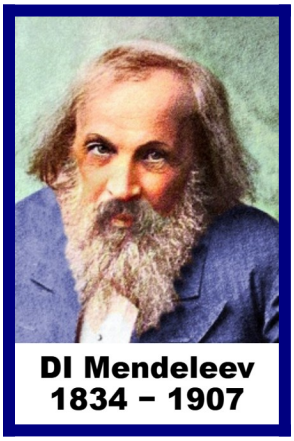
STEM: A Study of Dead Men's Names

Science History

Science, Technology, Engineering, Math (STEM): all of these disciplines require applications of fundamental Math & Science developed in the 18th, 19th & 20th centuries. If you have to learn knowledge in that part of Science & Math development, there is a near 100% chance you'll be studying contributions of names with ancient photos / paintings of some dead-white-men. I'm sorry; the names of dead male scientists & mathematicians are attached to many physical concepts, laws & constants. Women & minority students will just have to tolerate that.

Who is Дмитрий Менделеев?


DI Mendeleev
1834 – 1907

Occasionally, you will meet men such as Dmitri Ivanovich Mendeleev. Or is it Mendeleyev, or is it Mendeleef (ref [1])? At any rate, Dmitri was able to propose the chemical periodic table in 1869 ***despite*** living in a warring Europe.

Another decade; another war in 1800's Europe! Emperor Alexander II (1818 – 1881) of Russia, sold Alaska to the US preemptively in 1867 (ref [2]) to prevent the UK from getting it in some future European conflict. Russia had previously lost to England in the Crimean War (1853 – 1856). On the horizon, was the Russo-Turkish War (1877 – 1878) fought, in part, to regain land lost in the Crimean War.

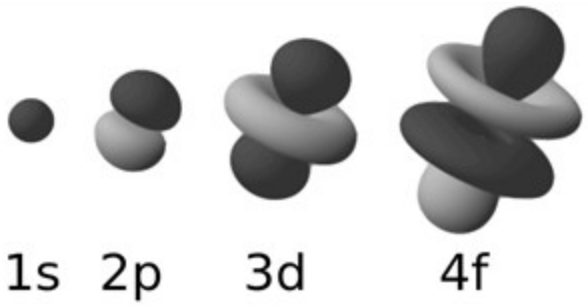
You will see Dimitri's name spelled differently in different settings since the only ***correct*** way is in Cyrillic (the Russian alphabet). In addition, he died before the connection of spherical harmonics & atomic electron configurations (ref [3]) was made around 1925 by Niels Bohr (1885 – 1962) & others (refs [4] & [5]).

Are Electron Orbits Circular? Not Exactly!!!

The theme of Quantum Theory is quantized states & one cannot usually guess the Quantum "Theme" in an application; the Science has to be led by experiment. For example, an electron reacts in some experiments as a point particle, yet it carries a negative charge that can only rotate or "spin" one quantized speed, either clockwise or counter clockwise. God may be a transcendental philosopher in many world religions, but around an atom, He is a mathematician (ref [6]). God uses a modified spherical harmonics as an orthonormal basis set to quantize the electrons' orbits. Exceptions & approximations exist, e.g., inner electrons shield outer electrons from the full nucleus charge. Nevertheless, electrons fill shells around an atomic nucleus as dictated by spherical harmonic basis functions ($Y_\ell^m(\theta,\varphi)$) (ref [7]). Here, (θ) is the polar angle in relation to an externally applied electromagnetic (EM) field; (φ) is the azimuthal angle.

Spherical Harmonics is reflected in the Periodic Table. However, Mendeleev, more or less, guessed this without making the mathematical connection & subsequently died never knowing the significance of his remarkable discovery.

The following figure shows the bizarre world of electrons orbiting a nucleus in the presence of an external EM field (ref [3]). What are atomic-bound electrons doing without an external EM field? I don't think anyone knows! But atoms are never really in isolation.



Angular Momentum Shells around an Atom

The s-shell is the only "realistic" orbital shell, but the electron has no angular velocity, with the azimuthal quantum number ($\ell = 0$). At zero angular velocity, the product of an electron's circumferential speed times its distance from the atom's nucleus, is zero. Multiply its mass times its angular velocity & one gets the electron's angular momentum. The s1-shell electron is, on average, within about 80 pm (ref [8]) from a hydrogen nucleus (1 pm = 1 picometer = 10^{-15} meters).

As the electron is given increasing angular momentum, ($\ell = 1, 2, 3$) & ($Y_\ell^m(\theta,\varphi)$) basis functions correspond to p, d & f, with more "lobes" and "tori" (donuts) developing. In each case, the electron is able to zoom through the nucleus in a process called "tunneling" no worse for the wear. In addition, the picture above shows discrete surfaces or boundaries, but everything is actually fuzzy. The lobes & donuts approximate areas of higher probability where the point particle electron will be found, and the probability dissipates outside the indicated surfaces.

In this article (ref [9]), Spherical Harmonics is further applied through the Periodic Table to explain technology like computer electronics. Hopefully, this brief presentation will appeal to your curiosity in learning more of the mysteries of atoms & motivate you to investigate further into this corner of science known as "Quantum Physics".

Get Motivated!!!!

One fundamental key to me getting ***motivated*** to study the material for a course is that these people were given a problem & this is what they did to solve it. You have to see how problems were solved in the past to solve new problems in the future! The way a problem was solved is included in a tech course, because it is ***very*** important! That fundamental approach is how I consistently made A's & B's in course work. There are STEM professionals now in NASA, JPL, CERN & elsewhere that can serve as role models for future problem solvers. Unfortunately, you have to study a lot of dead males, first. They were where the information was & made the effort to learn it! They were just humans of the past trying to move society forward in knowledge (ref [10]).

References

[1] Wikipedia.org, Dmitri Mendeleev, 2022.
[2] Wikipedia.org, Alexander II of Russia, 2022.
[3] Wikipedia.org, Electron Configuration, 2022.
[4] Wikipedia.org, Niels Bohr, 2022.
[5] Joseph, Kathy, KathyLovesPhysics.com, Niels Bohr's Nuclear Model, 2020.
[6] Kaku, Michio, PhD, Big Think – YouTube, Is God a Mathematician?, 2013.
[7] Wikipedia.org, Spherical harmonics, 2022.
[8] Stack Exchange Inc, Chemistry.StackExchange.com - questions, 2022.
[9] George, Everett, *Ideas Contributions*, Computer Chips Demystified, 2023.
[10] George, Everett, *Ideas Contributions*, SI Metric System Demystified, 2024.

Note: Please donate $50/year if you find Wikipedia useful!!!

Everett George 3 July 2024