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Abstract :

The existence of a material medium or ether for the propagation of electromagnetic waves was an essential requirement for the acceptance of Maxwell's theory in its early days. However, a series of observations culminating in the Michelson-Morley experiment lead to the abandonment of this hypothesis, and its replacement by the special theory of relativity. This forced Newton's ideas of the absolute nature of space and time to be set aside and in the process showed that Maxwell's equations for the electromagnetic field retained their covariant transformation properties under the new dispensation. In this paper we revisit the notion of an ether within the context of our exposure over a period of 100 plus years to evolving notions of the physical universe.

Specifically, the object of the research described in this paper is to examine the possibility of describing the physical properties of the classical ether of electromagnetism in terms of an infinitely flexible viscous plasma medium, consisting of elementary particles that carry a magnetic charge→ a monopole. Upper and lower bounds on the particle size can be calculated using cosmological data relating to the mass of the universe and its size. The motion of these particles is described by the probabilistic laws of statistical mechanics due to the random nature of the collisions of the particles comprising the plasma. The particles are subject to a force consisting of an ordered component with a superimposed disordered part. This force manifests itself as a tension force in an ensemble of particles that move collectively as a vibrating string with a determinate group velocity. We model the physics using a canonical ensemble for the probability density from which the pressure exerted by the particles is calculated. The thermodynamic properties of this plasma can then be computed, enabling the susceptibility and dielectric constants to be calculated.

The analysis is generalized to include gravitational effects. A Navier-Stokes like equation is proposed that incorporates classical viscous effects for the ethereal medium and includes Einstein's cosmological factor. A major focus of our analysis is to construct a self consistent theory compatible with the Michelson-Morley experiment. An added bonus is a first time estimate for the mass of a monopole.

Introduction.

To estimate the size of the particles in the plasma we appeal to Heisenberg's Uncertainty Principle , connecting the uncertainties in energy E and time t .

$$\Delta E \Delta t \approx \hbar$$

But, $\Delta E \approx \dfrac{\mathrm{M}c^2}{n}$; $\Delta t \approx \dfrac{D}{c}$

where M = mass of the universe, n = number of elementary particles in it , c = velocity of light , D = linear dimensions of the particle.

$$\therefore \quad D \approx \frac{n\hbar}{\mathrm{M}c} \ \text{cm} \tag{0}$$

1. Symmetrized Maxwell Equations

As a first step in this direction, we modify Maxwell's equations to include elementary particles that carry a magnetic charge (monopoles).

$$\vec{\nabla} \bullet \vec{E} = 4\pi\rho; \qquad \vec{\nabla} \bullet \vec{H} = 4\pi\rho_m \tag{1}$$

$$\vec{\nabla} \wedge \vec{E} = -\frac{4\pi}{c}\vec{j}_m - \frac{1}{c}\frac{\partial \vec{H}}{\partial t} \tag{1a}$$

$$\vec{\nabla} \wedge \vec{H} = \frac{4\pi}{c}\vec{j} + \frac{1}{c}\frac{\partial \vec{E}}{\partial t} \tag{1b}$$

Taking the gradients of (1a, 1b) in conjunction with (1) give the charge / monopole, conservation laws

$$\vec{\nabla} \bullet \vec{j}_m + \frac{\partial \rho_m}{\partial t} = 0 \tag{1c}$$

$$\vec{\nabla} \bullet \vec{j} + \frac{\partial \rho}{\partial t} = 0 \tag{1d}$$

Try solutions of the form,

$$\vec{H} = \vec{\nabla} \wedge \vec{A} + \vec{\nabla}\chi \tag{1e}$$

then from (1) we have,

$$\nabla^2 \chi = 4\pi\rho_m$$

$$\therefore \quad \chi(\vec{r},t) = -\int \frac{\rho_m(\vec{r}\,',t)}{|\vec{r}-\vec{r}\,'|} d\vec{r}\,' \tag{1f}$$

Substituting (1e) in (1a),

$$\vec{\nabla} \wedge \left(\vec{E} + \frac{1}{c}\frac{\partial \vec{A}}{\partial t} \right) = -\frac{4\pi}{c}\vec{j}_m - \frac{1}{c}\vec{\nabla}\left(\frac{\partial \chi}{\partial t}\right) \tag{1g}$$

Assuming the monopole flow is irrotational (in analogy with fluid dynamics),

$$\vec{j}_m = -\vec{\nabla}\psi \tag{1h}$$

Therefore taking the gradient of (1g) using (1h),

$$\nabla^2 \left(4\pi\psi - \frac{\partial \chi}{\partial t} \right) = 0 \tag{1i}$$

Taking the trivial solution,

$$\psi = \frac{1}{4\pi}\frac{\partial \chi}{\partial t} = -\frac{1}{4\pi}\int \frac{1}{|\vec{r}-\vec{r}\,'|}\frac{\partial \rho_m}{\partial t} d\vec{r}\,' \tag{1j}$$

using (1f). Equation (1g) then reduces to,

$$\vec{\nabla} \wedge \left(\vec{E} + \frac{1}{c}\frac{\partial \vec{A}}{\partial t} \right) = 0 \quad \Rightarrow \quad \vec{E} = -\vec{\nabla}\phi - \frac{1}{c}\frac{\partial \vec{A}}{\partial t} \tag{1k}$$

using (1e, 1k) in (1b) and simplifying we have,

$$\nabla^2\vec{A}-\frac{1}{c^2}\frac{\partial^2\vec{A}}{\partial t^2}=-\frac{4\pi}{c}\vec{j}+\vec{\nabla}\left(\vec{\nabla}\bullet\vec{A}+\frac{1}{c}\frac{\partial\phi}{\partial t}\right) \qquad (1l)$$

using the Gauge Condition,

$$\vec{\nabla}\bullet\vec{A}+\frac{1}{c}\frac{\partial\phi}{\partial t}=0 \qquad (1m)$$

equation (1l) becomes,

$$\nabla^2\vec{A}-\frac{1}{c^2}\frac{\partial^2\vec{A}}{\partial t^2}=-\frac{4\pi}{c}\vec{j} \qquad (1n)$$

and from (1, 1k, 1m)

$$\nabla^2\phi-\frac{1}{c^2}\frac{\partial^2\phi}{\partial t^2}=-4\pi\rho \qquad (1o)$$

