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CONTENTS

	Mathkari	*Inside the Haveli* and Margaret Laurence's *A Jest of God*	
15	Dr. Archana Durgesh, Md. Osama, Md. Ashraf, Md. Faiz, Md. Md. Kashif, Md. Ammaar	Revolution 2020 - Battle for a Perfect Life	**2415.PDF**
16	Mrs. Mishra Santwana Gopalchandra & Dr. K. L. Chincholikar	A Study of Correlation of Academic Achievement with Aptitude, Attitude and Anxiety	**2416.PDF**
17	Dr. Manju Lalwani Pathak	Economic Thoughts of Rabindranath Tagore	**2417.PDF**
18	Solanki Milind Kantilal	The Effect of History and Post-Modernism in Today's Indian English Literature	**2418.PDF**
19	Dr. Archana Durgesh & Dr. Pooja Singh	Communicating Across With a Touch & a Glance	**2419.PDF**
20	Anil Kumar Singh	Motifs of History in the Novels of Amitav Ghosh	**2420.PDF**
21	Dr. Franz Josef Gellert & Professor Dr. Hugo Velthuijsen	Gradual Retirement Schemes and Older Workers Social Inclusion and Employability in The Netherlands	**2421.PDF**
22	Dr. Raji Ramesh	Negotiating the Patriarchal Authority: The Magic Toyshop	**2422.PDF**
23	Jayasimha P.	Transmutation of Confession as Devotion: Cognitive Modeling of Saint Augustine's *Confessions of a Sinner - Book One*	**2423.PDF**
24	Bijayata Pradhan	Voices from the Margins: A Study on the Texts Based on the Life of The Tea Workers in the Tea Estates of Darjeeling	**2424.PDF**
25	Nivedita Ghosh	The Emerging Marital Trends in Indian Scenario	**2425.PDF**
26	S.N. Sithi Shamila	Redefining 'Quality' through Student Participation: A Holistic Perspective	**2426.PDF**
27	Isha Dhar & Zia Afroz	Bitcoin-A Historical Perspective of the Effects of the New Currency on the Global Economy with the Future Speculated	**2427.PDF**
28	Dr. Santosh J. Mishra	Painful Journey of Self Discovery through Different Cultural Spaces in *Desirable Daughters* by Bharati Mukherjee	**2428.PDF**
29	J. Kirubakaran & Dr. M. Dharmalingam	A Study on Impact of Financial Sector Reforms in India with Reference to Indian Capital Market	**2429.PDF**
30	Mr. Kailas B. Aute	Contesting and Voicing non-normative sexual Identity: A Critical Study of Shyam Selvadurai's *Funny Boy*	**2430.PDF**
31	Zia Afroz & Sumbul Fatima	Need of Entrepreneurship Development in Rural Sector in India	**2431.PDF**

Superheavy Elements: Its Annals

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Abstract

Right from the creation of the world the process of recording history has begun. Every element has history. Only worthy contributions in each field deserve to be recorded. The abilities and capabilities of the historian will be reflected during the process of recording the past. The unbiased, truthful and effective presentation by the writers of history will only stand the test of time and attracts the readers to get engrossed from the beginning to end. It must be noted that authentic presentations of the past is not an easy task .It requires an extensive study, knowledge and research in the field of which the recording of history is being done. The presentation of sequence of the events in a chronological way is necessary to arrest the attention of the reader and create an indelible impression on one's mind and heart.

This work circumferences four stages viz Prior to the Nuclear Atom, Quantum based concepts, the least time hypothesis, Cosmic crapshoot and Jean's hypothesis followed by Inference.

Key Words: shes: superheavy elements, shres: superheavy radioactive elements, hhes: hyperheavy elements, annals: the history

The annals of Superheavy elements [SHEs] have been covered from the last132years i.e., from 1880 to 2012. The different stages of waxing and waning among the scientists have been covered and how research was continued overcoming several potential hurdles. The experimentalists streamlined the various theories that were presented by physicist, chemists, mathematician and astronomers. This is a path breaking development not only for the scientists but also to all the younger generation students of Superheavy elements.

Now we need to see whether SHEs stop at Z=118 with extremely low half-life (less than a second) or are there any other SHEs with longer life in Stars and Nebulae? Is there any end to synthesizing of SHEs? Will there be an arrival of "Hyperheavy elements [HHEs]? What would be their life span and how would they help the society?

