 300°C
Silver	Spherical probe 20 mm in diameter cooled in 5% water solution of NaCl at 20°C	23380	41170	59800	78500
Silver	Spherical probe 20 mm in diameter cooled in 15% water solution of NaCl at 20°C	39380	66000	90650	100300
Silver	Spherical probe 20 mm in diameter cooled in 20% water solution of NaCl at 20°C	18460	23000	27400	89400
Stainless steel	Cylindrical probe 50 mm in diameter cooled in 1% water solution of UCON E at 23°C	4770	4590	2870	2600
Stainless steel	Cylindrical probe 50 mm in diameter cooled in 14 % water solution of NaCl at 23°C	3550	2930	2326	1440
Stainless steel	Cylindrical probe 12 mm in diameter cooled in 6% water solution of Na_2CO_3 at 20°C	121430	-	-	8890

As seen from Table 4, HTCs related to steel probes 12 and 50 mm in diameters are in good agreement with the existing theory of transient nucleate boiling processes taking place during quenching in electrolytes. Namely, the HTCs during nucleate boiling process follow the temperature gradients which were established during quenching of steel probes 12 mm and 50 mm (see Fig. 4). As known [16, 17], $\alpha_{nb} \propto q^{0.7}$. Since for smaller steel probe temperature gradient is larger (see Fig. 4), heat flux density released by it is larger too. It means that average HTC during nucleate boiling is larger for smaller probe. For steel probe 12 mm in diameter at a core temperature 600°C, HTC is equal to 12180 W/m^{2}K while for steel probe 50 mm in diameter HTC is equal to 3550 W/^{2}K. When core temperature in steel probe decreases, HTC decreases too (see Table 4). In contrast to obtained data, with decreasing core temperature of silver probe, the HTC increases almost three times. That can be true for developed film boiling process when it passes to transition boiling where HTC is significantly larger. However, HTCs are so large that they cannot belong to film boiling process. Such huge HTCs can be generated only by developed nucleate boiling process. In fact, it is something different that is not known yet to investigators.

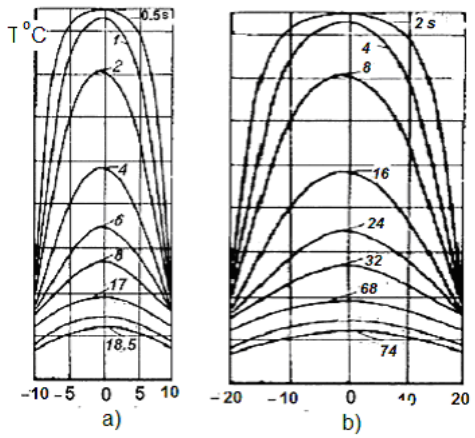

Fig. 4: Temperature fields during quenching of cylindrical probes 20 mm (a) and 40 mm (b) in water salt solution of elevated concentration.

To find out what happens during quenching of silver probe in cold electrolytes and guess what in reality the unusual forced heat transfer exchange is, let's consider one more time the achievements of nucleate boiling processes theory.

III. Contemporary Theory Of Nucleate Boiling Processes

As known, during quenching of metals they are heated and then immersed into a cold liquid, usually open quench tanks. At the time of immersion, boundary liquid boiling layer is formed. The boundary liquid layer is heated to the saturation temperature, and at the same time the part's surface is intensively cooled. Then the liquid at the boundary layer starts to boil and a certain heat flux density is reached that depends on the shape and sizes of the part and thermal conductivity of a material.

Depending on the initial heat flux density, film boiling can take place or can be absent.

It is important to find out the effect of vapor bubble behavior. As known, vapor bubble growth rate is determined as [16]:

$$\overline{W}'' = d_0 f \quad (5)$$

Experiments have not revealed the effect of heat flux density, which was changed by 4 or 5 times, on average value of $\overline{W}''$ [16].

The average vapor bubble growth rate $\overline{W}''$ is essentially affected by pressure

It is of great practical interest to know the effect of aqueous salt solution concentrations on inner characteristics of nucleate boiling process.

Results of experiments, dealing with boiling solutions of NaCl and Na_2CO_3 at normal pressure, are presented in Table 5.

Table 5: Effect of concentration on boiling inner characteristics [16]

Substance	d_0, mm	$f, 1/s$	$W'', mm/s$
Water	2.5	62	155
25% NaCl solution	2.4	64.5	155
29% Na_2CO_3 solution	2.4	65	156

As one can see from Table 5, for high-concentration solutions of NaCl and Na_2CO_3, their vapor bubble growth rates are the same and are equal to W'' of water. It means that concentration affects HTC during nucleate boiling process via Prandtl number Pr. It was shown that for different materials the vapor bubble growth rates are almost the same (see Table 6).

Table 6: Effect of heated surface material upon bubble release diameter and release frequency of vapor bubblers [16].

Material	d_o, mm	$f, 1/s$	$W'', mm/s$	Average value		
				d_o, mm	$f, 1/s$	$W'', mm/s$
Permanite	2.5	61	153			
Brass	2.3	67	157	2.5	62	155
Copper	2.8	56	157			

As follows from Table 6, inner characteristics of boiling process do not depend on sort of material. It means that for silver and steel inner characteristics of boiling process are similar.

Overheating in the boundary layer is higher when greater is heat flux density. When liquid overheating $\Delta T = T_w - T_s$ increases, the number of nucleating centers also increases. Number n of nucleating centers increases by direct proportion to the cube of temperature difference:

$$n \sim \Delta T^3 \tag{6}$$

At the same time, it is well-known that heat flux density at nucleate boiling in average is also proportional to the cube of temperature difference

$$q \sim \Delta T^3 \tag{7}$$

It means that

$$q_0 = \frac{q}{n} \cong const \tag{8}$$

When heat flux density q increases, overheating $\Delta T = T_w - T_a$ of boundary layer also increases and new nucleating centers are activated. Average characteristics d_0, f and $\overline{W}''$ are quite stable with respect to change of heat flux density. The most stable of them is average vapor bubble growth rate.

As known, $\alpha\left(\frac{W}{m^2K}\right)$ is considered during boiling as $\alpha = q/\Delta T$ [16, 17].

The above mentioned HTC is used at the computation of temperature fields during steel quenching.

Tolubinsky proposed the generalized equation for calculation of the heat transfer coefficient at nucleate boiling process which has the following form [16]:

$$\frac{\alpha}{\lambda}\sqrt{\frac{\sigma}{g(\rho' - \rho'')}} = 75\left(\frac{q}{r^* \rho'' w''}\right)^{0.7}\left(\frac{a}{\nu}\right)^{0.2} \tag{9}$$

Where $Nu = \frac{\alpha}{\lambda}\sqrt{\frac{\sigma}{g(\rho' - \rho'')}}$ is Nusselt number; the ratio $\sqrt{\frac{\sigma}{g(\rho' - \rho'')}}$ is proportional to bubble release diameter.

From Eq. (9) follows that

$$\alpha = 75\lambda\left[\frac{g(\rho' - \rho'')}{\sigma}\right]^{0.5}\left(\frac{a}{\nu}\right)^{0.2}\left(\frac{1}{r^* \rho'' w''}\right)^{0.7} \cdot q^{0.7} \tag{10}$$

or

$$\alpha = cq^{0.7} \tag{10a}$$

Where

$$c = 75\lambda'\left[\frac{g(\rho' - \rho'')}{\sigma}\right]^{0.5} \cdot \left(\frac{a}{\nu}\right)^{0.2}\left(\frac{1}{r^* \rho'' w''}\right)^{0.7}$$

A well known handbook [17] provides equation (11) to be used for heat exchange design of technological processes:

$$Nu = 0.082 K_Z^{0.33} \cdot K_q^{0.7} \cdot \mathrm{Pr}^{-0.45} \tag{11}$$

Here

$$Nu = \frac{\alpha}{\lambda'}\delta \;;\; \delta = \left[\sigma / g\left(\rho' - \rho''\right)\right]^{0.5};$$

$$K_Z = \frac{c_p \rho'\left(T_w - T_s\right)R_{cr}}{2\delta \cdot r^{\bullet} \rho''} \;;\; K_q = \frac{q\delta^2}{\rho'' r^{\bullet} a' l_x} \;;$$

$$l_x = \frac{c_p \sigma \rho' T_s}{r^{\bullet} \rho''}$$

From Eq. (11), one can get the same result

$$\alpha = cq^{0.7} \tag{11a}$$

This fact is used for analyzing our calculated data. Thus, different authors came to conclusion that heat transfer during nucleate boiling depends on heat flux density value and is proportional to $q^{0.7}$.

IV. New Heat Exchange Phenomenon Taking Place during Quenching of Silver Probes

According to statistical physics, free electrons in metal in heated area are under pressure P which is calculated as [18]:

$$P = nkT \tag{12}$$

Here n is a number of electrons in one sm^3 of metal; k is the Boltzmann constant which is equal to

$k = 1.3806488\ (13) \times 10^{-23}\ [K^{-1}]$ [18].

During immersion of heated to high temperature metallic probe into electrolyte, a double electrical layer is formed on the boundary liquid – metal which looks like it is shown in Fig. 5 [19 -21]. It happens due to movement of electrons from heated area to cold area. Maximum electrical forcers take place when electrolyte is at an optimal concentration.

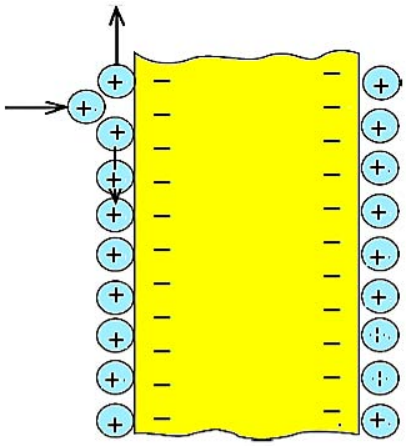

Fig. 5: A double electrical layer formed during immersion of heated probe into cold electrolyte [21].

A huge electrical force appears between surface of metal and electrolyte during quenching in electrolytes of optimal concentration. When quenching probe in cold electrolyte, cooling process can proceed by two ways as it is shown in Fig. 6 [20, 21].

During immersion of the heated probe into cold liquid, there are no bubbles on the metallic surface at all. At this time, cold liquid is heated to the boiling point of a liquid, and the surface temperature of the probe drops rapidly close to the saturation temperature T_s. During this extremely short period of time, heat transfer looks like a convection process. Any form and size of probe can be considered during this extremely short time as a semi – infinity plate which is intensively cooled. Cooling curves for different shapes and sizes are almost the same if film boiling is completely absent. Experiments of French support such behavior of cooling curves. When the liquid is overheated, shock boiling starts, and thousands of small bubbles appear, becoming larger with time. Simultaneously, a temperature gradient is established at the surface of the probe. From this moment of time, two different processes may be developed. The full film boiling is established when the initial heat flux density q_{in} is larger than the first critical heat flux density q_{cr1}, *i.e* $q_{in} > q_{cr1}$. Nucleate boiling process occurs immediately after shock boiling when $q_{in} < q_{cr1}$ [22 - 23].

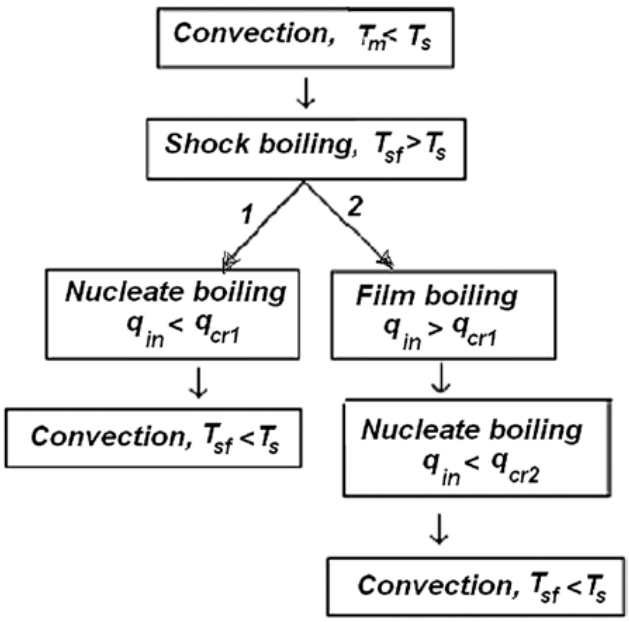

Fig. 6: Two possible boiling processes that may occur during quenching, depending on critical heat flux densities [22].