Equations (1m, 1n, 1o) are the standard equations of electromagnetism. However, in the present analysis there is an additional term in the expression for the magnetic field (1e), as described by the terms in (1c, 1f, 1h). They correspond to an ensemble of particles with a magnetic charge instead of an electric charge. The total magnetic charge within the medium is zero as there are no free magnetic poles.

$$\int\rho_m dV=0 \qquad (1p)$$

the integration being over the entire volume V of the universe. It should be emphasized that (1p) could be violated locally, as for instance within a given galaxy. These particles are aggregated as strings moving in the electromagnetic ether. Since it is not feasible to estimate the number of such monopoles, we have to use statistical methods to calculate the energy distribution of the plasma. The monopole velocities in terms of the current and the magnetic pole densities are given by,

$$\vec{j}_m=\rho_m\vec{v}_m \qquad (1q)$$

These monopole strings execute a motion similar to Brownian motion

2. Statistical Analysis

We assume a canonical distribution for the monopole ensembles with a probability density ,

$$\rho_m = \frac{e^{-\beta H}}{\int e^{-\beta H} d\lambda} \quad ; \quad \beta = \frac{1}{kT} \tag{2}$$

The integration being over all phase space.

$$d\lambda = \prod_{i=1}^{n} dq_i dp_i \quad ; \; n = \text{number of particles} \tag{2a}$$

The system Hamiltonian is given by,

$$H(\vec{r}_1, \vec{r}_2, ..., \vec{r}_n; \vec{p}_1, \vec{p}_2, ..., \vec{p}_n) = \sum_{i=1}^{n} \frac{p_i^2}{2m} + U \tag{2b}$$

Where U is the potential energy given by,

$$U(\vec{r}_1, \vec{r}_2, ..., \vec{r}_n) = \sum_{i<j} \frac{m_0^2}{|\vec{r}_i - \vec{r}_j|} \tag{2c}$$

where m_0 is the magnetic charge. The partition function is given by,

$$\mathrm{Z} = \int e^{-\beta H} d\lambda = \left[V (2\pi mkT)^{\frac{3}{2}} \right]^n \tag{2d}$$

where V is the volume of the universe, assuming the inter particle interaction U is negligible. The free energy is given by,

$$F = -kT \log Z \tag{2e}$$

with the particle pressure,

$$p=-\frac{\partial F}{\partial V} \qquad \text{(2f)}$$

using (2d, 2e) in (2f) we have,

$$p=\frac{nkT}{V} \qquad \text{(2g)}$$

For U nonzero we use the following approximation technique:

- (2d) → $Z=(2\pi mkT)^{\frac{3n}{2}}\int e^{-\beta U}d\vec{r}_1 d\vec{r}_2 ... d\vec{r}_n$, $U=\sum_{i<k} u(r_{ik})$; $\vec{r}_{ik}=\vec{r}_k-\vec{r}_k$
- Put $W(r_{ik})=e^{-\beta u(r_{ik})}-1$; $e^{-\beta U}=\prod_{i<k}(1+W_{ik})=1+\sum_{i<k}W_{ik}+\sum_{i<k}\sum_{i'<k'}W_{ik}W_{i'k'}+....$
- Term by term integration using a center of mass coordinate system R_{ik} gives for example,
- $\int W(r_{ik})d\vec{r}_i d\vec{r}_k=\int W(r_{ik})d\vec{r}_{ik}d\vec{R}_{ik}=V\int W(r_{ik})d\vec{r}_{ik}$ →
  $$=V\int W(r)4\pi r^2 dr$$
- $\int e^{-\beta U}d\vec{r}_1 d\vec{r}_2 ... d\vec{r}_n=V^n+V^{n-1}.{}^nC_2\int W(r)4\pi r^2 dr+....=$
  $$V^n\left(1+\frac{n^2}{2V}\int W(r)4\pi r^2 dr+....\right)$$
- $Z=(2\pi mkT)^{\frac{3n}{2}}\int e^{-\beta U}d\vec{r}_1 d\vec{r}_2 ... d\vec{r}_n=(2\pi mkT)^{\frac{3n}{2}}\times$
  $$V^n\left(1+\frac{n^2}{2V}\int W(r)4\pi r^2 dr+....\right)$$
- The free energy : $F=-kT\log Z$
  $$=-kT\left[\frac{3n}{2}\log(2\pi mkT)+n\log V+\frac{n^2}{2V}\int_0^\infty 4\pi r^2 W(r)dr+...\right]$$
- $p=-\dfrac{\partial F}{\partial V}=\dfrac{kTn}{V}-\dfrac{kTn^2}{2V^2}\displaystyle\int_0^\infty 4\pi r^2 W(r)dr+...$
  $$=\frac{kTn}{V}-\frac{kTn^2}{2V^2}\int_0^\infty 4\pi r^2\left(e^{-\beta U(r)}-1\right)dr+...$$

- Assume a Yukawa type potential function : $u(r)=\frac{e^{-\mu r}}{r}$; $\mu=\frac{mc}{\hbar}$, $\frac{1}{\mu}=$ range of forces.
- $e^{-\beta U(r)}-1\approx -1$, $0\le r\le 1/\mu$, $e^{-\beta U(r)}-1\approx -\beta U(r)$, $1/\mu<r<\infty$
- $\therefore\quad p=\frac{kTn}{V}-\frac{2\pi kTn^2}{V^2}\left[\int_0^{1/\mu}-r^2dr-\int_{0/\mu}^{\infty}r^2\beta Udr\right]$

$$=\frac{kTn}{V}-\frac{2\pi kTn^2}{V^2}\left[-\frac{1}{3\mu^3}-\beta\int_{1/\mu}^{\infty}r^2U(r)dr\right]$$

$$=\frac{kTn}{V}-\frac{2\pi kTn^2}{V^2}\left(-\frac{1}{3\mu^3}-\frac{2\beta}{\mu^2}e^{-1}\right)\qquad\text{(2h)}$$