In this work I presented the Annals and research of SHEs that would make every young scientist to ponder up on the theories of SHEs and take up research activity in this interdisciplinary area.

1. Introduction*:* In the present work that has been taken up I shall focus upon the history of Superheavy Elements[SHEs] which was brought into lime light by scientist in the past only for the short period of time and than eclipsed in to darkness. It was again brought into the forefront and later could not withstand. Nevertheless, we can find fluctuations in the concentrations on this work. Through this work I shall make an endeavor to present phase wise history of

SHEs that would enhance the horizons of knowledge among the students.

Before I proceed, a bank of questions need answers.

- How many chemical elements are there?
- How many can there be?
- Is there any limit to the atomic weight?
- Is there any exact 'stability limit' for SHEs?
- Do SHEs above Z≥118 or more exist?
- Are there any hyperheavy or other elements beyond SHEs?
- Is there any ending of chemical elements if no, how many periods would that be?
- Is there any relation or index by which we can predict similarities in between SHEs?
- Where the chemical element system should be ended?
- How many periods and columns does the final form contain?

As a physicist the above mentioned galaxy of questions reflect on the mind screen. This work aims at answering a few of these in an unbiased manner. To answer the entire question there is a need for extensive, large-scale research that might take decades.. The large-scale research program aims at synthesizing of SHEs with an atomic number larger than Z=107. The Joint Institute of Nuclear Research near Moscow reported the element Z=118 and provisionally named by IUPAC as 'ununoctium' or eka-radon and at the same time a team of physicists observed that there is controversy regarding the element Z=117 named as 'ununseptium' or eka-astatine which was announced in 2010. On the other hand, discovery report of Z=112, called unbibium or eka-thorium, remain confirmed.

Flag year: 1940-41, modern research field-heavy ion collision is nothing but the first step to produce chemical element using collision.

1.1 The research by Glenn Seaborg and his team[Lawrence Livermore National laboratory] dominated till 1960 had been produced transuranic metals neptunium(Z=93), plutonium (Z=96) including the last of the actinides Z=103 [Weeks 1968,pp 830-857 ; Seaborg 1994]. As a matter fact these two elements are by Fermi and his group in Rome named as "ausinium" and "hespernium" [Fermi 1965, p417] and Fermi himself explored this fact in his Nobel Lecture in Stockholm. This is seen as the beginning of experimental research in transuranic or superheavy elements, before Quantum theory and nuclear atom, actually may be less known. In other words Fermi & his team and Seaborg started the journey of SHEs.

1.2 Flashing SHEs : Based on SHEs three questions can explain the facts as to why there has been delay research on Superheavy Elements

First, were there Chemical claims and speculations before the introduction of the nuclear atom? Second was the Bohr-Sommerfeld theory of atomic nucleus led to suggestions of highest atomic number? And third in the 1920s were these several speculations about superheavy elements in the stars and nebulae. Generally, this subject invites an interdisciplinary approach so that all- Physicists, Chemists and astronomers combined can obtain a reasonably full picture which explains the above three questions feasible to be acceptable

researchers that would formulate and expose the facts to present the history of SHEs. The above three main questions are explained in the form of stages:

2.0 First Stage:

Prior to the nuclear atom:

While explaining the developments during this era, focus on the history of SHEs started in the year 1989 just after mid 18^{th} century. This was that period in which Dmitri I Mendeleev and Lothar Meyer worked about the arrangement, and number & location of the elements in the form which was later named as 'Periodic Table' and in it the place for the possible existence of elements lighter than hydrogen and heavier than uranium. This type of naming, location and proper arrangement has taken approximately 35 years from 1880 to 1915 and during this period the atomic number of an element was discussed properly. As far as Uranium which was discovered by a German chemist Martin Heinrich Klaporth in the year 1801, just the explanation 'Why Uranium is heavy: took some decades of time period. To explain the heaviness of Uranium scientists have even taken the support of numerology in particular Glasgow resident, occupationally a technical chemist, named Edmund Mills who is the top on list who adopted numerology though there is no conceptual value and significance to believe this instead of mathematically. He used a formula $y=15(p-0.9375^{x})$ to calculate atomic weight but this relation does not hold good if we go for $p\geq17$ and also x tending towards infinity. At that time the above relation was acceptable because of p=16 for x tending towards infinity and the A=240 value close to experimental value 239.70 as far as Uranium is concerned. On the whole no signals were received for the upper limit using the predicted relation since; it is purely based on numerology.

