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Editorial

Service to Science and Service to Defence : Moseley in the Light of the Centenary Year of his Landmark Publications in Defence of Science

Three words 'Moseley, Soldier and Science' in which the last two are so deeply associated with the name of the English scientist Moseley that these have become virtually synonyms of Moseley in the context of remembrance of the professional contribution and character of the unique soldier-scientist Moseley because these two words are very special for him in the sense that they often are essential to understand the personality of iconic Moseley. His keen interest in the service of Science as researcher and on the other hand, his involvement in the Defence services as soldier is really unique example of personification of total commitment to the cause of defence of his country and his deep dedication for the cause of unfolding the scientific truth towards building up a way forward to enrich human history. Moseley's dual personalities as a scientist and as a soldier rest on the framework of Science and Defence in which the ideas and appeal of Science is universal whereas the ideals of a soldier in Defence is purely national and personal; and that was manifested in his attitude and approach - so intimate and so intense that it would not be inappropriate to say that 'Service to Science' and 'Service to Defence' for this real world, as Moseley exemplified were in a way virtually two sides of the same coin. Thus, Moseley is truly a composite personality which can be understood from his passion for Science as essentially meant for global cause but his zeal as soldier for Defence was pristine and core to his heart. In fact, often such deeply motivated men contribute for creation of history of this real composite world.

The full name of Moseley is Henry Gwyn Jeffreys Moseley (1887-1915) which bears parts of the names of his parents - Henry Moseley is the part from his father and Gwyn Jeffreys is from his mother's. His father died when Moseley was quite young but he was very promising schoolboy enjoyed King's scholarship. Having graduated from the famous Trinity College of Oxford University he joined as physics demonstrator at Manchester University. In 1913 Moseley performed a systematic study of 38 target elements as the anode in an experimental setup measuring X-ray spectra of elements between Aluminium (Z=13) and Gold (Z=79). After data analysis, Moseley discovered that the peaks in the energy spectra emitted by the various elements corresponded to the atomic number squared.

This year 2013 is the 100th anniversary year of the landmark experiment conducted by Moseley to publish and establish the classical correlation of atomic number (Z) of the elements with the frequency (ν) of x-ray emitted from the corresponding targeted atoms what is later known by the name of Moseley's law and is expressed through the well known equation $\sqrt{\nu} = \alpha\,(Z - \sigma)$ where α is proportionality constant and σ is another constant to take care of the shell effect. Thus, Moseley was able to show that the frequencies of certain characteristic X-rays emitted from chemical elements are proportional to the square of a number which was close to the element's atomic number.

Since early days human mind whether a musician or a scientist always tried to compose something from the chaos. With such instinctive quest, the 19th century scientists made many efforts to arrange the elements in a sequence. In the process, one of the founding figures of chemistry, John Dalton prepared one of the first Tables of the elements in which he ordered them in accordance with their increasing atomic weight. In the following decades scientists observed that elements like lithium, sodium, and potassium shared similar chemical properties. Subsequently, the noted Russian chemist Dmitri Mendeleev composed a Table what was later transformed to a Periodic Table. Today's such modern Table is really a masterpiece of organised source of chemical information at a glance. The evolution of chemistry's Periodic Table into its current form is an astonishing achievement resulted from the major contributions of many famous chemists and eminent physicists. However, Mendeleev is generally credited of the first widely recognized periodic table where he developed his table to illustrate periodic trends in the properties of the then-known elements and also predicted some properties of then-unknown elements that would be expected to fill the gaps in that table. But his table suffers from few shortcomings for lack of new invention of instruments for experimental proof. Moseley's discovery showed that atomic numbers had an experimentally measurable parameter and was the basis of Periodic Table.

Moseley modified Mendeleev's belief in the sense that Moseley's experimental evidence was so class apart that it impacted the concept of construction of Mendeleev's periodic table. In fact, such impact led to reconfiguration of the Mendeleev's old table to a new version in which it accommodated not only the existing elements but also gave space for inclusion of possible future elements to be discovered in course of time through human endeavour. Moseley's law allows for the experimental determination of atomic number, and modified the belief of Mendeleev, who had visualised that periodicity was determined by atomic mass, even though some pairs of elements violated this order. For example, Potassium has lower atomic mass (A=39.09) than Argon (A=39.95) yet Mendeleev placed potassium after argon. In fact, Mendeleev's table ordered elements by their atomic mass was plagued by such exceptions and hampered the search for new elements. But it is Moseley who justifiably placed Argon (Z=18) before Potassium (*Z*=19) based on the result of their X-ray wavelengths, despite the fact that Argon has a greater atomic mass (A=39.95) than Potassium (A=39.09). In another case, even though the atomic mass of metal Cobalt (*Co*, A=58.93) is slightly larger than that of Nickel (*Ni*, A=58.69) yet Mendeleev violated his own belief and took liberty to place *Co* before *Ni* in the Table by putting forward certain quasi logic based on the observation of their chemical properties and behaviour. Similarly, Moseley was able to explain that Tellurium occurs before Iodine without revising the experimental atomic mass of Tellurium (A=127.6) as proposed by Mendeleev.