3. Magnetism

Consider a potential function in (1e) of the following form for a magnetic field $\vec{H}(\vec{r},t)$,

$$\vec{A}(\vec{r},t)=\frac{1}{2}(\vec{H}(\vec{r},t)\wedge\vec{r})\qquad\text{(3)}$$

$$\therefore\quad\vec{\nabla}\wedge\vec{A}(\vec{r},t)=\frac{1}{2}\left[(\vec{r}\bullet\vec{\nabla})\vec{H}-\vec{r}(\vec{\nabla}\bullet\vec{H})-(\vec{H}\bullet\vec{\nabla})\vec{r}+\vec{H}(\vec{\nabla}\bullet\vec{r})\right]$$

i.e. from (1)

$$\vec{H}=\vec{\nabla}\wedge\vec{A}+2\pi\rho_m\vec{r}-\frac{1}{2}(\vec{r}\bullet\vec{\nabla})\vec{H}\qquad\text{(3a)}$$

and,

$$\vec{\nabla}\chi=2\pi\rho_m\vec{r}-\frac{1}{2}(\vec{r}\bullet\vec{\nabla})\vec{H}\qquad\text{(3b)}$$

if the monopole density satisfies the condition,

$$2\pi\rho_m\vec{r}-\frac{1}{2}(\vec{r}\bullet\vec{\nabla})\vec{H}=0\ \Rightarrow\vec{\nabla}\chi=0\ \Rightarrow\ \chi=\chi(t)\qquad\text{(3c)}$$

from (1j) $\psi=\psi(t)$, and (1h) shows that an irrotationa monopole current is not possible and (1g) becomes,

$$\vec{\nabla} \wedge \left(\vec{E} + \frac{1}{c}\frac{\partial \vec{A}}{\partial t} \right) = -\frac{4\pi}{c}\vec{j}_m \tag{3d}$$

condition (3c) gives,

$$\rho_m = \frac{1}{4\pi r^2}\vec{r} \bullet \left(\vec{r} \bullet \vec{\nabla} \right)\vec{H} \tag{3e}$$

This expression can be written in terms of suffix notation, using the summation convention as,

$$\rho_m = \frac{1}{4\pi r^2}\left(\frac{\partial T_j}{\partial x_j} - 4\vec{H} \bullet \vec{r} \right) = \frac{1}{4\pi r^2}\left(\vec{\nabla} \bullet \vec{T} - 4\vec{H} \bullet \vec{r} \right) \tag{3f}$$

where, $\vec{T} = (\vec{r} \bullet \vec{H})\vec{r}$ (3g)

if the monopoles are stationary, $\vec{j}_m = \vec{0}$ and (3d) reduces to the standard form,

$$\vec{E} = -\frac{1}{c}\frac{\partial \vec{A}}{\partial t} - \vec{\nabla}\phi \tag{3h}$$

We assume the ether can be modeled as a plasma satisfying the Navier-Stokes equation,

$$\frac{d\vec{u}}{dt} = \vec{F} - \frac{\nabla p}{\rho_m} + \frac{\upsilon}{\rho_m}\nabla^2\vec{u} \tag{3i}$$

where $\vec{F}$ is the external applied force per unit mass and υ is the coefficient of viscosity. The viscosity term arises due to the strain of the medium itself or its resistance to the strain and is largely unknown, while $\vec{F}$ is known from electromagnetism.

4. Forces on deformable medium

To compute the stress in the ether we appeal to the Maxwell stress tensor given by,

$$T_{ij} = \frac{1}{4\pi}\left[-E_iE_j - H_iH_j + \frac{1}{2}\delta_{ij}(E^2 + H^2) \right] \qquad (4)$$

The electric and magnetic fields in (4) refer only to the contributions from the magnetic charges. The ether consists of magnetic monopoles and is assumed to be isotropic. Therefore, the pressure is given by,

$$p = \langle T_{ii} \rangle = \frac{1}{24\pi}\left(E^2(T) + H^2(T)\right) \qquad (4a)$$

where T is the temperature of the universe. For example, in the neighborhood of a star T approximates to the surface temperature of the star, while in intergalactic space T will correspond most of the time to the microwave background radiation. Gravitational effects are introduced through Einstein's cosmological constant, using a potential energy function

$$V(\vec{r}_1, \vec{r}_2, ..., \vec{r}_n) = -G \sum_{i<j;i,j=1}^{n} \frac{m_i m_j}{|\vec{r}_i - \vec{r}_j|} + V_c \qquad (4b)$$

$$V_c = -\frac{\lambda}{6}\sum_j m_j r_j^2 \qquad (4c)$$

where, $\vec{r}_j = \vec{r}_j(t)$ is the position vector of the particle of mass m_j at time *t*, measured from a fixed origin *O*. Assuming the monopoles have the same mass *m*, the corresponding force is,

$$\vec{F}_{cj} = -\vec{\nabla} V_c = \frac{\lambda}{3} m \vec{r}_j \qquad (4d)$$

Therefore the resultant cosmological force is,

$$\vec{F}_c = \frac{\lambda m}{3}\sum_{j=1}^{n} \vec{r}_j = \frac{\lambda m n}{3}\vec{\Re} \qquad (4e)$$

where $\vec{\Re}$ s the center of gravity of the universe with respect to O. Therefore $\vec{F}$ in equation (3i) is,

$$\vec{F} = \vec{F}_g + \vec{F}_c \quad ; \quad \vec{F}_g = -\vec{\nabla} V_g \quad ; \quad V_g = -G \sum_{i<j;i,j=1}^{n} \frac{m^2}{|\vec{r}_i - \vec{r}_j|} \qquad \text{(4f)}$$

In this formulation we have implicitly assumed a particle model ($n \to \infty$) and neglecting electromagnetic interactions.

5. *Viscosity Effects.*

If the monopoles are rigid, elastic attracting spheres of diameter D, then the coefficient of viscosity is

$$\upsilon = \frac{\gamma}{\pi^{\frac{3}{2}}} \frac{\sqrt{mkT}}{D^2} \qquad \text{(5)}$$

where $\gamma \approx 1$ is an undetermined factor. D is given by equation (0).