One of the member of Mills and Meyer group, Sima Losanitsch, a professor of Organic Chemistry in Belgrade, who in 1906 published a booklet not only proposed several elements heavier than uranium but also elementary particles much lighter than the hydrogen atom. This booklet came into limelight after 9^{th} or 10^{th} year from the date of the discovery of radioactivity. This has stimulated not only chemist but also physicist. Again after 4 yr of Sima , the British chemist William A Tilden pointed out that " there is nothing in theory to preclude the expectations of additions of new substances to either extremity of the series[1910]".This was broadly accepted among both chemists and physicists , because of still heavier atoms decaying to uranium, there was no reason to do so. Actually Meyer idea explained by both Mills and Meyer assuming two small periods of seven elements each and five larger ones of seventeen elements as $2\times7+5\times17+1=100$. This come under "the peculiar coincidence" but actually this is a kind of dubious reasoning. And this is fact that Sima Losannitsch is a member of Mills and Meyer, who presented an idea based on speculation but in 20^{th} century it has had its own significance regarding superheavy elements.

Discovery of radioactivity: A direction oriented for searching new elements with high atomic numbers. Based on this, Charles Baskerville permanent bird of North Carolina performed experiments in 1904 and found some sort of heavy fraction, the atomic

weight of which he determined to be 255.6 he proposed to name as 'Carolinium" but unfortunately he neither performed nor confirmed with 'spectral analysis. Later Losanitch placed carolinium in one of the periodic tables, assigning it atomic weight 254 and symbol Cn. This is worth mentioning because it may have been the first claim of an element heavier than uranium.

The prominent Czech chemist Bohuslav Brauner in the year 1901 was convinced that he had discovered a transuranic element and he was not able to present the spectral analysis of this new element, an American sensation, as Cn: it has marginal history in the branch of chemistry, mean , it failed to reorganization in the chemical community and suffered the same fate as helvetium , oceanium, austrium, coronium and numerous other elements: the name without reality.

For the identification of an element- the method of X-ray spectroscopy is the precise one . Many British chemists like Frederick H. Loring and Gerald J. F. Druce were the first to apply this technique and successfully they published a research paper in the year 1925 in Chemical News[1925] by announcing that they observed spectral line of manganese mineral. They not only claimed but wisely skipped. In the year 1934, after a 9 year period, another chemist/chemical engineer who belong to the same place Odolen Koblic announced that there is a transuranic element in pitchblende [uranium mineral] Using traditional method of ' chemical fractionation he named his new element as bohemium (Bo) in honor of his fatherland. Instead of encouraging O. Koblac, a lady from Berlin named Ida Noddack claimed that there is nothing detected from pitchblende as claimed by Koblic and he killed Koblic element but, she also passed a comment to Fermi's suggestion of having produced the element.

2.1 Second Stage:

Quantum based concepts:

To explain this era, we have to make some sort of oscillations in history to record the past in a chronological form:

Neither Physicists nor Chemists forget the remarkable discoveries like presentation of Nuclear Model by Ernest Rutherford, the recognition of isotropy, X-Ray spectra by Henry Mosley's and Quantum theory of atomic structure. All this was done in the years 1911-1913. Due to these discoveries there is an Impulse found on Periodic table since, the Z atomic number and atomic weight, helps to start the arrangement of all elements on this basis and older definitions are ruled out.

Now the question arises for the properties associated with element and many know that Thomson atomic model was not fit then, Bohr introduced an atomic model/ revised atomic theory of 1921-1923, that explains the orbit of an electron was characterized by two quantum numbers which fulfill the aim and to arrive at scientifically based answers rather than speculations that would help upper limit to the periodic table for addition. Quantum numbers are the first step to clear ground realities of an atom/element. He also suggested electron configurations for all the elements in the periodic system, even the heaviest ones. Also he predicted rare-earth series analogous to the lanthanides, but without being able to determine its beginning. He also placed the new series beyond uranium rather placing it as an

actinides series including uranium. No science student, teacher will forget the words of Bohr delivered during his series of lecture in Gottingen in June 1922 that "We might proceed further……..and construct hundreds or thousands of elements". Here we must note two things one: Bohr direction was towards the existence of elements like Superheavy & Hyperheavy in future. Second, he guided his colleagues to find out reality about the SHEs . However, one thing is clear that there is no hypothetical element.