During steel quenching in cold electrolytes of optimal concentration film boiling is absent because initial heat flux density is below its critical value q_{cr1} [22]. However, during quenching of silver probes in electrolytes, initial heat flux density is so huge that it is always larger than the critical value q_{cr1}. It is true because thermal conductivity of silver is almost 20 times larger as compared with steel. At room temperature thermal conductivity of silver is 400 W/mK while for stainless steel it is only 14 W/mK. During quenching of silver probes in electrolytes electrical forces try to resist film boiling process establishment. Due to their presence, the high heat transfer coefficients (HTCs) can be generated by such a way. When film boiling appears, electrical forces move charged liquid layer to metal surface. The shock boiling starts immediately that creates the new film boiling layer which is a reason for periodical process. And such the periodical cooling process looks like:

film boiling → shock boiling. → film boiling → shock boiling → film boiling → shock boiling Oscillating with the high frequency, shock boiling process generates the high HTCs.

This is a new physical process which can be very useful for practice because such physical process can be governed by external electrical forces to increase essentially HTCs. Especially, it is very important for direct quenching after forging of steel to receive super strengthened materials of high ductility and high wear resistance.

There are three vital ways of affecting and governing boiling processes during quenching to improve radically technological processes aiming service life increase of steel parts and environment improvement. They are:

- Adjusting pressure to delay or accelerate martensitic transformation
- Creating surface insulating layers to drop initial heat flux density below its critical value to prevent completely any film boiling process during quenching of steel parts
- Governing boiling process by external electrical forces to increase HTCs

V. Discussion

From consideration the existing theory of nucleate boiling processes follows that heat transfer coefficient during nucleate boiling is calculated as shown by Eq. (10 a) and Eq. (11a). Both equations can be rewritten as

$$\alpha = cq^{0.7}; \quad q = \alpha\left(T - T_s\right);$$

$$\alpha = c\alpha^{0.7}\left(T - T_s\right)^{0.7};$$

$$\alpha^{0.3} = c\left(T - T_s\right)^{0.7};$$

or

$$\alpha = c^{3.33}\left(T - T\right)^{2.33}. \tag{13}$$

Substituting obtained result (13) into third kind of a boundary condition, we obtain:

$$\left[\frac{\partial T}{\partial r} + \frac{\beta^{10/3}}{\lambda}\left(T - T_s\right)^{10/3}\right]_{r=R} = 0 \tag{14}$$

Based on the obtained boundary condition (14), an analytical solution was received [12] for quenching steel parts in liquid media that resulted in a well known characteristic of transient nucleate boiling process which is written now as:

$$\tau_{nb} = \overline{\Omega} k_F \frac{D^2}{a} \tag{15}$$

This final result was many times verified by accurate experiments which coincided very well with the calculated data. It means that above considered theory of boiling processes is suitable for steel parts quenching since it was many timers supported by experiments.

However, the theory cannot support the discussed above the unusual phenomenon on oscillating and periodical changes of shock and film boiling processes. In this specific case, the boundary condition should include the effect of electrical forces which were not considered yet by physicians. Further investigating the unusual heat exchange process, one can expect essential benefits for heat treating industry and other new technologies development.

VI. Conclusions

1. A new forced heat transfer phenomenon is considered in this paper. Its essence consists in periodical replacement of film boiling by shock boiling that considerably increases heat exchange process during quenching of metal components in water salt solutions of optimal concentration.
2. The discovered new phenomenon can be governed by external electrical forces that in the nearest future will compete with the powerful pumps and propellers focused on eliminating film boiling processes.

Nomenclature

Bi	Biot number
Bi_V	Generalized Biot number
Kn	Kondrat'ev number
Nu	Nusselt number
ψ	Non smoothness of temperature field
α	Heat transfer coefficient
α_{nb}	Heat transfer coefficient during NB
a	Thermal diffusivity of solid material
a'	Thermal diffusivity of liquid
c_p	Specific heat capacity
Ω	Function of convective Biot number
λ	Thermal conductivity of a solid material
λ'	Thermal conductivity of liquid
ρ'	Density of liquid
ρ''	Vapor density
R_{cr}	Critical radius of growing vapor bubble
$r^{\bullet}$	Latent heat of evaporation i
ν	Cooling rate during quenching
σ	Surface tension
D	Diameter or thickness
R	Radius
τ	Time in seconds

K	Kondrat'ev size factor in m^2
k_F	Form coefficient
q	Heat flux density
q_{in}	Initial heat flux density W/m^2
T_w	Wall temperature in °C
$\overline{T}_w$	Average wall temperature in °C
$\overline{T}_V$	Average volume temperature in °C
g	Gravity acceleration
W''	Vapor bubble growth rate
ν	Kinematic viscosity

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Global Journal of Science Frontier Research: a
Physics and Space Science
Volume 20 Issue 9 Version 1.0 Year 2020
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

A New Way to Separate Anions and Cations

By F. F. Mende

Abstract- Electrolysis is currently widely used for the production of various substances, as well as for the isolation of individual elements from the composition of chemical compounds, which by electrolysis are decomposed into anions and cations. For this purpose, electrolysis of aqueous solutions is used, which makes it possible to carry out such a separation in a simple way. For this, electrolyzers are used, where a current is passed through aqueous solutions, while the anions are grouped near the cathode, and the cations are near the anode, from where they are taken. The article considers a new method for the separation of anions and cations, which is based on the polarization of electrolytes. This method differs from the known ones in that it does not require passing current through the electrolyte, which reduces the cost of the production process.

Keywords: *electrolysis, electrolyzer, anion, cation, caustic, chlorine.*

GJSFR-A Classification: *FOR Code: 249999p*

Strictly as per the compliance and regulations of:

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I. Introduction

By electrolysis, salts, acids and other substances soluble in water are separated into their elements or individual groups. The processes occurring during electrolysis are shown in Fig. 1.

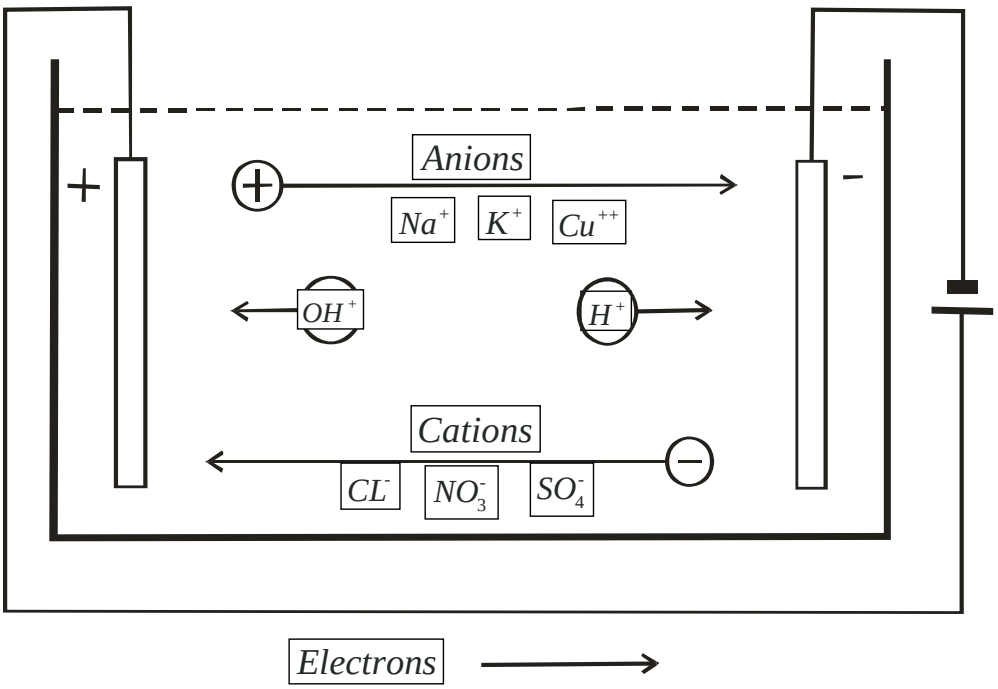

Fig. 1: The processes occurring during electrolysis

In aqueous solutions, salts and acids dissociate into anions and cations [1]. If a current is passed through such a solution, then the anions will move towards the cathode, and the cations will move towards the anode. Anions and cations give their charges to the corresponding electrodes, while neutral atoms accumulate near the cathode, and separate groups of atoms accumulate near the anode, from where they are taken for further use.

Industrial plants using this method are rather cumbersome (Fig. 2) and require significant energy consumption for their operation.

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Fig. 2: Industrial plants for the production of caustic soda and chlorine

II. Methods of Production of Caustic Soda

At the beginning of the 19th century, the production of caustic soda (NaOH) was closely associated with the development of the production of soda ash. This relationship was due to the fact that the raw material for the chemical method of producing NaOH was calcined soda, which was caustified with milk of lime in the form of a soda solution. At the end of the 19th century, electrochemical methods began to rapidly develop for the preparation of NaOH by electrolysis of aqueous NaCl solutions. In the electrochemical production method, chlorine is obtained simultaneously with NaOH, which is widely used in the industry of heavy organic synthesis and in other industries, which explains the rapid development of the electrochemical production of NaOH.

Today, caustic soda is produced either by electrolysis of a solution of sodium chloride (NaCl) to form sodium hydroxide and chlorine [2-4], or, less commonly, using an older method based on the interaction of a solution of soda ash with hydrated lime. A large amount of soda ash produced in the world is used to produce caustic soda.

Consider the process of interaction of a solution of soda ash with hydrated lime. Caustic soda is obtained from calcined at a batch or continuous plant. The process is usually carried out at moderate temperatures in reactors equipped with agitators. The caustic soda formation reaction is an exchange reaction between sodium carbonate and calcium hydroxide:

$$Na2CO3 + Ca\ (OH)\ 2 = CaCO3 + 2NaOH$$

Calcium carbonate precipitates, and sodium hydroxide solution is discharged into the collector.

On an industrial scale, sodium hydroxide is obtained by electrolysis of halite solutions (rock salt NaCl) with the simultaneous production of hydrogen and chlorine according to the scheme

$$2NaCl + 2H2O = H2 + Cl2 + 2NaOH$$

When a concentrated sodium chloride solution is electrolyzed, chlorine and sodium hydroxide are formed, but they react with each other to form sodium hypochlorite, which is used as a bleaching agent. This product, in turn, especially in acidic solutions at elevated temperatures, is oxidized in the electrolysis chamber to sodium perchlorate. To avoid these adverse reactions, electrolysis chlorine should be spatially separated from sodium hydroxide.

In most industrial plants used to produce electrolytic caustic soda, this is done using a diaphragm (diaphragm method) placed near the anode on which chlorine is formed. There are two types of installations: with a submerged or non-submerged diaphragm. The installation chamber with a submerged diaphragm is completely filled with electrolyte. A saline solution flows into the anode compartment, where chlorine is released from it, and a solution of caustic soda fills the cathode compartment. In an installation with an unloaded sub-diaphragm, a solution of caustic soda is discharged from the cathode compartment as it is formed, so that the chamber is empty. In some installations with an unloaded diaphragm, steam is introduced into the empty cathode compartment to facilitate removal of caustic soda and raise the temperature.

In diaphragm plants, a solution is obtained containing both caustic soda and salt. Most of the salt crystallizes when the concentration of caustic soda in the solution is brought to a standard value of 50%. Such a “standard” electrolysis solution contains 1% sodium chloride. The electrolysis product is suitable for many applications, for example, for the production of soap and cleaning products. However, the production of artificial fiber and film requires highly purified caustic soda containing less than 1% sodium chloride (salt). The “standard” liquid caustic can be properly cleaned by crystallization and precipitation.

The membrane method is similar to the diaphragm method, but the anodic and cathodic spaces are separated by a cation exchange membrane. Membrane electrolysis provides the most pure caustic.

Continuous separation of chlorine and caustic can also be carried out in a mercury cathode installation (mercury electrolysis). Sodium metal forms an amalgam with mercury, which is discharged into the second chamber, where sodium is released and reacts with water, forming caustic and hydrogen. Although the concentration and purity of the brine for the mercury cathode unit are more important than for the diaphragm unit, the former produces caustic soda suitable for the production of artificial fiber. Its concentration in the solution is 50–70%. Higher costs for installing a mercury cathode are justified by the benefits.

