# Proposal to extend the nuclear physics to include the magnetically charged particle as an additional ingredient

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**Abstract**

In 1960', the nuclear physics was extended to include the hyperon as an additional ingredient. Likewise today I would like to include the magnetically charged particle ( *e ) to the ordinary (p,n) system. For the case of the hyper-nuclei such an extension was done rather smoothly, since the order of magnitude of the interactions are the same, because of the SU(3) symmerty of the baryon system. First thing to do in our extension is to examine whether the strength of N-N interaction is nearly the same as *e-N interaction, namely interaction between the magnetic monopole and the nucleon. The *e-N interaction term is the energy of the magnetic dipole moment of the nucleon $\kappa_{tot}(e/2m)\vec{\sigma}$ in the magnetic Coulomb field $*e\vec{r}/r^3$ produced by the magnetic monopole fixed at the origin $\vec{r} = 0$. It is known that the total angular momentum $\vec{L}_{extra}$ of the system where the electric charge Q and the magnetic charge *Q coexist with the separation $\vec{r}$ is $(*QQ/c)\hat{r}$. If we impose the quantum condition that a component of the angular momentum can assume only the integer multiple of $\hbar/2$, we obtain $(*QQ/\hbar c) = n/2$ with $n = 0, \pm1, \pm2, ....$ This is the charge quantization condition of Dirac. From this condition, we can determine the value of the magnetic counterpart of fine structure constant: $*e^2/\hbar c = (e^2/\hbar c)^{-1}/4 = 137.0/4$. Since $*ee/\hbar c = 1/2$, the energy of the nucleon in the magnetic Coulomb field is the order of the strong interaction. Therefore the extention of the nuclear physics to *e-A system goes rather smoothly. The hamiltonian of the *e-A system is the sum of the terms of the nucleons in the magnetic Coulomb field plus the nuclear potential terms:

$$H_{^*e-A} = \Sigma_{j=1}^{Z} H^{(j)}_{^*e-p} + \Sigma_{k=1}^{A-Z} H^{(k)}_{^*e-n} + V_{nucl}, \tag{1}$$

where $V_{nucl}$ is the nuclear potential. The hamiltonians of the magnetic monopole and the nucleons are

$$H_{^*e-N} = \frac{1}{2m_p}(-i\vec{\nabla} - Ze\vec{A})^2 - \kappa_{tot}\frac{^*ee}{2m_p}\frac{(\vec{\sigma}\cdot\hat{r})}{r^2}F(r), \tag{2}$$

where the form factor function $F(r)$ of the nucleon is

$$F(r) = (1 - \exp[-ar](1 + ar + \frac{a^2}{2}r^2)) \quad \text{with} \quad a = 6.04\mu_\pi, \tag{3}$$

in which $a$ is related to the radius of the nucleon $\bar{r}$ by $a = \sqrt{12}/\bar{r}$, and numerically $\bar{r} = 0.81$fm.. Once the hamiltonian is known, it is not a difficult matter to solve the Schrödinger equation, if the mass number A is not large , $A < 5$ say. We shall explain the characteristic phenomena in the talk. One of the most spectacular phenomena is the fusion reaction starting from the zero incident energy. When two deuterons are trapped by the same magnetic monopole *e, in which the orbital radius of the deuterons are around several fm., they are fused to become the more stable $\alpha$-particle. Since the spin of the $\alpha$ is zero, it cannot form a bound state with the magnetic monopole. So it is simply emitted, and there remains fresh magnetic monopole. It start to attract the surrounding feul deuterons. In this way, the magnetic monopole plays the role of the catalyst of the nuclear fusion reaction.