Bohr and his institute [in Copenhagen] invited scientists from different countries for the research work and one from Japan named Yoshio Nishina, to whom Bohr assigned a job to check suspected elements Z=93,94 or 96 homologous to uranium minerals through X-ray spectroscopy.Bohr also wanted to know whether there were heaviest combinations. This remains unknown as Nishina never disclosed anything with regards to his research. It is also not known whether Nishina has actually done anything in this regard.

In the year 1922 Bohr has derived the configuration for Z=118, number of electrons in the various "shells" or energy levels ' n' from 1 to 7 was 2,8,18,32,32,18,8 . Clinton Nash [2005] of the University of New England, more than 80 years later, calculated and found the same electronic structure of ununoctium, and indicated that element 118 was more active than radon and probably not a gas under normal condition. From the history of Superheavy elements and role played by different physicists specially Bohr the probability on believing the existence of Superheavy elements is not clear but, one thing subscribed by Bohr is that" nuclei of atoms with a total charge greater than 92 will not be sufficiently stable to exist under conditions where the elements can be assumed"[Bohr1924 p.p.112]. No body would be able to reject the work done about the heavy elements in the institute of Bohr. Even, in early 1920's the three important things discussed by Bohr and his colleagues were (i) the possibility of transuranic elements (ii) the question of an upper limit of the periodic system(iii) investigation made by a Norwegian physicist Svein Rosseland, stayed 4 year at Bohr Institute between 1920 & 1924. He made a note about radioactivity caused by the influence of the orbital electron.

The speculations of Rosselands were cleared and this circumference alone offers a hint toward an understanding of the limitation in the atomic number of existed elements. Remarks by Bohr were elaborated by Sommerfeld in the fourth edition of his classified work '***Atombau und Spektrallinien***' using relativistic energy and derived fine structure theory for electron atom.

In the early 1920s quantum numbers were discussed in the light of anomalous Zeeman Effect and supported for heavy elements. A conclusion of Canadian physicist, Joh McLennan arrived at the same conclusion in the year 1923. The behavior electrons in the light of quantum numbers would also suggest the presence of heaviest elements.

Later, Bohr atomic theory[relativistic extension: Sommerfeld] replaced by the quantum mechanical theory built on the Dirac equation ,started from the lowest bound state in one electron system is unchanged.

Exact solution was presented by Walter Gordon at the University of Hamburg. However quantum based suggestions come forward and play key role to regarding the understanding of an atom in the light of quantum mechanics.

2.2 Third Stage:

The minimum time hypothesis

Under this topic, SHEs origin and presence is considered with 'smallest value assumed by the continuous function defined on a close interval and according to this:

A fixed minimum duration ΔT below which time measuring would have no meaning [Kargh and Carazz 1994]. This was also called "Choron". This is useful and represent the period and velocity of an electron. This, place or limit on the atomic number can also be seen from the relationship of the simple Bohr Theory. This theory mainly reflects the time. There were several speculations of stellar elements of very high atomic number. And as per Flint[1932] minimum-time principle had demonstrated a definite limit to the number of existing elements. This minimum-time hypothesis used by many physicists like Gordon in 1928 , Walter Glaser of and Kurt Sitte both from Germany was just for the sake of calculations and explanations about the atomic number and they found the maximum atomic number as $Z_{\max} = 90.5 \pm 0.5$.

Given the existence of uranium with Z=92 the number comes out too small, but Glaser and Sitte argued the effects caused by the second k-electron that would result in a correction that might increase the number to 92. To discuss this, they took the support of the physicist and philosopher Philipp Frank, who had pointed out that the question of highest atomic number could also be considered from the perspective of Louis de Broglie's old idea of matter waves.

Off-main stream theory is another attempt to calculate the maximum atomic number by the Indian mathematician Vishnu Narlikar in the year 1932 (the father of the Cosmologist Jayant Narlikar) applied Eddington's so-called E-algebra ambiguous to the problem in a way that the number 137 to 92, and from this he calculated that "there can be no element beyond uranium".