III. Polarization Method for the Separation of Anions and Cations

As already mentioned, the separation of anions and cations in an electrolytic bath requires passing currents through the solution, which requires a certain amount of energy. But there is a method that does not require such expenses, but this method has not yet been described in known sources. If, as shown in Fig. 3, an electric field is applied to the electrolyte, then it is polarized, while anions will collect on the left side of the bath, and cations will collect on its right side. The charged anions and cations discharged through the openings in the lower part of the bath fall into separate baths, forming two poles of the battery, which generates current if the load is connected between these poles. Upon completion of the cycle of work and a complete discharge of the lower baths, the components of electrolysis remain in them.

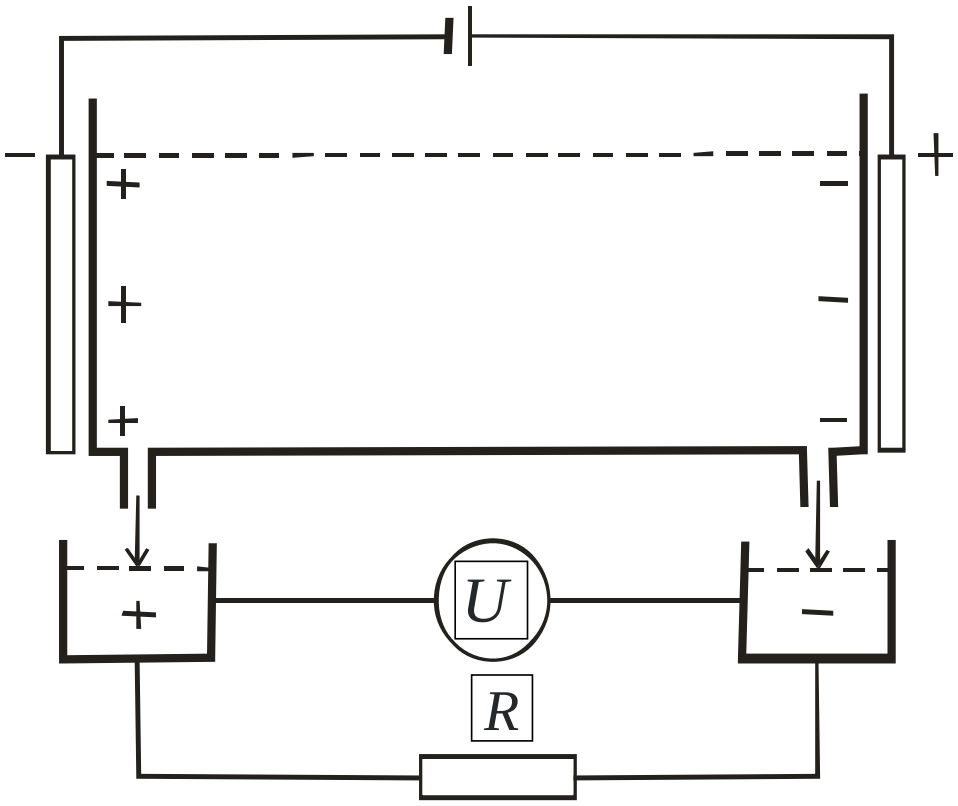

Fig. 3: Installation diagram for the separation of anions and cations by polarization

IV. Conclusion

Electrolysis is currently widely used for the production of various substances, as well as for the isolation of individual elements from the composition of chemical compounds, which by electrolysis are decomposed into anions and cations. For this purpose, electrolysis of aqueous solutions is used, which makes it possible to carry out such a separation in a simple way. For this, electrolyzers are used, where a current is passed through aqueous solutions, while the anions are grouped near the cathode, and the cations are near the anode, from where they are taken. The article considers a new method for the separation of anions and cations, which is based on the polarization of electrolytes. This method differs from the known ones in that it does not require the passage of current through the electrolyte, which simplifies and reduces the cost of the production process.

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Global Journal of Science Frontier Research: a
Physics and Space Science
Volume 20 Issue 9 Version 1.0 Year 2020
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

An Intelligent Cosmos: Philosophy of Science

By Berov G. Lyubomir

Abstract- In this article, I propose a new hypothesis which offers a novel interpretation of the anthropic principle and argues against the premise th\at the Universe is “configured” (via its characteristic constants) specifically so that human life can exist.

Keywords: anthropic principle, universe, humanity, dark energy, dark matter, big bang theory, origin of universe and human life.

GJSFR-A Classification: FOR Code: 240102

Strictly as per the compliance and regulations of:

An Intelligent Cosmos: Philosophy of Science

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Abstract- **In this article, I propose a new hypothesis which offers a novel interpretation of the anthropic principle and argues against the premise th\at the Universe is "configured" (via its characteristic constants) specifically so that human life can exist.**

Keywords: anthropic principle, universe, humanity, dark energy, dark matter, big bang theory, origin of universe and human life.

Dear reader, what do you think? Could we help the modern physics a little bit via a peculiar hypothesis that provides a new explanation of the anthropic principle?

The anthropic principle is used by many world-renowned physicists to explain some of the fundamental physical constants of our universe. This principle is the philosophical premise that any data we collect about the universe is filtered by the fact that, in order for it to be observable at all, the universe must have been compatible with the emergence of conscious and sapient life that observes it. In other words scientific observation of the universe would not even be possible if the laws of the universe had been incompatible with the development of sapient life. It explains why this universe has the age and the fundamental physical constants we observe - for example the gravitational constant, the charge and mass of the electron, the mass of the proton and others, necessary to accommodate conscious life.

In simple words, the anthropic principle is based on the premise that everything around us is created only so that we, humans, can exist and create our messes. Here! Time and time again, man comes first. I believe that with my new hypothesis, everything can get a much more meaningful explanation.

So, dear reader, let's start with a brief history of our universe. According to the Big Bang theory, which is prevalent among the scientific community, the expansion of the universe begins with an extremely hot and dense phase called the Planck era, where all the mass and energy of the observable universe was concentrated in a very tiny space. From that moment on, the universe has expanded, reaching its present state. Several independent experiments confirm the theoretical formulations of the Big Bang theory. According to those experiments, the universe will continue to expand indefinitely.

The universe is very old, and both the universe itself, and our perception of it continue to evolve. The most accurate approximation of the age of the universe, based on observations of relic radiation, is 13.7 billion years. The universe is constantly changing, and the state of the universe today is different from any other state in its history. For example, the number of quasars and galaxies is changing and the galactic space itself is expanding.

But what is the universe made of? Its smallest component is the ordinary matter. The ordinary matter consists of us and all life on Earth, the planets, the stars, the galaxies. This matter is approximately 4 percent of the composition of the universe. Then, about 23 percent of the universe is the invisible (dark) matter. "Invisible" means that it does not interact with any form of radiation, including the electromagnetic radiation. It does not emit in the electromagnetic spectrum. It does not reflect either. Simply, the invisible matter does not interact with the electromagnetic spectrum, which is the main tool we use to observe matter. So how do we know dark matter exists? We know this because of its gravitational effect.In fact, dark matter dominates on a large scale the gravitational effects in the universe, and there is clear evidence to prove this. One example is the speed at which stars orbit galaxies. This speed is too high, and the reason is that the galaxies are covered by dark matter. The speed at which galaxies orbit within a cluster is also too high for the same reason.

The third major ingredient of the universe is the dark energy which comprises about 73 percent. Its existence has been confirmed both experimentally and theoretically. Experimentally, the existence of dark energy was confirmed through the discovery of the rate of expansion of the universe. Recent studies confirm previous results that the properties of dark energy have not changed over billions of years. Theoretically, the confirmation of dark energy's existence is through the idea that dark energy is best explained by the "cosmological constant", proposed first by Einstein, which is equivalent to the energy of the vacuum.

Dear reader, after these explanations, I believe that we are ready for my peculiar new hypothesis.

This hypothesis is based on the experimental confirmation, that we just discussed, that dark energy has not changed over billions of years. I expand on this discovery, by proposing the idea that not only dark energy has remained unchanged during the life of our universe, but it also existed at the time of the creation of our universe. And, most importantly, I assume that dark energy WAS the creative force of our universe. In my human imagination, dark energy is an intelligent Being with unimaginably powerful intellectual and creative

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abilities. In my hypothesis, I assume that there are an infinite number of other dark energies, similar to the one in our universe, that have created and continue to create other universes.

And now, let's focus on our universe. I have no idea why it was created. I have only great hopes that we, humans, as beings with some basic intelligence, are needed by its creative force. And when it comes to the puzzling values of the physical constants mentioned above, and, for that matter, all the physical laws that govern our universe, those are simply inherent to the intelligent Being (aka the dark energy) that has created the universe and carries it within itself. As for us, humans, we have simply adapted to those constants and laws. And this is the new interpretation of the famous anthropic principle that I propose.

To expand further, I am convinced that there are an infinite number of other intelligent beings in our universe who have come to exist and adapted to live in conditions very different from ours. Those other intelligent beings are, therefore, very different from us, but there is still something that connects us and unites us with them. The uniting link is the intelligence (albeit in different degrees of development), and our common goals, that connect us all with our creative force– the dark energy in our universe. I think that realizing the need to connect with the other intelligent beings that are closest to us is one of the most important priorities we face.

Dear reader, I am firmly convinced that, even at this very moment, we are in contact with other intelligent beings in our universe. However, I believe that this contact, this relationship, is one-sided – on their part it is conscious, and on our part, we are yet to realize it. But I also believe that this realization is about to happen in the very near future.

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Global Journal of Science Frontier Research: a
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Volume 20 Issue 9 Version 1.0 Year 2020
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New Types of the Electrostatic Generators

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Abstract- One of the first electrostatic generators is Calvin's dropper, which invented the lord Calvin in 1863. This generator gave the possibility to obtain voltage of up to 20 kV. Further development of electrostatic generators was the invention of the electric generator, developed between 1880 - 1883 the British inventor By James by Whimshurst. This generator gave the possibility to obtain voltage of up to 100 kV and it is above. Wide practical use in the accelerating technology obtained de Graaf's generator. This is the generator of the high voltage, the operating principle of which is based on the electrization of that moving dielectric tape. Such generator was developed American by the physicist By Robert van de Graaf in 1929 for year it made possible to obtain the voltage to 80 kV. In 1931 - 1933 they built the more powerful generators, which made it possible to reach voltage in 1 MV and 7 MV respectively. In the article are described three new constructions of the electrostatic generators, one of which is pulse.

Keywords: *electrostatic induction, polarization, dropper of calvin, electrical generator, belt generator.*

GJSFR-A Classification: *FOR Code: 240504*

Strictly as per the compliance and regulations of:

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I. Introduction

One of the first electrostatic generators is Calvin's dropper, which invented the lord Calvin in 1863 [1]. This generator gave the possibility to obtain voltage of up to 20 kV.

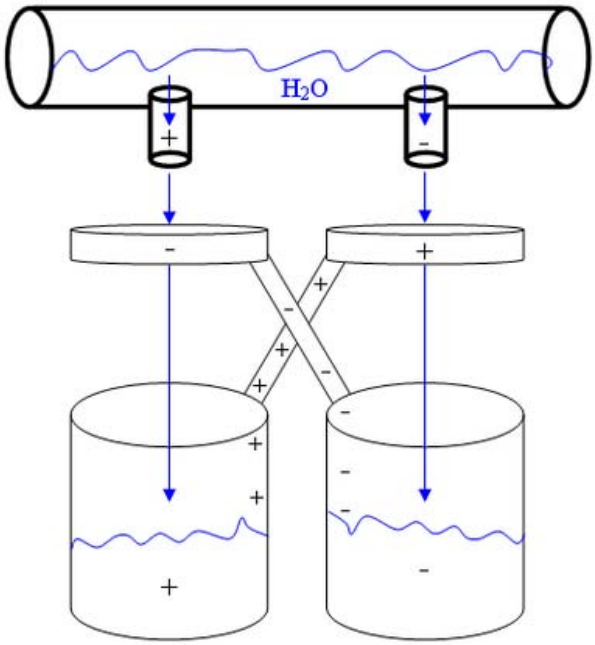

Fig. 1: Calvin's dropper

Further development of electrostatic generators was the invention of the electric generator, developed between 1880 - 1883 the British inventor By James by Whimshurst [2]. This generator gave the possibility to obtain voltage 100 kV and it is above.

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Fig. 2: The electric generator, invented by James by Whimshurst

Wide practical use in the accelerating technology obtained de Graaf's generator [3].

