The Physics and Chemistry of Dirac Magnetic Monopoles

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Abstract

Dirac magnetic monopoles are hypothetical elementary particles. By assuming their existence one can explain the quantization of electric charge, the August Kundt experiment, and the conservation of baryon and lepton number. Here I show that Dirac magnetic monopoles can form low-mass bound states which are analogous to mesons, baryons, atoms, and molecules. I point out that these bound states could be the major component of cold dark matter.

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1 Introduction

Magnetic monopoles were suggested to describe electricity and magnetism equivalently. Dirac was able to show that electric charge can appear only in discrete units if magnetic charges exist [1]. I presented a very simple proof for this Dirac quantization condition for a special case [2]. A manifestly covariant quantum field theoretical description of Dirac magnetic monopoles requires the existence of the Salam magnetic photon [3], as I have shown some time ago [4]. By using this concept, I argued [5] that August Kundt has already observed an effect of the magnetic photon radiation [6]. I suggested a desktop experiment to verify the magnetic photon [7].

A consistent formulation of quantum field theory requires that the electric-magnetic duality is generalized to the other interactions.

This generalization requires the existence of new bosons which I named isomagnetic W and Z bosons and chromomagnetic gluons [8]. I have shown that the conservation of baryon and lepton number is a consequence of this generalization [8]. In the same publication I predicted the quantum numbers of both the fermionic and bosonic Dirac magnetic monopoles [8].

Here I will show that Dirac magnetic monopoles usually do not appear as free particles, but in bound states. This is similar to quarks and leptons which usually appear in bound states such as mesons, baryons, atoms, and molecules.

2 Definitions and Nomenclature

The content of this paper is new to readers. So it is necessary to list the new definitions and nomenclature first. An understanding of Ref. [8] is useful.

(i) Hanselons are defined as elementary fermionic Dirac magnetic monopoles with chromomagnetic color. I will denote them by H.

(ii) Neutral hanselons are defined as hanselons with zero magnetic charge $q = 0$. I will denote them by N^0.

(iii) Charged hanselons are defined as hanselons with (negative) unit magnetic charge $q = -g$. I will denote them by C^-.

(iv) Gretelons are defined as elementary fermionic Dirac magnetic monopoles with zero chromomagnetic color. I will denote them by G.

(v) Single charged gretelons are defined as gretelons with (positive) unit magnetic charge $q = +g$. I will denote them by S^+.

(vi) Double charged gretelons are defined as gretelons with twice the (positive) unit magnetic charge $q = +2g$. I will denote them by D^{++}.

(vii) Red, green, and blue are defined as the chromoelectric colors of quarks and chromoelectric gluons. They are denoted by r, g, and b.

(viii) Huey, dewey, and louie are defined as the chromomagnetic colors of hanselons and chromomagnetic gluons. I will denote them by h, d, and l. – Huey, Dewey, and Louie are the nephews of the comic figure Donald Duck. They look identical and differ only by the color of their cap.

(ix) The octet of (the first generation of) fermionic Dirac magnetic monopoles is therefore denoted as N_h^0, N_d^0, N_l^0, C_h^-, C_d^-, C_l^-, S^+, and D^{++}.

(x) A pairon is defined as a bound state of a hanselon and an antihanselon. This is analogous to the meson which is a bound state of a quark and an antiquark. I will denote a pairon by P.

(xi) A triplon is defined as a bound state of three hanselons. This is analogous to the baryon which is a bound state of three quarks. I will denote a triplon by T. – In analogy to mesons and baryons, the hanselons of pairons and triplons are bound together by virtual chromomagnetic gluons.

(xii) Schwinger dyons [9] are defined as elementary particles which have both electric charge and magnetic charge.

(xiii) Iso-dyons are defined as elementary particles which have both isospin and magnetic isospin. All quarks, leptons, hanselons, and gretelons are iso-dyons [8].

(xiv) Chromo-dyons are defined as elementary particles which have both chromoelectric color and chromomagnetic color.

(xv) Mass-spin-dyons are defined as elementary particles which have both rest mass and spin. All quarks, leptons, hanselons, gretelons, W and Z bosons, isomagnetic W and Z bosons, and the tordion are mass-spin dyons.

3 Bound States

At zero temperature the electric coupling constant is

$$\alpha_E = e^2/4\pi \simeq 1/137.036 \qquad (1)$$

At zero temperature the magnetic coupling constant is

$$\alpha_M = g^2/4\pi \simeq 308.331 \qquad (2)$$

Both coupling constants are running coupling constants and I expect that they become of order unity at the Planck scale (Planck temperature) [2].

Nevertheless, the huge value of α_M would lead to negative energy densities unless the rest masses of the free hanselons and gretelons are of the order of the Planck mass [2].

Because of the large coupling constant the (negative) binding energies are expected to be huge. As a consequence, the rest masses of chromomagnetically neutral pairons and triplons can be expected to be much smaller than the rest masses of their constituents (hanselons).

Pairons and triplons are the analogues to mesons and baryons. The nuclear force between baryons is mediated by the exchange of virtual mesons. This nuclear force is a remnant of the chromoelectric interaction between quarks which is mediated by the exchange of virtual chromoelectric gluons.