Moseley had also shown that there were gaps in the atomic number sequence at numbers 43, 61, 72, and 75. These gaps are now known to be the places of two radioactive synthetic elementsTechnetium, Promethium, and two quite rare naturally-occurring stable elements Hafnium, Rhenium respectively. Thus, Moseley's experimental X-ray spectra demonstrated that the atomic numbers of elements are not just arbitrary numbers based on the intuition of chemists like Mendeleev, but rather, they have a firm experimental foundation from the physics.

Yet another interesting worthy information came to the fore. For example, Lanthanum (*La*, A=138.9) was discovered in 1839 and Lutetium, (*Lu*, A=174.9) in 1907, but no one could say with certainty how many elements might lay between *La* and *Lu*. Once the atomic numbers were determined to be 57 and 71 respectively, scientist could find some justification for the existence of 14 lanthanides to appear in this slot. In fact, scientist could even determine chemical identities by matching an unknown's spectrum to known spectra.

By sheer intuition, Mendeleev had also predicted the existence of a missing element at atomic number Technetium. The possibility of more such missing elements particularly of the large family of the lanthanide series of rare earth elements had been a standing problem among the chemists. Moseley was able to demonstrate that these lanthanide elements must precisely have 15 members – neither more nor less. The number of elements in the lanthanides had been a question that was very far from being settled in the early 20th century. In those olden times chemists hardly had enough experimental skill and they could not then produce pure samples of all the rare-earth elements, nor even in the form of their salts, and in some cases they were unable to distinguish between mixtures of two very similar rare-earth elements (Neodymium and Praseodymium) from the nearby pure metals in the Periodic Table. In Moseley's time even the method of separating the rare-earth elements by the method of ion exchange had not been invented, yet they could be identified through Moseley's technique.

Until Moseley's work, atomic number was merely an element's allocation in the periodic table, and was not known to be associated with any measureable physical quantity. Moseley's work was the first to give a firm meaning to the concept of atomic number (Z) as distinct from atomic mass (A) and confirmed the shell model of the atom. Moseley's law is historically important in quantitatively justifying the conception of the nuclear model of the atom, with nearly all, positive charges of the atom located in the nucleus, and associated on an integer basis with atomic number. In Bohr's model of atom, the atomic number is the same as the number of positive charges in the nucleus of the atom. One interesting point, simple modification of Rydberg's and Bohr's formulas was found to give theoretical justification for Moseley's empirically-derived law for determining atomic numbers.

In spite of Moseley's brilliant mind and motif, destiny brought him to a different motility altogether. In the early of 1914, Moseley resigned from his position at Manchester University with a plan in his mind to pursue his research in physics at Oxford University. But World War-I broke out in August 1914, so he did not accept the job offer and instead joined in the Royal Engineers of his country's Army as a technical officer. But alas, he received a bullet hit at his head while he was in the act of telephoning an official message and that cost his life in the battle field at his young age of around 27 years. Many scientists believe, only 27 years old at his untimely death else he could have contributed a lot to the knowledge of atomic structure had he survived in the battle field and that his death is one of the most costly single death of the War to mankind. Even Danish physicist Niels Bohr once said that "Moseley has secured a place among the foremost researchers in science of his time, although he was not able to devote more than four short years to scientific investigation. On the other end, the noted popular science writer, Isaac Asimov commented that in the event that he had not been killed, Moseley might very well have been awarded the Nobel Prize.

Thus clearly, Moseley's measurements were spectacularly successful as could be understood from the words of one of the pioneers in experimental science, Millikan who measured the charge of electron by 'oil drop method': 'In a research which destined to rank as one of the dozen most brilliant in conception, skilful in execution, and illuminating in results in the history of science, a young man 26 years old threw open the windows through which we could glimpse the subatomic world with a definiteness and certainty never dreamed of before'.

In the 100th anniversary year of the path breaking publication of a person like Moseley who entailed both Science and Defence personalities together, the remembrance of *Defence Science Journal* has become more relevant than ever before to recall its role in the service of publication. Physicist Moseley's contribution through his publications enlightened many of the chemists to understand the subject concept with greater clarity as in the case of Periodic Table; thus enable the researchers to think that they belong to Science irrespective of their disciplines; and that bridges the gap between research communities and removes inhibition and build up trust among the professionals for interaction and collaboration to carry forward the journey of Science for further progress.

At the end I would like to add an anecdote that 'Moseley is the other name of Defence' as it requires 7 letters to breath out either of them. Moseley acted to '*de*-fence' the mental barrier of his time to establish Moseley's law as a gift for this globe;

on the other hand he also acted in 'defence' of his country. Likewise publications of *Defence Science Journal* actually *de***-**fence to help unleash more interaction and understanding among researchers and professionals working at any corner of this globe in different fields of science, engineering or technology; and extending services in defence of scientific culture in the interest of greater cause of human society of this composite world. Since 1949 *Defence Science Journal* (*DSJ*) is capturing and carrying the frescos of peer reviewed good publications from across the globe to disseminate knowledge for generations. *DSJ* has acquired both poise and popularity among the researchers because it is essentially '***D****edicated* to ***S****cience* ***J****ourney* – the other name of *Defence Science Journal*'.

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