Fig. 3: Belt generator for the first in Hungary linear accelerator

This is the generator of the high voltage , the operating principle of which is based on the electrization of that moving dielectric tape. The first generator was developed American by the physicist By Robert van de Graaf in 1929 for year it made possible to obtain the voltage to 80 kV . In 1931 - 1933 they built the more powerful generators, which made it possible to reach voltage in 1 MV and 7 MV respectively.

The history of the development of the new types of electrostatic generators concludes on this also in the scientific literature other types of such generators are not described.

II. New Constructions of the Electrostatic Generators

Oscillator circuit, intended for obtaining the high voltages, it is represented in Fig. 4.

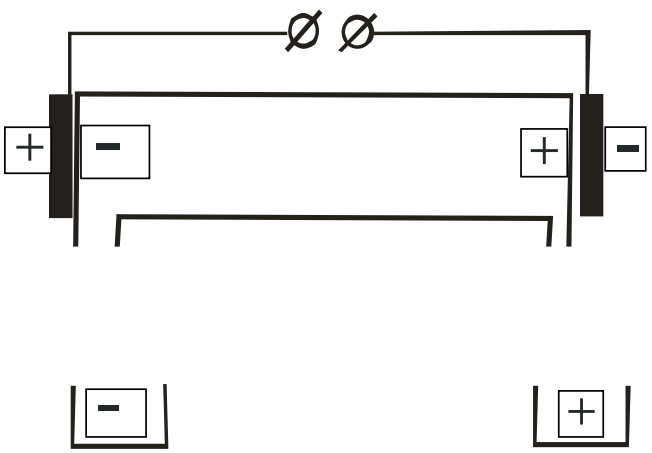


Fig. 4: Electrostatic generator with the forced polarization

In this diagram the forced polarization of water in the upper capacity is achieved. Polarization is achieved with the aid of the external source, whose voltage is applied to the electrodes, located on the ends of capacity. In this case the water jet, which escapes from lateral openings, bears on itself the charges, which it falls into the lower capacities.

The schematic of pulse electrostatic generator is represented in Fig. 5.

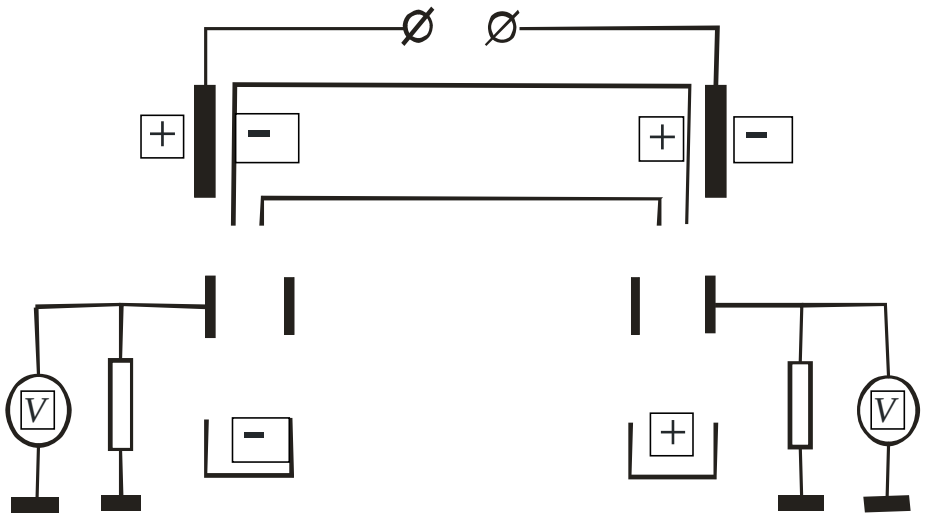


Fig. 5: Pulse electrostatic the generator

In comparison with the generator with the forced polarization this generator has two additional annular electrodes, capacities with the water located below. The charged drop, flying through these electrodes, induces in them the charges of opposite sign. These charges, flowing through the load resistances, and create on them the appropriate surge voltage. The form of this voltage depends on the relationship of the height of electrodes and diameter of drop. If these sizes are commensurate, then bipolar pulse will be observed. But if the diameter of drop is considerably less than the height of electrodes, then will be observed two short pulses of the different polarity, spread on the time to the transit time of the drop through the electrode.

For investigating the new types of generators was assembled the multifunctional mock-up of dropper, in which is possible the realization of different regimes. Depending on the commutation of its different elements can be assembled the mock-up, both the mock-up of Calvin's dropper and, etc the modification of generators. Block diagram of the multifunctional dropper it is shown in Fig. 6.

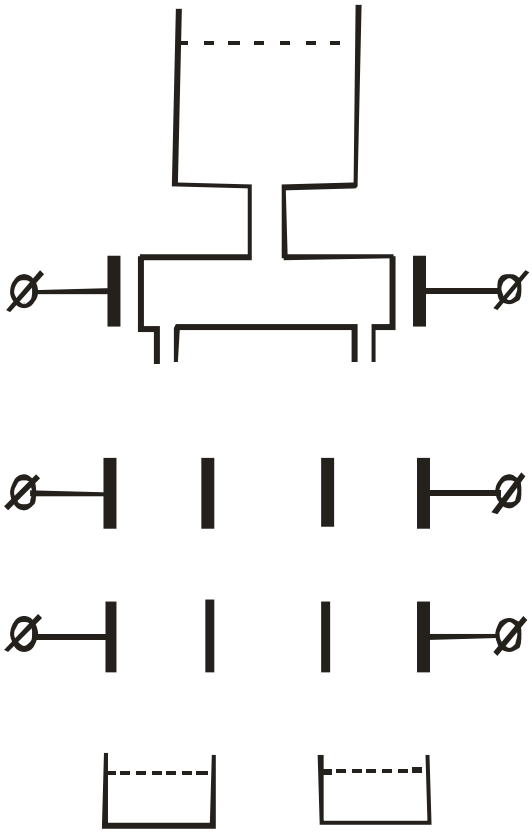


Fig. 6: Block diagram of the multifunctional the dropper

Electric generator for obtaining the high voltages was also prepared.

The common form of the mock-up of dropper and electric generator is shown in Fig. 7.

Fig. 7: The common form of the multifunctional dropper and the electric generator

The maximum voltage, which it could ensure generator, is approximately 50 kV.

The mock-up of multifunctional dropper consists of two separate droppers, each of which has on two pairs of electrodes, to which can be connected the electric generator. One of such regimes is represented in Fig. 4. In this regime on the lateral electrodes of upper capacity will be supplied voltage from the electric generator. The electric field of these electrodes polarizes water in the capacity. The carried out experiments showed that this regime differs little from the regime Calvin's dropper.

The experiments were further carried out according to the diagram, represented in Fig. 8.

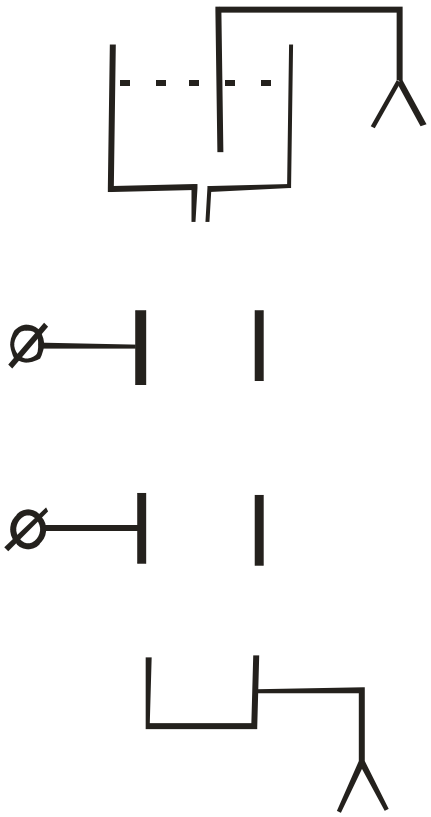
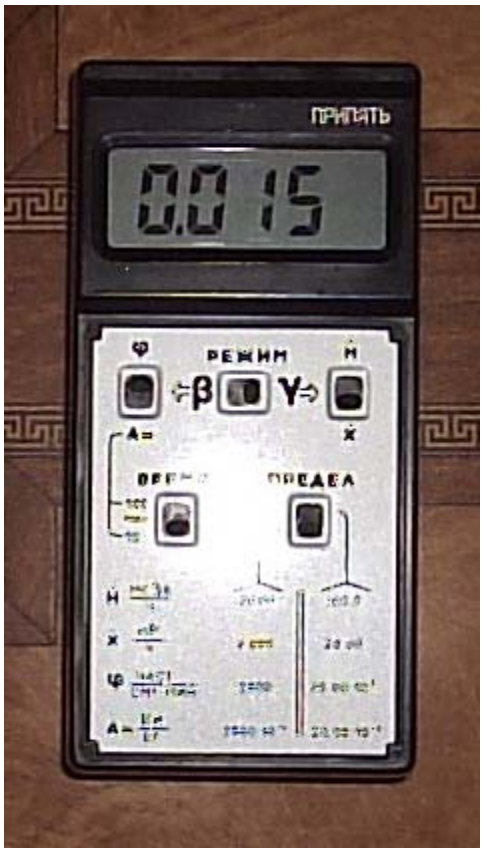
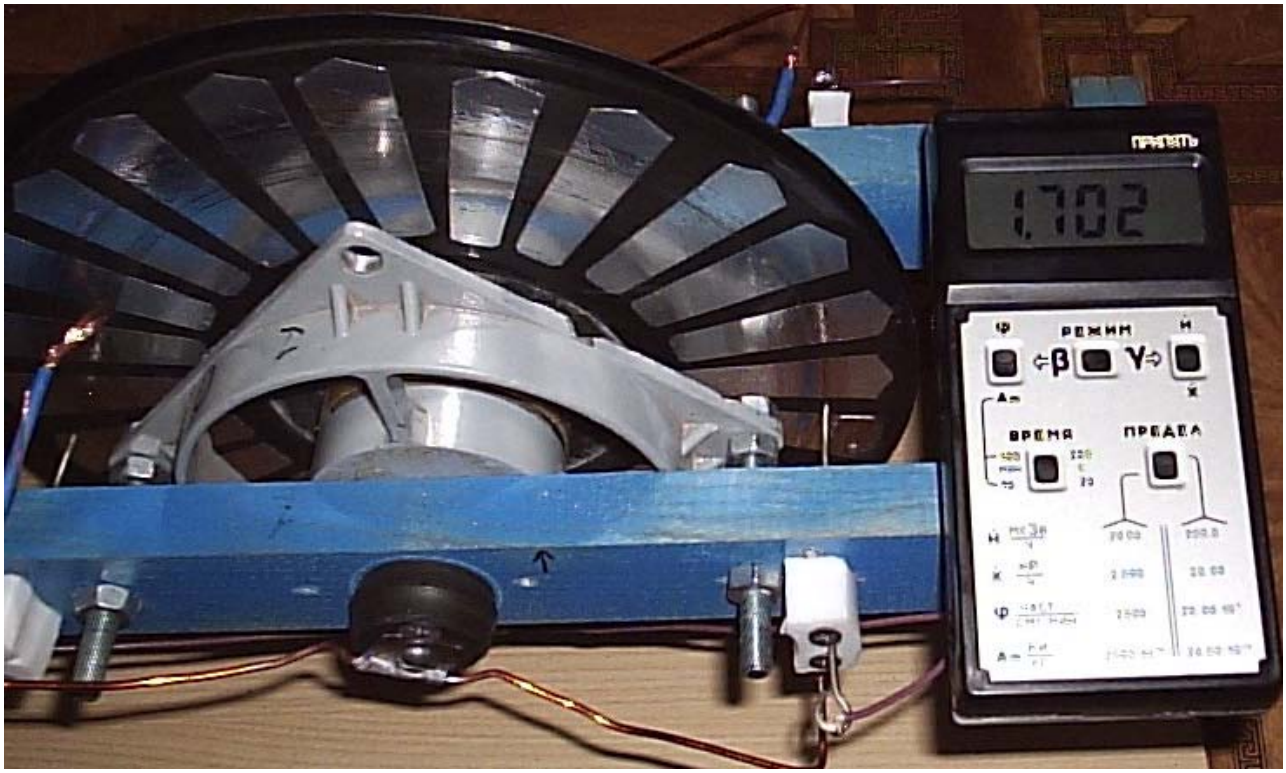


Fig. 8

In this case the voltage from the electric generator is connected to two intermediate electrodes, located between the upper and lower capacity, in that place, where the water jet already became drops. As can be seen from Fig. 7, upper capacity is established on two plastic counters and is reliably isolated from the platform, on which is installed the dropper. In the process of conducting the experiment it was explained that the potential of upper capacity remains constant and does not change for entire time interval, thus far upper capacity not to be freed from the water. At the same time the potential of lower capacity, grows, reaching 20 kV, and it has direct dependence on the voltage, supplied from the electric generator of the appropriate electrodes. From this it is possible to conclude that the charges, which fall into the lower capacity, enter not of the upper capacity, but are seized by the polarized drops waters during their flight between the electrodes. This is confirmed by that fact that the process of the electrization of lower capacity considerably increases, when electric generator in immediate proximity is located from the electrodes. This generator is powerful ionizers of atmosphere. The power of the exposure dose of the gamma – emission of normal radiation background comprises order 0.010 - 0.020 mR/h. Here are these indications of radiometer.