6. *Boltzmann Equation*

The Boltzmann equation for the distribution function f is given by,

$$\frac{df}{dt} = \left(\frac{\partial f}{\partial t} \right)_{coll} \qquad \text{(6)}$$

where the kinetic term is ,

$$\frac{df}{dt} = \frac{\partial f}{\partial t} + \frac{\partial f}{\partial \vec{r}} \bullet \vec{v} + \frac{\partial f}{\partial \vec{v}} \bullet \frac{\vec{F}}{m} \qquad \text{(6a)}$$

and the collision term is,

$$\left(\frac{\partial f}{\partial t} \right)_{coll} = -\iint (ff_1 - f'f_1') a\, du_1 dv_1 dw_1 d\varpi \qquad \text{(6b)}$$

with, $a = a_{12 \to 1'2'} = a_{1'2'' \to 12} =$ transition probabilities

$d\varpi = \sin\theta d\theta d\phi$ = surface element on unit sphere, or solid angle.

the primes denote the particle velocities after collisions

Case (1) : local equilibrium

$$\left(\frac{\partial f}{\partial t}\right) = 0 \tag{6c}$$

This corresponds to an equilibrium distribution, which remains unaltered with respect to collisions and is given by,

$$f(\vec{r},\vec{v},t) = A\exp\left\{-\beta(\vec{r},t)\left[\frac{mv^2}{2} + E_{pot}(\vec{r},t) - m\vec{v}\bullet\vec{c}(\vec{r},t)\right]\right\}$$

(6d)

The local temperature, which occurs in β is a function of position and time $(\vec{r},t)$ and $\vec{c}(\vec{r},t)$ is a local drift velocity. In accordance with the results of the Michelson-Morley experiment we take the local drift velocity to be zero, except in the vicinity of massive star such as a neutron star or a black hole. For the potential energy $E_{pot}(\vec{r},t)$ in (6d) we take the gravitational potential energy V_g (4f) and the effect of the cosmological constant (4c). To calculate the inter-particle forces $\vec{F}$ we could assume for purposes of simplicity that the particles behave like rigid elastic spheres
in (6a), or more general formulations based on the strong force of particle physics.

$$E_{pot} = V_g + V_c + V_m \tag{6e}$$

where V_e is the monopole interaction term.

Case (2) : high frequency limit $\left|\frac{\partial f}{\partial t}\right| >> \left|\left(\frac{\partial f}{\partial t}\right)_{coll}\right|$

In this case,

$$\left(\frac{\partial f}{\partial t}\right)_{coll} = -\frac{f - f_0}{\tau} \tag{6f}$$

where τ is the relaxation time, and f_0 is a stationary distribution of the type (6d).

$$\tau \approx \frac{\lambda}{<c>} \tag{6g}$$

where λ is the mean free path and <*c*> is the average velocity of a monopole constituting the ether.

7. Scattering Cross Section

To calculate the effects of the monopole collisions, we use the Rutherford cross section for two monopoles each of strength m_1 and mass m,

$$\frac{d\sigma}{d\Omega} = \frac{1}{4}\left(\frac{m_1^2}{\hat{m}u^2}\right)^2 \cos ec^4\left(\frac{\theta}{2}\right) \qquad (7)$$

where θ is the polar angle for large r after scattering.

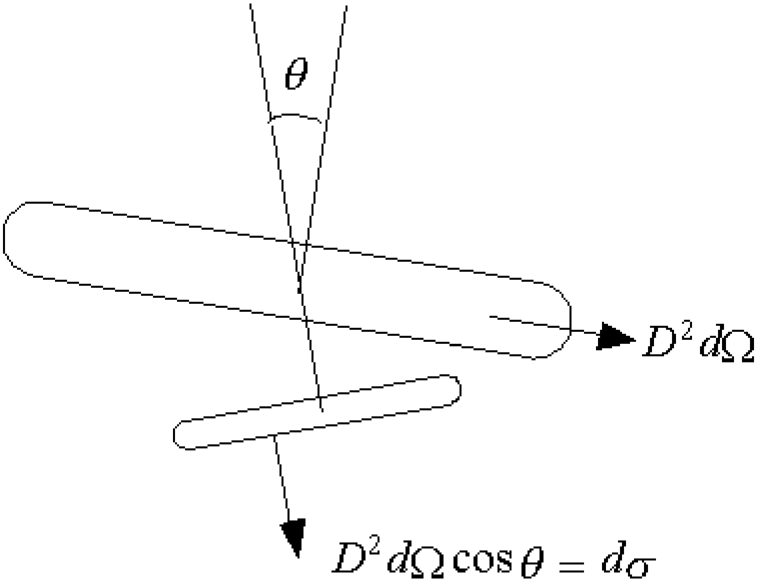

Fig 1

If the impact parameter b is in the range (b , $b + db$), the scattering angle is in the range $(\theta, \theta + d\theta)$. $\hat{m}$ is the "reduced" mass = $m/2$. The impact parameter is

$$b = \frac{m_1^2}{\hat{m}u^2}\cot\left(\frac{\theta}{2}\right) = \frac{2m_1^2}{mu^2}\cot\left(\frac{\theta}{2}\right) \qquad (7a)$$

where u is the velocity of the incident beam

Let $\vec{c}_1$ and $\vec{c}_2$ be the velocities of the monopoles , arbitrarily labeled particles 1 & 2 respectively, before the collision and $\vec{c}_1', \vec{c}_2'$ their velocities after the collision.

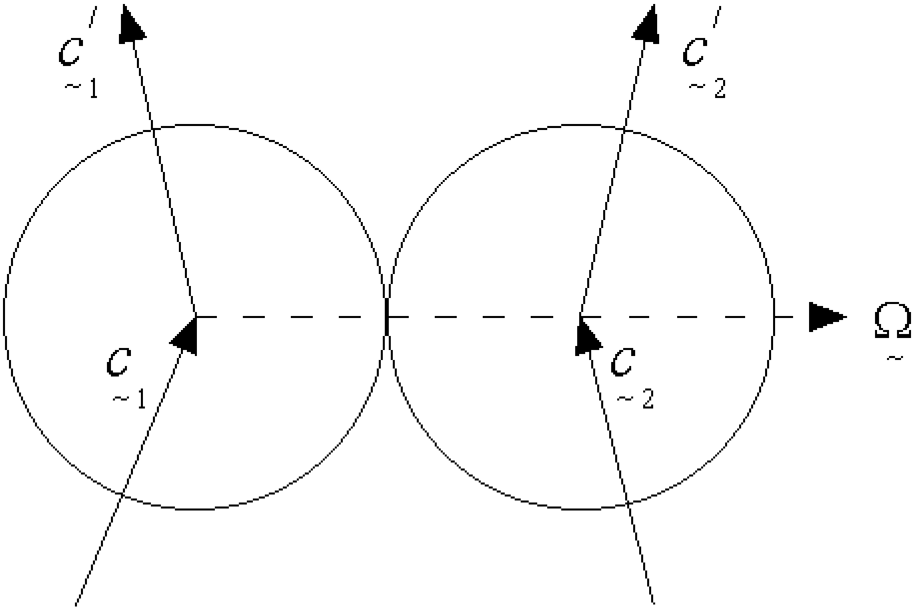

Fig 2

The velocity of the center of mass of the two particles (before and after impact) is,