Analogously, one can expect a magnetic nuclear force between triplons which is mediated by the exchange of virtual pairons. This force is a remnant of the chromomagnetic interaction between hanselons which is mediated by the exchange of virtual chromomagnetic gluons.

Baryons which consist of the first generation of quarks (up and down) appear as isospin multiplets which have nearly the same rest mass. Proton and neutron have approximately the same rest mass. The four Delta hyperons Δ^{++}, Δ^+, Δ^0, and Δ^- have approximately the same rest mass. This results from the fact that the rest masses of their constituents (up and down quarks) are much smaller than the energy of the virtual chromoelectric gluons.

By contrast, the rest masses of the neutral hanselon N^0 and the charged hanselon C^- (of the first generation of hanselons) can be quite different. This mass difference might be larger than the energy of the virtual chromomagnetic gluons.

So magnetic isospin multiplets of triplons need not have approximately the same rest masses. The multiplet T^{---}, T^{--}, T^-, T^0 of triplons consists of the hanselons $C^-C^-C^-$, $C^-C^-N^0$, $C^-N^0N^0$, $N^0N^0N^0$. The repulsive magnetic field between two or more C^- causes a large T^{---} rest mass.

Because of the large coupling constant α_M hanselons, gretelons, and magnetically charged pairons and triplons are unlikely to exist as free particles. They should be bound to magnetically neutral atoms. Examples are $T^{---}S^+D^{++}$, $T^{--}D^{++}$, $T^{--}S^+S^+$, T^-S^+, and $T^-T^-D^{++}$. Because of the large binding energies these atoms should be much lighter than the pairons and triplons.

It would not be surprising if these atoms could be bound to molecules. Because of the binding energies, these molecules should be lighter than the atoms they consists of. It remains the task for future researchers to find out the properties of this Dirac magnetic monopole chemistry.

4 Cold Dark Matter

There appear to exist much more baryons than antibaryons in the universe. So the baryon number of the universe appears to be huge ($B \sim 10^{78}$ within the Hubble sphere).

However, hanselons have lepton number $L = 1$ and gretelons have baryon number $B = 1$ [8]. If there exist more antigretelons than gretelons in the universe, then the baryon number of the universe could be zero.

This requires that there exist as many antigretelons as baryons. The rest masses of free gretelons are expected to be of the order of the Planck mass [8]. So they should not exist as free particles but be bound in atoms and molecules. Cosmological observations set upper limits for the masses of these atoms and molecules. The cold dark matter [10] content of the universe is approximately 23% of the critical mass of the universe, whereas the baryonic matter content is only 4% of the critical mass of the universe. So if there are indeed as many antigretelons as baryons, then the mass of the lightest Dirac magnetic monopole atoms and molecules cannot be more than 6 GeV per antigretelon which they consist of. For example, if T^-S^+ is the lightest of these atoms or molecules, then its mass would be 6 GeV.

5 Summary

In this paper I have introduced new particles (pairons and triplons) and I have introduced new symbols for the hanselons and gretelons whose quantum numbers I have determined in Ref. [8]. I have shown that hanselons can form bound states (pairons and triplons) which are analogues to mesons and baryons. Moreover I have argued that triplons and gretelons can form atoms and molecules. These atoms and molecules may be the major component of cold dark matter.

References

[1] P. A. M. Dirac, Quantised Singularities in the Electromagnetic Field, *Proceedings of the Royal Society of London A* **133**, 60–72 (1931).

[2] R. W. Kühne, The Coupling Constant of Dirac Magnetic Monopoles is Not 34.259 But 308.331, *Qeios* (2024), doi:10.32388/1BSRZ6 .

[3] A. Salam, Magnetic Monopole and Two Photon Theories of C-Violation, *Physics Letters* **22**, 683–684 (1966).

[4] R. W. Kühne, A Model of Magnetic Monopoles, *Modern Physics Letters A* **12**, 3153–3159 (1997).

[5] R. W. Kühne, Quantum Field Theory with Electric-Magnetic Duality and Spin-Mass Duality but Without Grand Unification and Supersymmetry, *African Review of Physics* **6**, 165–179 (2011).

[6] A. Kundt, Ueber die electromagnetische Drehung der Polarisationsebene des Lichtes im Eisen, *Annalen der Physik und Chemie* **27**, 191–202 (1886).

[7] R. W. Kühne, Quantum Electromagnetodynamics, *Zenodo* (2025), doi:10.5281/zenodo.15111240 .

[8] R. W. Kühne, Conservation of Baryon and Lepton Number is an Effect of Electric and Magnetic Charges, *Qeios* (2024), doi:10.32388/DGIRV1 .

[9] J. S. Schwinger, A Magnetic Model of Matter, *Science* **165**, 757–761 (1969).

[10] P. J. E. Peebles, Large-Scale Background Temperature and Mass Fluctuations Due to Scale-Invariant Primeval Perturbations, *Astrophysical Journal Letters* **263**, L1–L5 (1982).