But if radiometer was placed directly on the working electric generator, in as shown in following photograph, then counter shows radiation dose more than one hundred times large of standard. This is the same radiation background, which was observed in the Chernobyl' zone the month after the explosion of reactor.



Thus, carried out experiments indicate the the fact that polarized drops of water they can seize ions from the atmosphere, which were formed as a result the action of external radiation background.

III. Conclusion

One of the first electrostatic generators is Calvin's dropper, which invented the lord Calvin in 1863. This generator gave the possibility to obtain voltage of up to 20 the sq. Further development of electrostatic generators was the invention of the electric generator, razrabotanogo between 1880 - 1883 the British inventor By James by Whimshurst . This generator gave the possibility to obtain voltage of up to 100 kV and it is above.

Wide practical use in the accelerating technology obtained de Graaf's generator. This is the generator of the high voltage, the operating principle of which is based on the electrization of that moving dielectric tape. This first generator was developed American by the physicist By Robert van de Graaf in 1929 for year it made possible to obtain a potential difference to 80 kV . In 1931 - 1933 they built the more powerful generators, which made it possible to reach voltage in 1 MV and 7 MV respectively.

Both the generators examined provide the possibility of obtaining the high values of voltage with the low currents; therefore as the generators of power they are used be they cannot also for this reason for practical application they did not have.

The history of the development of the new types of electrostatic generators concludes on this also in the scientific literature other types of such generators are not described.

In the article are examined three new constructions of the electrostatic generators, one of which is pulse.

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Global Journal of Science Frontier Research: a
Physics and Space Science
Volume 20 Issue 9 Version 1.0 Year 2020
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Spectroscopic Studies on Ti^{3+}-Doped Na_2O-Pbo-Al_2O_3-B_2O_3-Sio_2 Glasses

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Keywords: optical absorption, FT-IR, XRD, DTA analysis, physical parameters.

GJSFR-A Classification: FOR Code: 020503

Strictly as per the compliance and regulations of:

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K. Vijaya Babu [α] & V. Madhuri [σ]

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Keywords: optical absorption, FT-IR, XRD, DTA analysis, physical parameters.

I. Introduction

In recent years glasses are receiving significant attention due to their unique properties like hardness, good strength, transparency, excellent corrosion resistance. Hence much attention has been paid in research to oxide glasses doped with transition metal ions due to their technological importance in the development of tunable solid-state lasers and new luminescence materials.

Among the oxide glasses, borosilicate glasses are especially attractive because they have many and diverse applications. They generally have lower thermal expansion values, chemical resistance, high dielectric strength, high softening temperatures than other commercial glasses. For this reason, they are used as glassware and also used in industrial piping, bulbs or hot lamps. Thus, they are having a wide range of applicability. Recent studies prove that they can also take a role in the immobilization of nuclear waste to perform bioactivity [1, 2]. B_2O_3 is considered as a basic glass former because it has a lower heat of fusion, cation size, higher bond strength. In general, the high bond strength of B-O bonds in B_2O_3 leads to the high field strength of B^{3+} and make these borates as very stable glasses. Boron is recognized as it has more than one stable configuration i.e., boron triangles $[BO_3]^{3+}$ and tetrahedrally coordinated $[BO_4]^{3+}$ in the glass matrix [3, 4].On the other hand, silica attracts attention due to its long infrared cutoff along with higher chemical and thermal stability as compared to the B_2O_3 containing glasses [5]. Vitreous SiO_2 has a higher glass transition temperature (T_g) and softening temperature (T_s) due to higher network connectivity and hence higher amount of bridging oxygen [6]. Na_2O is a common flux, reduces the dispensation temperature and changes the properties of glass. On the other hand, PbO addition to its glass composition ensures an improvement of the chemical durability and enhances the resistance against diversification [7]. The presence of Al_2O_3 in the glass matrix makes the glasses more resistant to attack by alkali metal ions like Li^+ and Na^+. $Al_2O_3$is entering into the glass network with AlO_4 structural units that crosslink the neighboring borate and silicate chains. Al_2O_3 is often used to modify the glass structure, which improves chemical stability and physical properties. The Al^{3+} ions not only affect thermo-mechanical properties, but also laser properties. Al_2O_3 mixed borosilicate glasses are being widely used in industrial applications as sealing materials, separators in batteries, precession mirror-blanks for space, microwave cavities, and dental cement components on the whole, the glass properties are related to its inter-atomic forces and as well as the potential of the local structure. Therefore, the addition of modifier and intermediate oxides can introduce change in the local structure and as well as the energy band gap. Variation in optical absorption and its relationship with structure is one of the important parameters for glasses.

Borosilicate glasses have been widely used in many applications such as semiconductor technology, optical communications and other areas of electronics [8-10]. The properties of borosilicate glasses include chemical and thermal resistance in various fields such as electronic displays, house hold glasses and optoelectronics, sealing glasses to nuclear waste immobilization and also as a construction material. Moreover, these materials have excellent optical clarity, low electrical conductivity, low thermal expansion coefficient, good UV transparency and low susceptibility.

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Hence these glasses are used as lenses in high-quality flash lights and astronomical reflecting telescope [11].

Oxide glasses containing transition metal ions (TMI) [12, 13] are of interest because of their applicability in memory switching, electrical threshold, and optical switching devices, etc.,[14]. The nature of these glasses is due to the presence of two valence states of the transition metal ions [12, 13, 15]. By altering the chemical composition of glass by incorporating the transition metal (TM) ions into the network can change its local environment leading to in-homogeneities in the crystal field around the transition metal ion. These structural modifications may be well reflected in the EPR and optical absorption spectra of the TM ions.

Glasses containing titanium have gained much importance in recent years due to their possible applications in non-linear optical devices such as ultra-fastswitch and power limiter 100 [16, 17]. Titanium oxide is considered as a nucleating agent of crystallization in the amorphous materials. However, the presence of small quantities of TiO_2 in the glass matrix is observed to enhance the glass-forming ability and chemical durability of the glasses [18]. In general, the ions of titanium exist in the glass network states in Ti^{4+} state and participate in the glass network forming with TiO_4, TiO_6 and sometimes TiO_5 (comprising of trigonal bi-pyramids) structural units [19, 20]. However, there reports suggesting that these ions may also exist in Ti^{3+} state in some of the glass networks [16]. The empty or unfilled d-shells of titanium ions contribute more strongly to the non-linear polarizabilities. Usually, the d-orbital contribution to non-linear polarizability is found to be more for bond lengths less than 2Å [17]. The bond length of Ti-O is estimated to be 1.96 Å. Aliterature survey on the glasses containing TiO_2 indicates that these glasses possess a negative non-linear refractive index that induces a self-focusing radiation beam in the material; as a result, the devices can be operated at a smaller input power [21]. Further, the investigation on the coordinate chemistry of Ti^{4+} ions in alkali alumino borosilicate glass network is of interest in itself because these ions are expected to influence the physical properties of the glasses to a large extent. EPR spectroscopy can be used to determine the ratio of different valence states in these glass systems [22]. Optical absorption studies of glasses give rise to ligand field absorption energies, which sensitively reflect the distortion of the cubic, octahedral, tetrahedral coordination. The spectroscopic investigation of titanium bearing glasses taken with a view to understand the site symmetry of the metal ion, oxidation state and splitting of energy levels. In the present matrix, four samples of composition $20Na_2O$-10PbO-(5-x) Al_2O_3-$40B_2O_3$-$25SiO_2$-$xTiO_2$ with x = 0, 0.3, 0.6 and 0.9 (mol %) were prepared and their specific spectroscopic properties were studied. The details of the composition are as follows:

$20Na_2O$-10PbO-5.0 Al_2O_3-$40B_2O_3$-$25SiO_2$

$20Na_2O$-10PbO-4.7 Al_2O_3-$40B_2O_3$-$25SiO_2$-$0.3TiO_2$

$20Na_2O$-10PbO-4.4 Al_2O_3-$40B_2O_3$-$25SiO_2$-$0.6TiO_2$

$20Na_2O$-10PbO-4.1 Al_2O_3-$40B_2O_3$-$25SiO_2$-$0.9TiO_2$

II. Materials and Methods

a) Glass preparation

The glass samples are prepared by conventional melt quenching method using analar grade chemicals of Na_2O, PbO, Al_2O_3, B_2O_3, SiO_2 and TiO_2 as starting materials with 99.9% purity. The raw materials are thoroughly mixed in an agate mortar and the homogenized mixture was transferred into a silica crucible. The compositions of the materials are melting in the air in silica crucibles in an electric furnace at temperature 1200^0C for 20 min until a bubble-free liquid is formed.At the end of the melting process in order to obtain homogeneous glass, the melts are poured on brass mold and subsequently annealed at 400 ^{0}C for 8hrs and cooled slowly to release the thermal stress. The glass matrix obtained is transparent and colorless. The samples are then ground and optically polished.

b) Measurements

The amorphous nature of the prepared glass was confirmed by an X-ray powder diffractometer (XRD) on XRD-6100 SHIMADZU X-Ray diffract meter in the scanning range of 10-80^0 (2θ) using Cu K_α radiation having a wavelength of 1.5406 Å at room temperature. The Optical absorption spectra of glass samples are recorded using JASCO V-670 UV-vis-Spectro-photomètrein the wavelength region of 200-1200 nm. The EPR spectra are recorded for all glass samples at the X-band using JOEL JES-FA200 EPR Spectrometer with 100 KHz field modulation at room temperature. The Fourier transform infrared transmission spectra of different prepared glasses are measured using the KBr pellet method on SHIMADZU-IR Affinity-1S FT-IR spectrophotometer in the region of 4000-400 cm^{-1} wave number range. The density of the samples was determined to an accuracy of ± 0.001 by standard Archimedes' principle by using O-xylene (99.99% pure) as a buoyant liquid with VIBRA HT density measurement kit and some other physical parameters are also evaluated.

III. Results and Discussion

a) Physical parameters

Fig. 1 shows the variation of density (d) and molar volume (V_m) of these glasses as a function of TiO_2 content. It is clear from this Fig. 1 that, with increasing TiO_2, density increases and molar volume decreases. The physical parameters shows that, the variation of density (d) and calculated average molecular weight, various physical parameters such as titanium ion

concentration (N_i), molar volume (V_m), mean titanium ion separation (r_i) and polaron radius (r_p) are evaluated using conventional formulae and the values obtained are listed in Table 1.