$$\vec{w} = \frac{\vec{c}_1 + \vec{c}_2}{2} = \frac{\vec{c}_1' + \vec{c}_2'}{2} \tag{7b}$$

on the assumption the particles are treated as elastic spheres. The relative velocity of the two particles before and after the collision are respectively,

$$\vec{u} = \vec{c}_2 - \vec{c}_1 \quad , \quad \vec{u}' = \vec{c}_2' - \vec{c}_1' \tag{7c}$$

with the change in relative velocity given by,

$$\delta\vec{u} = \vec{u}' - \vec{u} \tag{7d}$$

Solving for $\vec{c}_1, \vec{c}_2$ using (7b) and the first equation in (7c), we have,

$$\vec{c}_1 = \vec{w} - \frac{1}{2}\vec{u} \ , \ \vec{c}_2 = \vec{w} + \frac{1}{2}\vec{u} \qquad (7e)$$

and similarly

$$\vec{c}_1' = \vec{w} - \frac{1}{2}\vec{u}' \ , \ \vec{c}_2' = \vec{w} + \frac{1}{2}\vec{u}' \qquad (7f)$$

From (7c-7e),

$$\delta\vec{c}_2 \equiv \vec{c}_2' - \vec{c}_2 = \frac{1}{2}\delta\vec{u} \quad , \quad \delta\vec{c}_1 \equiv \vec{c}_1' - \vec{c}_1 = -\frac{1}{2}\delta\vec{u} \qquad (7g)$$

The number of collisions per cm^3 in a time interval dt between atoms with velocities between ($\vec{c}_1$, $\vec{c}_1 + d\vec{c}_1$) on the one hand and particles with velocities between ($\vec{c}_2$, $\vec{c}_2 + d\vec{c}_2$) on the other hand, while their line of centers lie within a solid angle $d\Omega$ is given by the expression,

$$D^2 u \cos\theta f(u_1, v_1, w_1) f(u_2, v_2, w_2) du_1 dv_1 dw_1 du_2 dv_2 dw_2 d\Omega dt \qquad (7h)$$

which is obtained by the number of particles per cm^3 with velocities in the range $(\vec{c}_1, \vec{c}_1 + d\vec{c}_1) \rightarrow f(u_1, v_1, w_1) du_1 dv_1 dw_1$, multiplied by the number of type 2 monopoles with velocities between ($\vec{c}_2$, $\vec{c}_2 + d\vec{c}_2$) which collide with a single type 1 monopole in a time interval dt such that the line of centers has a direction $\vec{\Omega}$ within a solid angle $d\vec{\Omega}$. To calculate this, consider a cylinder of base area = $D^2 d\Omega$ where D is the diameter of a monopole with a slant height = $|\vec{u}|\, dt = udt$. The volume of this cylinder = $D^2 u \cos\theta d\Omega dt$, where θ angle between the line of centers and $\vec{u}$.

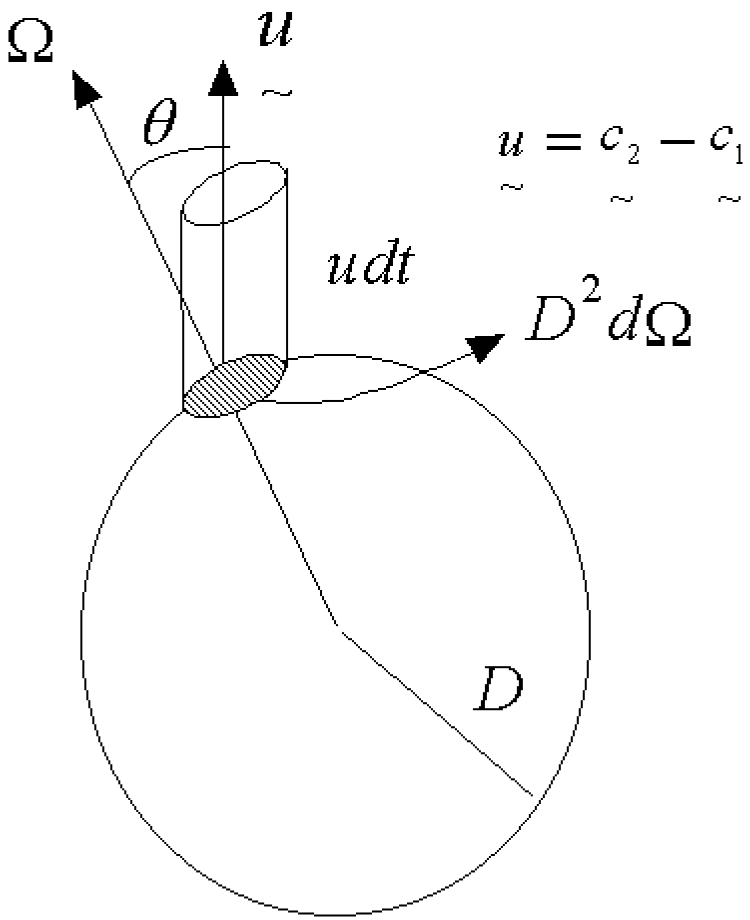

Fig 3

The effective volume is zero if $\cos\theta \le 0$. Taking 1 as the scattering center, all particles of type 2, which lie within a solid angle $d\Omega = 2\pi \sin\theta d\theta$, will correspond to incident particles that lie within a circular ring of area $= 2\pi b db$. In expression (7h),

$$D^2 \cos\theta d\Omega = d\sigma \tag{7i}$$

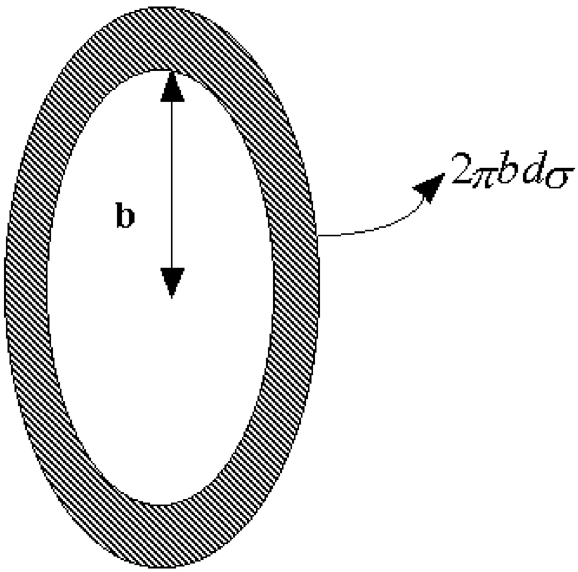

Fig 4

where $d\sigma =$ projection of the area $D^2 d\Omega$ onto a line perpendicular to the initial relative velocity $\vec{u}$.

$$\therefore \quad d\sigma = 2\pi b db \qquad (7j)$$

Integrating (7h) with respect to monopoles of type 2, using (7i, 7j)

$$D^2 u \cos\theta f(u_2, v_2, w_2) du_2 dv_2 dw_2 d\Omega dt = uf(u_2, v_2, w_2) d^3 c_2 d\sigma \, \mathrm{dt}$$

$$\therefore \int uf(u_2, v_2, w_2) d^3 c_2 d\sigma dt = n_0 u d\sigma dt \qquad (7k)$$

where n_0 is the number of monopoles per cubic centimeter.

