Pauli's exclusion principle

Paulis exclusion principle is a theory about how electrons behave. This theory was proposed by Wolfgang Pauli, An Austrian Scientist in the year 1925. Initially, they thought electrons only act according to this principle and later it is found that due to the fermionic property of electron they react to it. Thus, all fermions obey it. To simply put, his theory states that no two electrons with identical set of quantum numbers can be in same atom. Therefore, it excludes the other electron with same identical set of quantum numbers. In other words, no two electrons can occupy the same orbital and two electrons in the same orbital must have opposite signs. In 1945, Pauli won Nobel prize in physics for this work. Before 1925 scientists believed that there were only three quantum numbers which describes energy states. Later, from the Zeeman effect they identified there is also another quantum number which defines spin value too i.e., electronic spin. This electronic spin plays the major role in the Pauli’s exclusion principle. Even though he was awarded with Nobel prize no theoretical proof of the Pauli’s exclusion principle can be given yet and for the present it is regarded as something empirical added to and regulating the atom model.

To get better understanding of this topic, some keywords need to be known, they are fermions, four quantum numbers, their properties, Zeeman effect etc. Fermions are particles that possess half- integral spin. One of the well-known examples of this half-integral spin is electron (±1/2). Muons, baryons are also one among them. The quite opposite particle which possess integral spin and identical in nature are called bosons. Examples are photons, gluons etc. Fermions obey Pauli’s exclusion principle as well as Fermi-Dirac principle. Likewise, bosons obey Bose- Einstein’s Statistics.

Four Quantum numbers are Principal, Azimuthal/Angular, Magnetic and Spin quantum number. Principal quantum number is denoted by n(shell), and it can’t be zero. It can have any values from 1,2,3 and so on. It only designates the principal electron shell to the atom. The second quantum number is Azimuthal quantum number. It is denoted by l (number of subshells), which describes the shape of orbital. l can be zero but always one less than that of n. (i.e.,) l=0,1, 2,……(n-1). The third quantum number is magnetic quantum number. It is denoted by which denotes the number of orbitals and their orientation with subshell. It depends on angular quantum number. =-l,(-l+1), (-l+2),…,-2,-1,0,1,2,……(l-1),(l-2),+ l. The fourth quantum number is Spin quantum number (). It does not depend on other three quantum numbers. For electron, the spin number . + means Spin up and – denotes Spin down. Through this one can determine the ability to generate magnetic field or not.

Zeeman effect is the splitting of spectral line into several components through the application of magnetic field. It is related to quantum mechanics as it is related to the energy states of quantum particles. It describes the energy difference between states with more than one direction for the angular momentum vectors with their degeneracy is lifted by an ext. magnetic field. [Degeneracy – more stationary states having same quantum energy but different wave function].

Thus, it is concluded that the Pauli’s exclusion principle is just a theory about the behaviour of fermions or more certainly electrons which can’t be in the same atom when all the four quantum numbers (discussed above) are same. If it is same, it will surely be excluded by the atom. At least spin number needs to be different if the fermion must exist in the same atom as other.