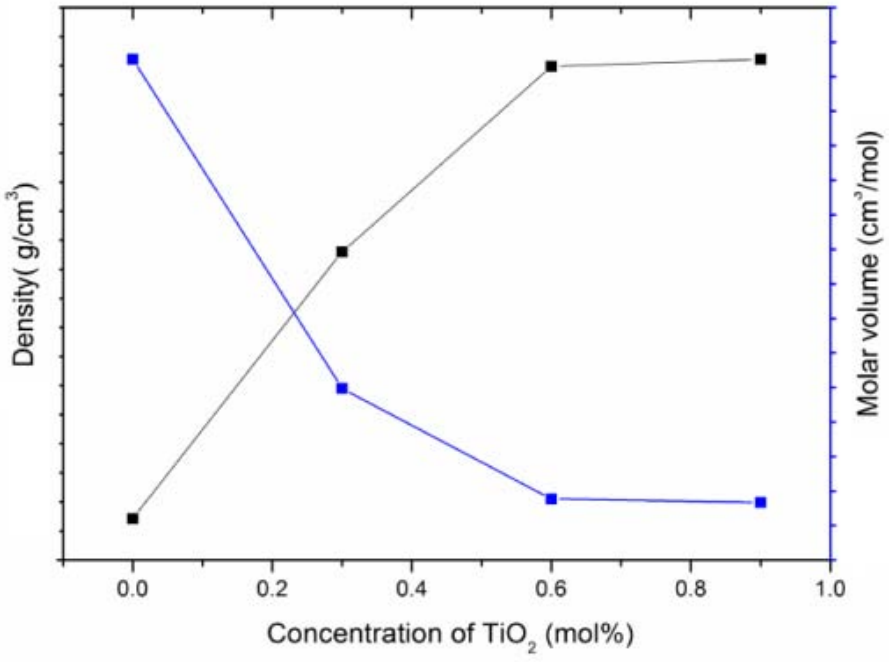

Fig. 1: Density and molar volume values with a varied TiO_2 content inNPABS glasses

Density is an influential property capable of exploring the changes in the glasses. Density is affected by the softening/compactness, change in geometrical configuration, coordination number, cross-link density and dimensions of interstitial spaces of the glass. Thus, the addition of any transition metal ions to the glass leads to a linear or nonlinear variation, i.e., either increase or decrease in the density with changing composition [23]. It is clear from this figure that, with increasingTiO_2, density increases and molar volume decreases with TiO_2 additions. The sample T_3 exhibited a higher density 3.022 than the sample T_2 of density 2.997 g/cm^3. This slight decrease in the density of the sample $T_3$when compared to the sample T_2 may be attributed to the volume expansion due to the formation of the octahedral TiO_6 structural unit in the glass network. This could further be confirmed through FT -IR measurements of the glasses [24].

Table 1: Various physical properties of TiO_2 doped NPABS glass system

Parameters	Pure	T_1	T_2	T_3
Density (g/cm^3)	2.960	2.987	2.997	3.022
Molar volume	29.854	29.562	29.440	29.175
Ion.Conc (Ni)x10^{20}	-	0.6112	1.2277	1.858
Inter ionic distance r_i (Å)	-	0.2306	0.1725	0.1510
Refractive index n_d	1.653	1.654	1.655	1.656
Polaron radius r_p (Å)	-	0.1043	0.0822	0.0715
Optical Basicity	0.4296	0.4298	0.4299	0.4300

b) X-ray diffraction (XRD) studies

The powdered XRD patterns for the prepared glass samples are presented in Fig. 2. These patterns confirmed the glassy nature of the samples with broad peaks at 2θ values around 20-40° and are free from any detectable crystalline phases [25].

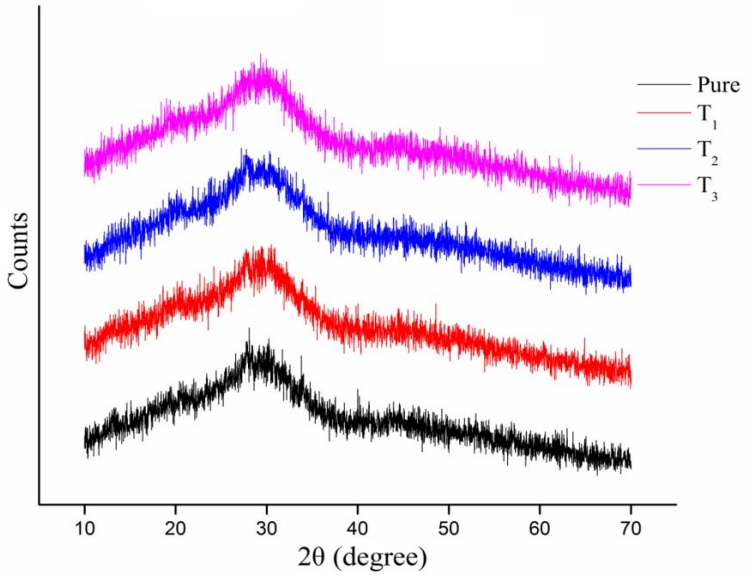

Fig. 2: XRD Spectra of TiO_2 doped NPABS glasses

c) Fourier transform infrared (FT-IR) spectroscopy

From Fig. 3, the FT-IR spectra of TiO_2 free glass show four visible bands. The band at about 466 cm^{-1} is due to Si-O-Si asymmetric vibration and the small shoulder at 715 cm^{-1} is attributed to bending vibration of B-O-B in [BO_3] triangles [26, 27] is observed. The main intense band at 850 -1100 cm^{-1} is due to the combined stretching vibrations of Si-O-Si and B-O-B network of tetrahedral structural units [28]. Here the distinguished feature of glass samples is the shift of the broad band at 967 cm^{-1}, indicating that Ti^{3+} exists in octahedral coordination. A strong absorption band at 1375 cm^{-1} is attributed to the B-O stretching vibration of [BO_3] triangles (characteristic for BO_3 group) [29]. With the addition of Al_2O_3 content, the frequency of the band between 850 and 1100 cm^{-1} exhibits a shift to lower wave number and the width becomes wide by decreasing Al_2O_3 content. While the frequency of the band at around 1375 cm^{-1} does not have any changes with the decreasing Al_2O_3 content. It may be worth mentioning here that the earlier studies on the IR spectra of various other glasses containing TiO_2 indicate the presence of a vibration band at about 769 cm^{-1} due to vibrations TiO_4 groups. Hence, there is a possibility for the formation of single boron-oxygen-titanium frame work in the glass network. In addition, the spectrum of T_3 glass exhibited a single well-resolved band at 710 cm^{-1} due to B-O-Ti linkages. The summary of the data on the position of various band head in the TiO_2 doped NPABS glasses are presented in Table 2.

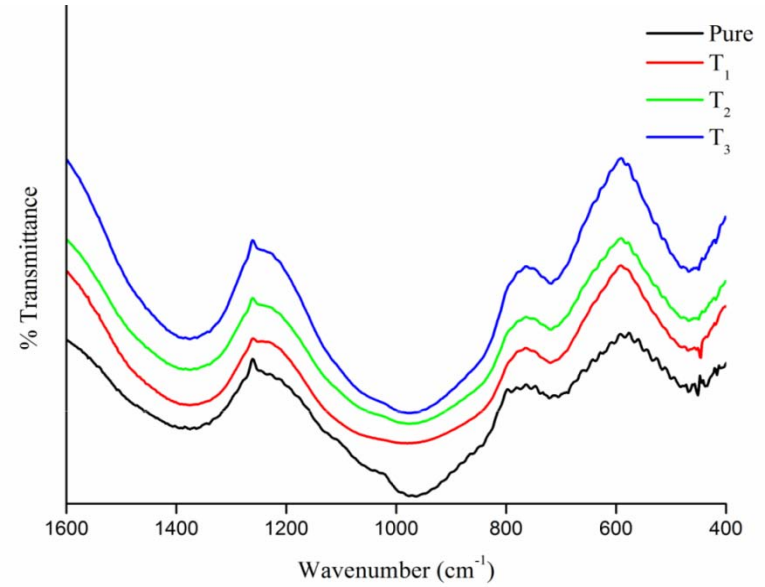

Fig. 3: FT-IR spectra of TiO_2 doped NPABS glasses

Table 2: FT-IR spectra f TiO_2 doped NPABS glass system

Pure	T_1	T_2	T_3	Assignment
453	454	459	463	Asymmetric Vibration of Si-O-Si
714	716	718	720	Bending Vibration of B-O-Bin [BO_3] triangles
-	-	765	-	B-O-Ti groups
-	-	-	787	TiO_4 groups
969	976	981	982	Combined Stretching Vibrations of Si-O-Si and B-O-B
1380	1383	1385	1385	Stretching Vibrations of [BO_3]

d) Differential thermal analysis (DTA)

In the Fig. 4 DTA scans for title glasses doped with different concentrations of TiO_2 are presented, all the traces exhibited typical glass transition with the inflection point between 527-543 ^{0}C due to glass transition, it is interesting that the glass transition temperature is increasing with the increase of TiO_2 content [30]. In the region, 950-1000 ^{0}C, an endothermic peak due to crystallization is observed in the trace of all the glasses [31]. The parameter (T_c-T_g), a measure of thermal stability of glass against diversification, increases with the increase of TiO_2 concentration. Such trend indicates the decrease of augmented cross-link density of various structural groups in the network and closeness of packing.

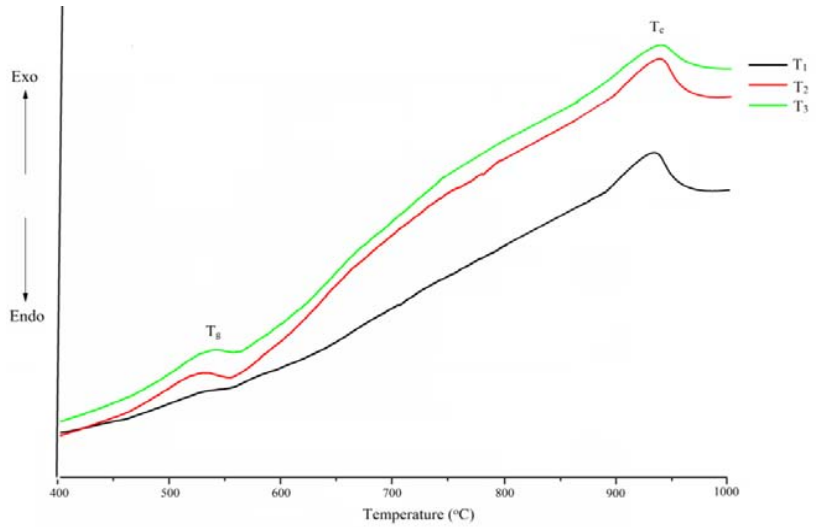

Fig 4: DTA tracers of TiO_2 doped NPABS glasses

e) Optical absorption studies

Fig. 5 shows the optical absorption spectra of the sodium lead alumino borosilicate glass samples with different amount of TiO_2 recorded at room temperature in the wavelength region 600-900 nm, the absorption edge is observed at 305 nm for the pure glass. It is also observed that the position of the fundamental absorption edge and cut-off wavelength shift towards red as the content of TiO_2 increases. It appears that a part of TiO_2 is responsible for the increase in the absorption of non-bridging oxygen (NBO) due to which this shift is obtained [32]. The spectrum of all the prepared glass samples exhibited two resolved absorption bands at about 691 nm and 832 nm. The bands are attributed due to $^2B_{2g} \rightarrow {}^2A_{1g}$ (691 nm) and $^2B_{2g} \rightarrow {}^2B_{1g}$ (830 nm) transitions of $3d^1$ electron of the Ti^{3+} ions in tetragonal distorted octahedral sites respectively. Normally, under ordinary conditions of melting, it is difficult to get Ti^{3+} in glasses as Ti ion tends to achieve its higher valence state (Ti^{4+}). The Ti^{4+} ion does not show any absorption in the visible range of the spectrum as it has an electronic configuration $3d^0$. Thus, it can be concluded that Ti ions in these glasses are present as Ti^{4+} ions [33].

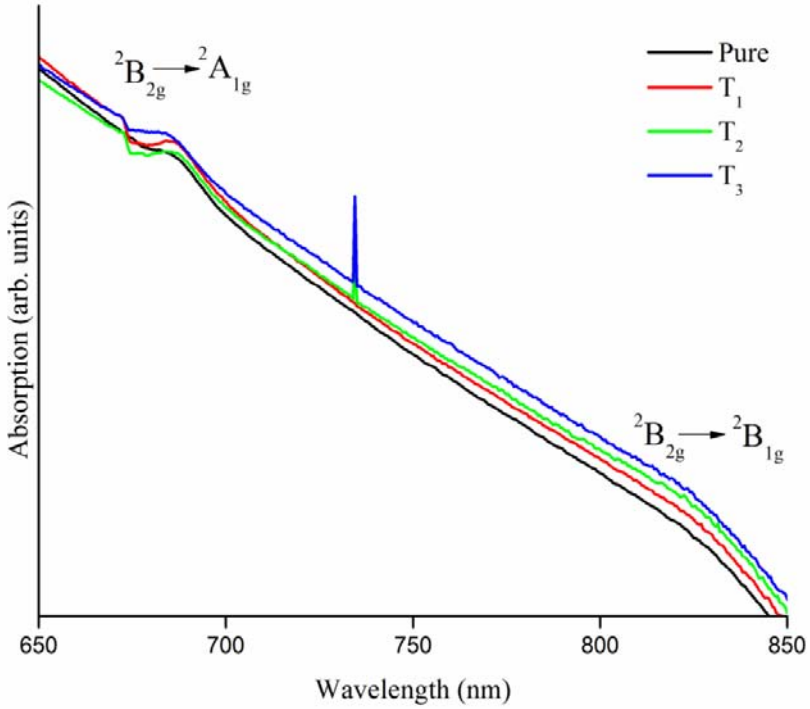

Fig. 5: Optical absorption spectra of different TiO_2 doped NPABS glasses

f) Band gap and Urbach energy analysis

The optical band gap and Urbach energies are obtained from their ultraviolet absorption edges. The optical band gap in the amorphous system is closely related to the energy gap between valence and conduction bands[34, 35].In glasses, the conduction band is influenced by the glass-forming anions; the cations play an indirect but significant role [34, 36]. The Urbach energy gives the width of the tails of localized states within the optical band gap. At the absorption edge, random internal electric fields will dominate the broadening of the excitation levels due to lack of long-range order or presence of defects [34, 37]. The least ΔE, i.e. sharp absorption edge, suggests that defects are minimum facilitating long range order.