$\therefore$ from (7g, 7h, 7k)

$$\left\langle \frac{\delta c_{2r}}{\delta t} \right\rangle = \frac{1}{2}\int d^3 c_1 f(u_1, v_1, w_1)\{\delta u_r\} \qquad (7l)$$

where, $$\{\delta u_r\} = \int u \delta u_r \frac{d\sigma}{d\Omega} d\Omega \qquad (7m)$$

For perfectly elastic impacts, $|\vec{u}| = |\vec{u}'|$. Without loss of generality we take our coordinate system such that prior to collision,

$$\vec{u} = u(0,0,1) \qquad (7m1)$$

and after collision

$$\vec{u}' = u(\sin\theta\cos\phi, \sin\theta\sin\phi, \cos\theta)$$

Therefore from (7d),

$$\delta\vec{u} = u(\sin\theta\cos\phi, \sin\theta\sin\phi, -2\sin^2\frac{\theta}{2}) \qquad (7n)$$

and (7m) becomes,

$$\{\delta\vec{u}\} = \int u^2(\sin\theta\cos\phi, \sin\theta\sin\phi, -2\sin^2\frac{\theta}{2})\frac{d\sigma}{d\Omega} d\Omega \qquad (7o)$$

From (7j),

$$\{\delta\vec{u}\} = (0,0,-\pi\left(\frac{2m_1^2}{mu}\right)^2 \int_0^{\pi} \frac{\sin\theta}{\sin^2\frac{\theta}{2}} d\theta)$$

$$\therefore \quad \{\delta u_1\} = \{\delta u_2\} = 0 \ , \ \{\delta u_3\} = -\pi\left(\frac{2m_1^2}{mu}\right)^2 \int_0^{\pi} \frac{\sin\theta}{\sin^2\frac{\theta}{2}} d\theta \qquad (7p)$$

$$\therefore \ \{\delta u_3\} = -4\pi\left(\frac{2m_1^2}{mu}\right)^2 \left[\ln\left(\sin\frac{\theta}{2}\right)\right]_0^{\pi}$$

This integral diverges as $\theta \to 0+$. To handle this situation we use equation (7a),

$b = b_{\max} \Rightarrow \theta = \theta_{\min}$, where $\theta_{\min}$ satisfies the requirement,

$$\tan\left(\frac{\theta_{\min}}{2}\right) = \frac{2m_1^2}{mu^2 b_{\max}} \qquad (7q)$$

$$\{\delta u_3\} = -4\pi\left(\frac{2m_1^2}{mu}\right)^2 \left[\ln\left(\sin\frac{\theta}{2}\right)\right]_{\theta_{\min}}^{\pi} = 4\pi\left(\frac{2m_1^2}{mu}\right)^2 \ln\left(\sin\frac{\theta_{\min}}{2}\right) \qquad (7r)$$

$b_{\max}$ is the ***Debye length*** and represents the maximum distance over which the magnetic force is operative. For $b_{\max} >> 1$, we see from (7q),

$$\theta_{\min} \approx \frac{4m_1^2}{mu^2 b_{\max}} \qquad (7s)$$

similarly we can define (see equations 7l, 7m) ,

$$\left\langle \frac{\delta c_{2r}\delta c_{2s}}{\delta t} \right\rangle = \frac{1}{4}\int d^3c_1 f(u_1, v_1, w_1)\{\delta u_r, \delta u_s\} \qquad (7t)$$

where, $\{\delta u_r, \delta u_s\} = \int u\delta u_r \delta u_s \frac{d\sigma}{d\Omega} d\Omega$ (7u)

again from (7n),

$$\{\delta u_r, \delta u_s\} = 0 \quad \text{if} \quad r \neq s$$

$$= \frac{\pi m_1^4}{m^2 u}\int_{\theta_{\min}}^{\pi} \frac{\sin^3\theta}{\sin^4\left(\frac{\theta}{2}\right)} d\theta \qquad \text{if} \quad r = s = 1,2$$

$$= \frac{8\pi m_1^4}{m^2 u}\int_0^{\pi} \sin\theta d\theta = \frac{16\pi m_1^4}{m^2 u} \quad \text{if} \quad r = s = 3 \qquad (7v)$$

Evaluating the above integrals we have,

$$\{\delta u_1, \delta u_1\} = \{\delta u_2, \delta u_2\} = \frac{4\pi m_1^4}{m^2 u}\left\{-4\ln(\sin\left(\frac{\theta_{\min}}{2}\right)) - 2\right\} \quad (7w)$$

retaining only the dominant terms in (7r, 7w, 7v) for small $\theta_{\min}$,

$$\{\delta u_3\} = 4\pi\left(\frac{2m_1^2}{mu}\right)^2 \ln\left(\sin\frac{\theta_{\min}}{2}\right) = -\frac{4\Gamma}{u^2} \quad (7x)$$

$$\{\delta u_1, \delta u_1\} = \{\delta u_2, \delta u_2\} = \frac{4\Gamma}{u} \quad (7y)$$

$$\{\delta u_3, \delta u_3\} = 0 \quad (7z)$$

$$\text{where, } \Gamma = \frac{4\pi m_1^4}{m^2}\ln\left(\frac{2}{\theta_{\min}}\right) \quad (7z1)$$

generalizing the result (7m1) we have using (7x, 7y, 7z),

$$\{\delta u_r\} = \; = -\frac{4\Gamma u_r}{u^3} \quad (7z2)$$

$$\{\delta u_r, \delta u_s] = 4\Gamma\left(\frac{\delta_{rs}}{u} - \frac{u_r u_s}{u^3}\right) \quad (7z3)$$