2.3 Fourth Stage:

Cosmic crapshoot:

Superheavy elements in this section can be called as Superheavy Radioactive Elements[SHREs] with a valued using SHEs attempt to understand astrophysical and cosmological phenomena. Second, ratio of uranium to radiogenic lead provided an estimate of the age of the earth of at least one billion years. But where did uranium come from? How it is that uranium is still present on the earth and elsewhere in the universe? OR uranium and thorium were themselves decay products of even heavier elements. Arthur Erich Haas, a physicist at the University of Vienna, in the year 1911, delivered a lecture in which he considered the possibility of " a mother substance of uranium in the form of another and possibly unknown element". However, he found the hypothesis to be absurd. Here the question is 'whether uranium is '*adinfinitum'* and rises. At the same moment Bohr, in the year 1923, in his presidential address to the British Association for the Advancement of

Sciences, said " the element, uranium and thorium, represent the sole survivals in the Earth today of types of elements that were common in the long distant ages, when the atoms now composing the Earth were in course of formation". According to Walther Nernst, who received Nobel Prize in 1920, also thought that 'superheavy radioactive elements had existed; he also thought they were still being formed in the deposit of space. Seven years later after receiving Nobel Prize Nernst wrote "the source of energy of the fixed stars must be looked in radioactive elements which are of higher atomic weight than uranium". Nernst explanation of stellar energy production favored cosmological view of an eternal steady-state universe.

Nernst's student and physical chemist Paul Günther agreed that the hypothesis of his teacher was "not implausible". One might possibly direct traces of elements with atomic number larger than 92 in the interior of the earth. The positive attitude was shared by a few other German scientists. Thus, to the mind of the astronomer Walter Schulze, Nernst theory was in "complete agreement with the recent findings" in cosmic rays studies. Lastly, Superheavy Cosmic Elements[SHCEs] offered an explanation of the nature and fluctuations of the cosmic rays.

2.4 Fifth Stage:

Jean's Superheavy Elements [JSHEs].

James Jeans renowned physicist and astronomer convinced that the universe was irreversibly running down /or from the complex to simple. This supported not only Jean's but Nernst ideas about very heavy radioactive elements in the stars and nebulae, and therefore the universe evolves from the complex to simple. Theory of Stellar composition concluded that in the centers of the stars, including the sun, there were elements of "exceptionally high atomic weight" means A≥240 and the source of sun's energy comes from elements of atomic number higher than 92".

Explanation of James Jean was that the Stars younger and more massive than the Sun would consist mainly of the superheavy elements, as that the nebulae would be particularly rich in elements of the highest atomic weights. According to Jeans-two important questions would remain unanswered: the nature of the stellar energy production & the presence of uranium and thorium in the crust of the earth. With regards to the first problem, the answer ends with the elements of higher atomic number and second question refer to Nernst hypothesis (about ether). However, every chemist and physicist and astronomer indicates the presence of Superheavy Elements and the **Ultimate Superheavy Atom**

Inference:

As written in this review, several chemists and physicists expressed their interest in the possibility of Superheavy elements. On the other hand astronomers, by taking the support of different hypothesis and past and present thesis, explain the presence of superheavy elements with ground realities. These played good role as absolute reflectors.

In this work, more than one very important and biased hypothesis discussed to point out not only superheavy elements/superheavy radioactive elements but, their upper limit

with respect to atomic number, atomic weight and placement in chemical periodic system in addition.

The heaviness of uranium is well discussed in recent research work presented in the form of books, research papers and here I have not taken into account as per the title of this work. More than one superheavy element may be present or formed in space, stars, nebulae and the sun and their energy. Based this…..progressive research irrespective to the subject and race but one day 'Hyperheavy element also reflects in addition to the superheavy radioactive elements. There may be two thousand or more elements with twenty two periods that would change the face of present periodic system(an approximation). Regarding the radioactivity, forthcoming elements are all radioactive but regarding half life i.e., more or less than the existing superheavy elements values and decay mode. No one can be sure that there is no boundary limits to discuss future of these, based on speculations or hypothesis.

Super or Hyper heavy elements would leave indelible impression and put them selves on par with the present valued elements. With a little modification during chemical production of these elements by sort of some method, gives terrific consequences and acts as substitutes.

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