The absorption coefficient α (ν) can be determined near the edge using the formula:

$$\alpha(\nu) = (1/d) \ln (I_o/I_t) = 2.303(A/d) \quad (1)$$

where A is the absorbance factor at frequency ν and 'd' is the thickness of the sample.

The absorption coefficient α (ν)as a function of the photon energy (hν) for direct and indirect transitions according to Mott and Davis [38] is given by

$$\alpha(\nu) = B(h\nu - E_{opt})^n / h\nu \quad (2)$$

where B is the energy-independent constant [72] and the index takes different values depending on the mechanism of inter band transitions, i.e., n = 2 and n = 1/2 for allowed direct and indirect transitions.

From Eqs 1 and 2 and by plotting $(\alpha h\nu)^{½}$ and $(\alpha h\nu)^2$ as a function of photon energy hν, the optical band gaps for indirect and direct transitions can be estimated respectively. The values of indirect and direct band gap energy E_{opt} can be obtained by extrapolating the absorption coefficient to zero absorption in $(\alpha h\nu)^2$ vs hν and$(\alpha h\nu)^{1/2}$ vs hν plot and is shown in Fig's. 6 and 7. Plots are also drawn between ln(α) and hν (Fig. 8) and the Urbach energy value (ΔE) is calculated by taking the reciprocal of the slopes of linear portion in the lower photon energy region of the curve as stated with following relation [40].

$$\alpha(\nu) = \alpha o \exp (h\nu / \Delta E) \quad (3)$$

The optical band gaps for direct, indirect transitions and Urbach energies obtained in the present work are listed in Table 3.

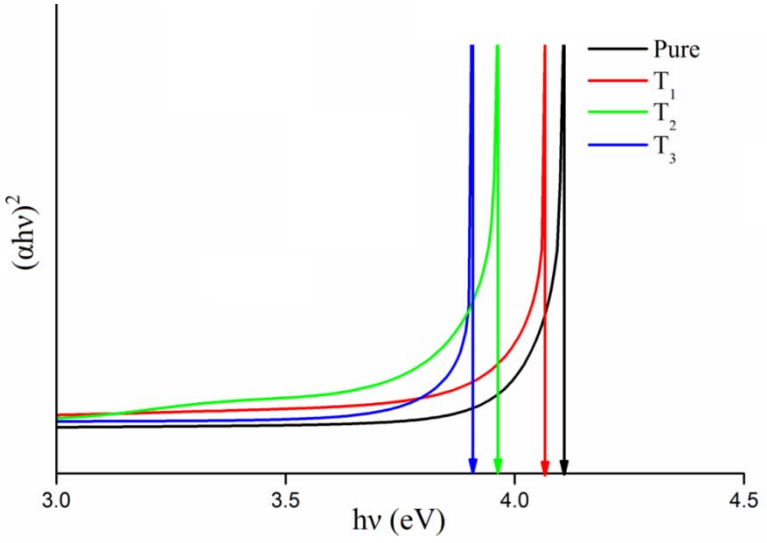

Fig. 6: Direct bands of TiO2 doped NPABS glasses

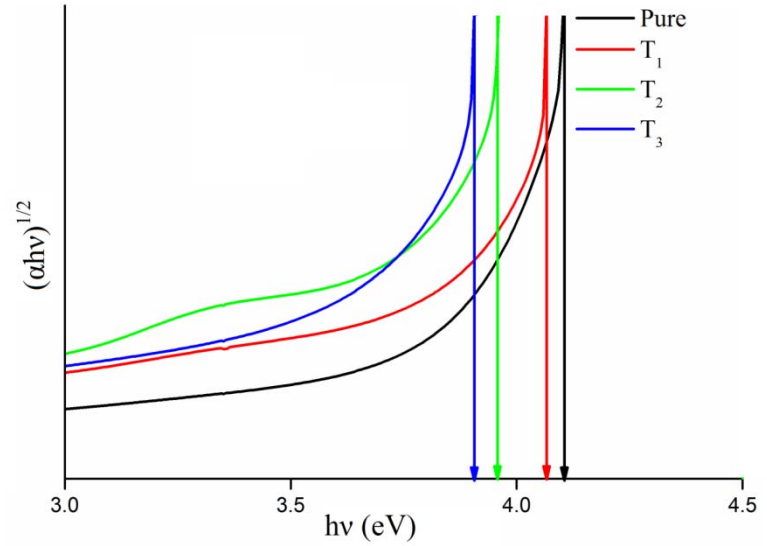

Fig. 7: Indirect bands of TiO_2 doped NPABS glasses

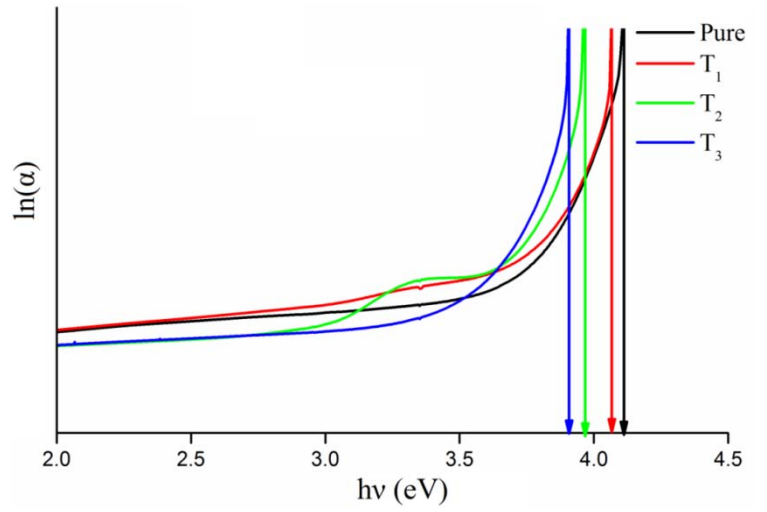

Fig. 8: Urbach plots of TiO_2 doped NPABS glasses

Table 3: Optical band gap energy (E_{opt}) for direct and indirect transitions and Urbach energy of TiO_2 doped sodium lead alumino borosilicateglasses

Sample code	Cutoff wavelength (nm)	Energy band gap (E_{opt}) eV			Urbach energy
		Calculated	Direct	Indirect	
Pure	305	4.073	4.005	4.003	0.252
T_1	310	4.007	3.973	3.971	0.254
T_2	313	3.969	3.878	3.842	0.264
T_3	317.5	3.912	3.842	3.764	0.269

The optical band gap energies shown in Table 3, revealed that the optical band for indirect transition values varies from 4.003 to 3.764 eV and $(\alpha h\upsilon)^2=0$ for direct transitions, whose values vary from 4.005 to 3.842 eV. The optical band gap energies decrease with the increase of titanium ion concentration. Also, Urbach energy values increase from 0.252 to 0.269 eV with the increase of titanium ion concentration.

g) Electron paramagnetic resonance (EPR) spectra

EPR spectra of title glasses with different concentrations of TiO_2 recorded at room temperature are shown in Fig. 9. In the pure glass no EPR signal was detected. When Ti^{3+} ions are introducing into the titled glasses, all the samples exhibit absorption lines. The EPR spectrum exhibits broad unresolved spectrum due to Ti^{3+} and its g value is 1.9532. The broadness arises due to the dipolar-dipolar interaction of Ti^{3+} ions. The resonance signal observed in this spectrum with g = 1.9532 is due to distorted octahedral sites of Ti^{3+} ions with $|x\ y\ |>$ ground state. The presence of large concentration of such ions may distort the glass network more and induce bonding defects. The near absence of such signal in the spectra of glass T_3 indicates the low concentration of such ions in this glass network. The g-value a little less than 2.002 is typically due to Ti^{3+} ions and agrees well with the reported values for Ti^{3+} [41]. Except for the variation in signal intensity no important modifications are observed while increasing the dopant concentrations (Fig. 9). A slight shift in the resonance signals is also observed when modifying the starting glass composition.

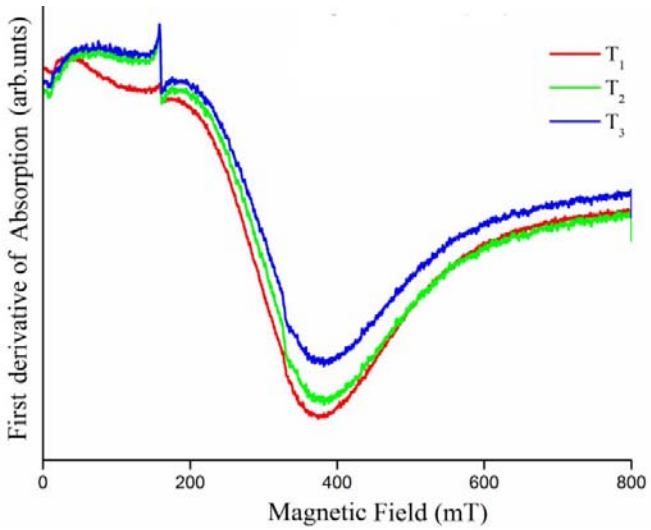

Fig. 9: EPR spectra of TiO_2 doped NPABS glasses

IV. Conclusion

The physical parameters, spectroscopic properties and FT-IR studies on the network structure of titled glasses doped with TiO_2 reveals the following conclusions:

The XRD pattern confirms the amorphous structure of the glasses studied. The physical properties like density, average molecular weight (M), titanium ion concentration (N_i), molar volume (V_m), mean titanium ion separation (r_i) and the polaron radius (r_p) are evaluated for the glasses studied in the present work varies linearly with x mol% except for density values. From the DTA curve, the thermal stability of the glass matrix is confirmed by the difference between glass transition and crystallization temperatures. The IR spectral investigations indicate the Ti^{3+} ions exist in octahedral positions and also form B-O-Ti linkages. The optical absorption spectra of the present glass system are attributable to Ti^{3+} ions, which contains two broad, intense bands analyzed on the based on axially elongated octahedral coordination. The band gap of glasses varies from 4.005 to 3.842 eV and 4.003 to

3.764 eV (direct and indirect) and 0.252 to 0.269 eV (Urbach)depending on the chemical nature of intermediate oxide. Urbach energy values suggest that defects can increase due to the increase in Urbach energy with titanium content.

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Global Journal of Science Frontier Research: a
Physics and Space Science
Volume 20 Issue 9 Version 1.0 Year 2020
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Assimilation of Cu by the Chromium Resistant Bacterium *Arthrobacter Globiformis* 151b in the Presence of Ca in Growth Media

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Abstract- The process of assimilation of Cu by chromium-resistant bacteria (Arthrobacter globiformis 151B) and the influence of high-concentration Ca ions on this process have been studied in the article. The bacteria are known for their property to assimilate intensively the hexavalent chromium [Cr(VI)] ions from the environment, to convert them into trivalent form [Cr(III)] and to accumulate it in cell. This bacterium is also characterized by the absorption of other elements from the nutrient medium. The strain of bacteria under investigation was isolated from basalt samples, taken from the places highly contaminated by Cr(VI) in Kazreti (Georgia). The solutions of the studied elements Cu and of Ca were introduced simultaneously into the nutrient medium. We studied the influence of different concentrations of Ca ions during different period of time of bacteria cultivation (17 h, 24 h, 48h, 96h, 144h) on the process of assimilation of Cu by bacteria. Ca concentration in food medium made up 100 mkg/ml, 400 mkg/ml and 1600 mkg/ml. The concentration of Cu in media was 1 mkg/ml.