Substituting (7z2, 7z3) in (7l, 7t)

$$\left\langle \frac{\delta c_{2r}}{\delta t} \right\rangle = -2\Gamma \int d^3 c_1 f(u_1, v_1, w_1)\frac{u_r}{u^3} \quad (7z4)$$

$$\left\langle \frac{\delta c_{2r}\delta c_{2s}}{\delta t} \right\rangle = \Gamma \int d^3 c_1 f(u_1, v_1, w_1)\left(\frac{\delta_{rs}}{u} - \frac{u_r u_s}{u^3}\right) \quad (7z5)$$

To make further progress, we appeal to the following results based on the first of equations (7c)

$$\frac{u_r}{u^3} = -\frac{\partial}{\partial c_{2r}}\left(\frac{1}{u}\right) \tag{7z6}$$

$$\frac{\delta_{rs}}{u} - \frac{u_r u_s}{u^3} = \frac{\partial^2 u}{\partial c_{2r}\partial c_{2s}} \tag{7z7}$$

The Rosenbluth potentials are defined by,

$$G = \int d^3 c_1 f(u_1, v_1, w_1) u \tag{7z8}$$

$$H = 2\int d^3 c_1 f(u_1, v_1, w_1)\frac{1}{u} \tag{7z9}$$

Therefore, equations (7z4, 7z5) become using (7z6, 7z7)

$$\left\langle \frac{\delta c_{2r}}{\delta t} \right\rangle = \Gamma \frac{\partial H}{\partial c_{2r}} \tag{7z10}$$

$$\left\langle \frac{\delta c_{2r}\delta c_{2s}}{\delta t} \right\rangle = \Gamma \frac{\partial^2 G}{\partial c_{2r}\partial c_{2s}} \tag{7z11}$$

8. *Fokker – Planck Equation*

$$\frac{\partial f}{\partial t}+c_{2r}\frac{\partial f}{\partial x_{2r}}+a_{2r}\frac{\partial f}{\partial c_{2r}}=$$
$$-\frac{\partial}{\partial c_{2r}}\left(\left\langle\frac{\delta c_{2r}}{\delta t}\right\rangle f\right)+\frac{1}{2}\frac{\partial^2}{\partial c_{2r}\partial c_{2s}}\left(\left\langle\frac{\delta c_{2r}\delta c_{2s}}{\delta t}\right\rangle f\right) \qquad (8)$$

For the magnetic field $\vec{\mathrm{H}}$ created by the monopoles this becomes using (7z10, 7z11),

$$\frac{\partial f}{\partial t}+c_{2r}\frac{\partial f}{\partial x_{2r}}+\frac{m_1}{m}\mathrm{H}_r\frac{\partial f}{\partial c_{2r}}=$$
$$-\Gamma\frac{\partial}{\partial c_{2r}}\left(f\frac{\partial H}{\partial c_{2r}}\right)+\frac{1}{2}\frac{\partial^2}{\partial c_{2r}\partial c_{2s}}\left(f\frac{\partial^2 G}{\partial c_{2r}\partial c_{2s}}\right) \qquad (8a)$$

A particular, solution corresponds to a uniform distribution, $f=f^*$, giving

$$\nabla_{c_2}^2 H=\frac{1}{2}\nabla_{c_2}^4 G \qquad (8b)$$

where the gradient operators are with respect to the type 2 monopole velocity $\vec{c}_2$ and the Rosenbluth potentials (7z8, 7z9) reduce to,

$$G=f^*\int u d^3 c_1 \qquad (8c)$$

$$H=2f^*\int\frac{1}{u}d^3 c_1 \qquad (8d)$$

$\therefore$ using (8c, 8d) in (8b) we have the differential equation for the monopole velocities,

$$\nabla_{c_2}^2\int\frac{1}{u}du_1 dv_1 dw_1=\frac{1}{4}\nabla_{c_2}^4\int u du_1 dv_1 dw_1 \qquad (8e)$$

where, from (7c),

$$u=\sqrt{(u_1-u_2)^2+(v_1-v_2)^2+(w_1-w_2)^2} \tag{8f}$$

The limits of integration for each velocity component is *(-c,+c*), where *c* is the velocity of light. Carrying out the integrations in (8e) using spherical polar coordinates in velocity space, we see that condition (8e) is identically satisfied.

9. Monopole Plasma

Consider the evolution of a plasma that is almost neutral with respect to magnetic charge. We shall allow for a difference of temperature between negative monopoles and positive monopoles. The mass density and magnetic charge density are

$$\rho=(n_+ + n_-)m \tag{9a}$$

$$\xi=m_1(n_+ - n_-) \tag{9b}$$

where n_+, n_- are the number densities respectively of positively charged and negatively charged magnetic monopoles. The r-th component of their mean velocities are,

$$C_{+,r}=\frac{1}{n(\vec{r},t)}\int f(\vec{r},\vec{c},t)c_{+,r}d^3c \tag{9c}$$

$$C_{-,r}=\frac{1}{n(\vec{r},t)}\int f(\vec{r},\vec{c},t)c_{-,r}d^3c \tag{9d}$$

where the number density is given by,

$$n(\vec{r},t)=\int f(\vec{r},\vec{c},t)d^3c \;=\; n_+ + n_- \tag{9e}$$

define the number velocity ,

$$C_r=\frac{n_+C_{+,r}+n_-C_{-,r}}{n_+ + n_-} \tag{9f}$$

the magnetic current density is given by,

$$J_r=\frac{m_1}{c}(n_+C_{+,r}-n_-C_{-,r}) \tag{9g}$$

the velocities relative to the mean number velocity is given by

$$w_{+,r} = C_{+,r} - C_r \quad : \quad w_{-,r} = C_{-,r} - C_r \qquad \text{(9h)}$$

the corresponding symmetric pressure tensors are,

$$p_{+,ts} = m\int f_+ w_{+,t} w_{+,s} d^3c \ ; \ p_{-,ts} = m\int f_- w_{-,t} w_{-,s} d^3c \qquad \text{(9i)}$$

For steady state conditions in which no monopoles are created or destroyed or recombines,

$$\left(\frac{\partial n_+}{\partial t}\right)_{coll} = 0 \ : \ \left(\frac{\partial n_-}{\partial t}\right)_{coll} = 0 \qquad \text{(9j)}$$