Keywords: *bacteria (arthrobacter globiformis 151b), biomass, ca, cu, concentration.*

GJSFR-A Classification: *FOR Code: 240599*

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Abstract- The process of assimilation of Cu by chromium-resistant bacteria (Arthrobacter globiformis 151B) and the influence of high-concentration Ca ions on this process have been studied in the article. The bacteria are known for their property to assimilate intensively the hexavalent chromium [Cr(VI)] ions from the environment, to convert them into trivalent form [Cr(III)] and to accumulate it in cell. This bacterium is also characterized by the absorption of other elements from the nutrient medium. The strain of bacteria under investigation was isolated from basalt samples, taken from the places highly contaminated by Cr(VI) in Kazreti (Georgia). The solutions of the studied elements Cu and of Ca were introduced simultaneously into the nutrient medium. We studied the influence of different concentrations of Ca ions during different period of time of bacteria cultivation (17 h, 24 h, 48h, 96h, 144h) on the process of assimilation of Cu by bacteria. Ca concentration in food medium made up 100 mkg/ml, 400 mkg/ml and 1600 mkg/ml. The concentration of Cu in media was 1 mkg/ml.

For determination of the content of Cu in the cell, after the cultivation of bacteria the precipitation of cells by centrifuge and the preparation of the obtained bacterial pellet for the analysis were carried out. The content of metals was measured by atom-absorption spectrometry.

Keywords: bacteria (arthrobacter globiformis 151b), biomass, ca, cu, concentration.

I. Introduction

Some metals have toxic and carcinogenic properties. It is very important to develop the technologies by means of which it is possible to remove the toxic metals from the environment. Among the most prospective methods of remediation of polluted environment are the biological technologies based on the use of different microorganisms [1, 2].

The pollution of the environment by the materials containing Cr(VI) and other toxic elements is an urgent problem for many countries [3].

The recent researches proved that many of the well-studied bacterial species, Are not metal resistant/tolerant. They lose their viability in co-existence of high concentrations of heavy metals. Thus, it is reasonable to isolate the bacteria under investigation directly from soil, mineral strata and water contaminated by metals [4-8]. At present, the testing of technologies based on endogenic microorganisms is carried out intensively in many countries [9-11], providing that recently the application of biotechnologies is of high priority in the process of environment reduction in many countries [12]. The efficiency of biotransformation depends on the mechanism of bacteria-metal interaction, thus, for bacteria of any specific species it is necessary to study preliminarily this mechanism in detail.

The natural vital medium of bacteria we are interested in, contains, alongside with the elements under investigation (Cu) as well the elements (macroelements) that are widely spread in the nature (Ca, Na, K, Si, etc.). These elements have an influence on the growth – evolution of bacteria, including the process of assimilation of elements by bacteria and the biochemical process proceeding in bacteria [13,14].

It is interesting to study the influence of Ca on the process of assimilation and distribution of Cu in bacteria. Ca ions are important activators of enzymes inside the cell [13-15]. Calcium is the key intracellular metabolic regulator. Ca is also important for the functioning of cell membranes [16]. Ca is involved in life processes and cause compaction of cell membranes (in opposite of sodium and potassium ions, which increase permeability). Copper belongs to the life-essential metals as it is a part of more than 25 copper-containing proteins and enzymes, and is implicated in their activity. The experimental material, obtained as a result of the proposed investigation, makes it possible to draw a certain conclusion about the biochemical processes, taking place in bacteria and about the mechanisms, by which the assimilation of metals and the conversion of their compounds are made.

II. Objectives and Methods

For the object of investigation we chose the bacteria of *Arthrobcter globiformis* 151B. As is known, the bacteria of Arthrobacter family are aerobic gram-positive bacteria living in soil. They belong to Arthrobacteria class, type – Actinomycetales. Among the reductive bacteria, the interest to the bacteria of this

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family is great as, according to the existing data [17, 18] they have a high potential of remediation of chromium-contaminated environment. The Georgian investigators studied the distribution of Cr(VI) – resistant microorganisms in basalt rocks, taken from ecologically the most contaminated regions of Georgia (Kazreti, Zestaphony) [19]. The object of investigation is bacterial strains isolated from Kazreti basalts. This bacterium intensively absorbs various elements from the nutrient medium (Zn, Mg, Mn, Cr, etc.) [20, 21].

For studying the influence of Ca on the process of assimilation of Cu by Arthrobcter globiformis *151B, we cultivated bacteria in 500 ml Erlenmaier flasks in 100 ml TSB broth. We additionally introduced Ca solution in the form of $CaCl_2$ into some samples (flasks), thus, the concentration of Ca, added in the nutrient medium, was 100 mkg/ml, 400 mkg/ml and 1600 mkg/ml.*

In five samples, we additionally introduced a solution of Cu, the final concentration of which in the nutrient medium was 1 μg/ml. The nutrient medium also (itself) contained elements of the following concentrations: Na-3.5mg/ml, K- 0.6 mg/ml, Ca-25 μg/ml, Cr - 7 μg/ml, Zn - 1 μg/ml. The cultivation of bacteria proceeded during 17 h, 24 h, 48 h, 96 h and 144 h. After cultivation we carried out the precipitation by centrifuge (3000 rpm, 10 min., 0^0C), we poured out supernatants and the remained bacterial pellet washed in sterile distillated water. We dried the obtained biomasses by low-temperature lyophilizer [22] and weighted them (the whole masses). From the total quantity of bacterial pellet we took the amount necessary for analyses, weighted it (~30 mg) and put it into test tubes. In order to convert the samples into a liquid state, we added the concentrated nitric acid (1 ml) into the test tubes, heated it and after a complete ashing dissolved it by bidistillate to a certain volume. The analysis of the obtained samples on the content of metals was made by atom-absorption spectrometer (Analyst 800, acetylene–air flame). We studied the process of assimilation of Cu by bacteria and the influence of Ca ions of this process.

III. Results and Discussion

The results of measurement are given in Figs. 1 and 2.

The intensity of Cu uptake process from the nutrient media is practically similar during the whole experiment, when the concentration of Ca added in media is 1600 mkg/ml and 0 mkg/ml. When Ca concentration in nutrient media is 100 mkg/ml and 400 mkg/ml, the uptake of Cu is sharply increased at the start of experiment (17 h). During the following period of experiment (96 h and 144 h) the intensity of Cu uptake is decreased and the corresponding curves become similar to the curves that correspond to Ca concentrations 1600 mkg/ml and 0 mkg/ml.

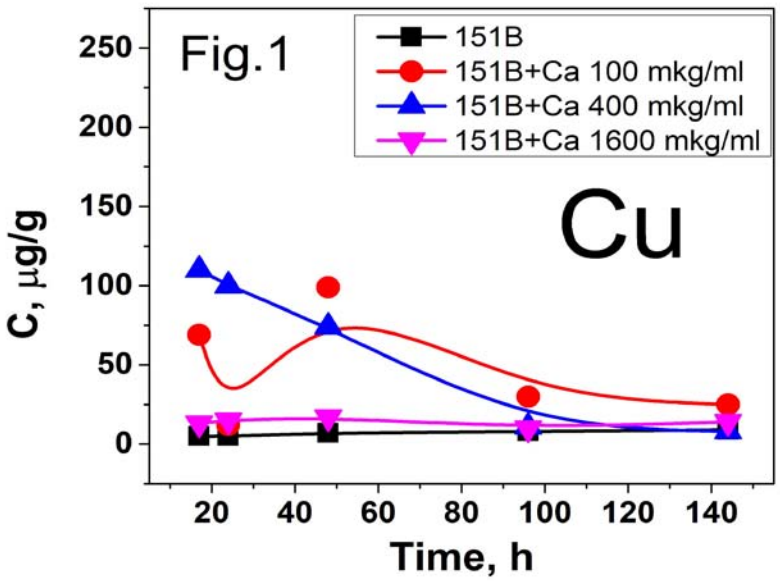

Fig. 1: The effect of Ca on the process of uptake Cu by bacteria (*Arthrobacter globiformis* 151B). *T(hours)*- The growth time of bacteria. The Ca concentration in the food medium is 100 mkg/ml, 400 mkg/ml and 1600 mkg/ml.

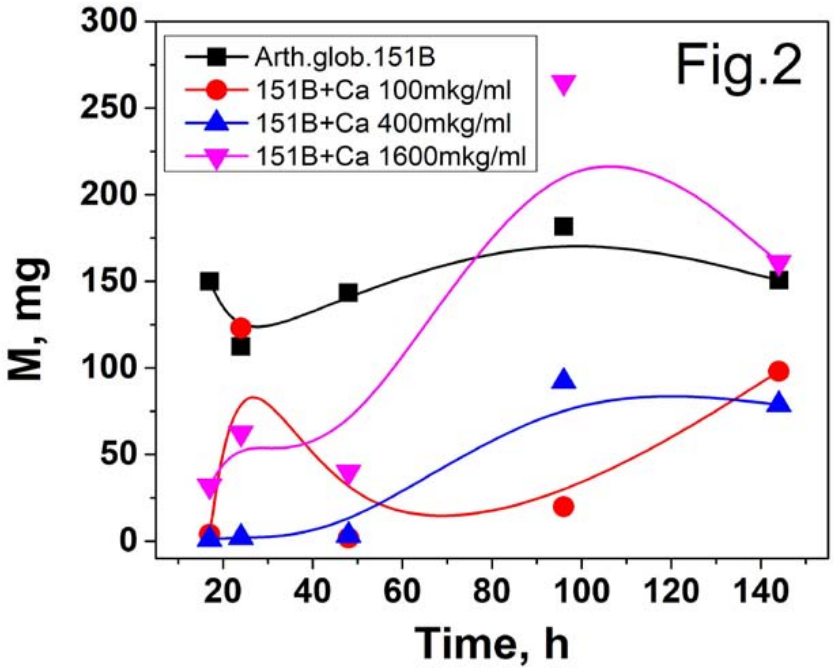

Fig. 2: Dependence of the bacterial growth mass M(mg)on time T(*hours*) *Arthrobacter globiformis*151B. The Ca concentration in the food medium is 100 mkg/ml, 400 mkg/ml and 1600 mkg/ml.

The addition of Ca to the medium slows down the growth of bacteria for the entire period of the experiment, when the concentration of calcium in the food medium is 100 μg / ml and 400 μg / ml. When the concentration of calcium in the food medium is 1.6 mg/ml, the growth of bacteria decreases at the initial stage of the experiment (17 hours, 24 hours, 48 hours). In this case, the mass of bacteria is much less than when calcium is not added to the food environment. At later stages of the experiment (96 h and 144 h), the bacterial mass is not less than when calcium is not added to the food medium. At the next period of cultivation, the bacterial masses grow and approach the value that bacteria have, cultivated without adding Ca.

IV. Conclusion

As shown by the results of the experiment, the addition of calcium in the medium does not reduce the penetration of copper in bacteria. At the initial stage of the experiment (17 h, 24 h, 48 h), when the concentration of calcium in the food medium is 100 μg/ml and 400 μg/ml, copper penetration increases sharply compared to the case, when calcium is not added to the food medium.

The addition of Ca in the medium slows the growth of bacteria, at various concentrations of Ca. The addition of Ca in the food medium leads to a sharp decrease in the bacterial mass. The exception is when the Ca concentration in the food medium is 1.6 mg/ml.

Interference is pronounced at the initial stage of the cultivation of bacteria. In the next cultivation period, the bacterial masses grow and approach the value that bacteria have, cultivated without adding Ca.

Acknowledgments

This work was funded by Grant STCU-SRNSF #6316/STCU-2016-09 from the Science and Technology Centre in Ukrainian (STCU) and Shota Rustaveli National Science Foundation of Georgia (SRNSF).

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Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

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Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.

Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11'", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

a) A title which should be relevant to the theme of the paper.
b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
d) An introduction, giving fundamental background objectives.
e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
f) Results which should be presented concisely by well-designed tables and figures.
g) Suitable statistical data should also be given.
h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
j) There should be brief acknowledgments.
k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

Format Structure

It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, “What words would a source have to include to be truly valuable in a research paper?” Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.

Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

Preparation of Eletronic Figures for Publication

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

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Tips for Writing a Good Quality Science Frontier Research Paper

Techniques for writing a good quality Science Frontier Research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of science frontier then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow here.

6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

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References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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ISSN 9755896