Conservation of momentum and energy densities given by,

$$\frac{d\vec{P}}{dt} = 0 \ ; \ \vec{P} = \int m\vec{c} f(\vec{r},\vec{c},t) d^3c$$
$$= \int m\vec{c}\left(f_+ + f_-\right) d^3c$$

$$\therefore \ K_r = m\int c_{+,r}\left(\frac{\partial f_+}{\partial t}\right)_{coll} d^3c_+ = -m\int c_{-,r}\left(\frac{\partial f_-}{\partial t}\right)_{coll} d^3c_- \qquad \text{(9k)}$$

$$\frac{dE}{dt} = 0 \ ; \ E = \frac{1}{2}\int m\vec{c}^{\,2} f(\vec{r},\vec{c},t) d^3c$$
$$= \frac{1}{2}\int m\vec{c}^{\,2}\left(f_+ + f_-\right) d^3c$$

$$\therefore \ \mathrm{E} = \frac{m}{2}\int c^2{}_{+,r}\left(\frac{\partial f_+}{\partial t}\right)_{coll} d^3c_+ = -\frac{m}{2}\int c^2{}_{-,r}\left(\frac{\partial f_-}{\partial t}\right)_{coll} d^3c_- \qquad \text{(9k)}$$

K_r represents the relative "frictional" force between the (+) and (-) monopoles, while E represents the rate of transfer of energy.

10. Symmetrization of Time

We now study the implications of embedding the ether in an electro-gravitational field. For a 3-dimensional time vector (t_1, t_2, t_3), where t_1 is the (real) time (*t*) of everyday experience, and $[t_2, t_3]$ are pure imaginary numbers,

$$t_1 = t \quad , \quad t_2 = i\tau_2 \quad , \quad t_3 = i\tau_3 \qquad (10)$$

with τ_2, τ_3 being real entities, which have the dimensions of time. Unlike its special relativistic counterpart, space and time are independent variables that comport to Newtonian ideas. Specifically, the 3 components of space = *(x,y,z)* are embedded in Euclidean space. We use the method of dimensions to analyze the significance of τ_2, τ_3 .In a deviation from classical dynamics, τ_2, τ_3 are assumed to be dependent on the distribution of matter in their neighborhood. In this sense, the present approach is another bridge between relativity and Newtonian gravitation. This dichotomy between the electromagnetism of Faraday and Maxwell and gravitation is explored further in the tract by de Silva & Lawson, where an alternate scenario to the search for grand unification theories is proposed. The fundamental constants of nature, such as the gravitational constant (*G*), Planck's constant (*h*) and the velocity of light (*c*) have the dimensions,

$$[G] = M^{-1}L^3T^{-2} \quad , \quad [h] = ML^2T^{-1} \quad , \quad [c] = LT^{-1} \qquad (10a)$$

we further assume,

$$\tau_2 = k_2 mt \quad , \quad \tau_3 = k_3 mt \qquad (10b)$$

where (k_2, k_3) are real constants, *m* is the local mass and *t* the time as commonly understood.

$$[k_2] = M^{-1} = G^{\alpha} h^{\beta} c^{\gamma} = M^{-\alpha+\beta} L^{3\alpha+2\beta+\gamma} T^{-2\alpha-\beta-\gamma}$$

equating corresponding exponents of (M, L, T) we have,

$$-\alpha + \beta = -1 \quad , \; 3\alpha + 2\beta + \gamma = 0 \quad , -2\alpha - \beta - \gamma = 0 \qquad (10c)$$

solving for (α, β, γ)

$$\alpha = \frac{1}{2} \ , \ \beta = -\frac{1}{2} \ , \ \gamma = -\frac{1}{2} \tag{10d}$$

$$\therefore \quad k_2 = \sqrt{\frac{G}{hc}} \tag{10e}$$

In cgs units,

$$\begin{aligned} G &= 6.673 \times 10^{-8} \qquad cm^3 g^{-1} \sec^{-2} \\ h &= 6.63 \times 10^{-27} \qquad \text{erg sec} \\ c &= 3 \times 10^{10} \qquad cm \sec^{-1} \end{aligned}$$

$$\therefore \ k_2 = k_3 = 1.83 \times 10^4 \qquad gm^{-1} \tag{10f}$$

From (10b),

$$\tau_2 = a_2 \sqrt{\frac{G}{hc}} mt \ , \quad \tau_3 = a_3 \sqrt{\frac{G}{hc}} mt \tag{10g}$$

where (a_2, a_3) are dimensionless universal constants. From (10b, 10e) we have,

$$. \ \tau_2^2 + \tau_3^2 = \frac{Gm^2}{hc}(a_2^2 + a_3^2)t^2 \tag{10h}$$

This corresponds to a two sided cone about the *t* axis with its center at the origin.. The intersection of this cone with a plane, $t = t_0$ (constant), is a circle of radius,

$$mt_0 \sqrt{\frac{G}{hc}(a_2^2 + a_3^2)}$$

The generators of the cone make an angle

$$\pm \tan^{-1}\left(m\sqrt{\frac{G}{hc}(a_2^2 + a_3^2)} \right) \qquad (10i)$$

with the time axis. With the classical spatial coordinates there is associated a triad of numbers (s_1, s_2, s_3), corresponding respectively to (t_1, t_2, t_3), where

$$s_1 = s \;, \quad s_2 = i\hat{s}_2 \;, \quad s_3 = i\hat{s}_3 \qquad (10j)$$

where s is the Euclidean spatial coordinate, and $\hat{s}_2, \hat{s}_3$ are real numbers, associated with the imaginary or virtual time coordinates τ_2, τ_3. The emission of light is visualized as somewhat similar to the firing of pellets from a toy gun whose trajectories correspond to light rays in the Newtonian picture. The velocity of such a ray is then defined by,

$$\frac{ds_1}{dt_1}, \ \frac{ds_2}{dt_2}, \ \frac{ds_2}{dt_2} \qquad (10k)$$

This corresponds to,

$$\frac{ds}{dt} = c \;, \quad \frac{d\hat{s}_2}{d\tau_2} = v_2 \;, \quad \frac{d\hat{s}_3}{d\tau_3} = v_3 \qquad (10l)$$

with (v_2, v_3) being the velocities associated with the virtual particles populating the (τ_2, τ_3) time subspace, and from (10b, 10g)

$$\frac{d\hat{s}_2}{d\tau_2} = v_2 \quad \Rightarrow \quad d\hat{s}_2 = v_2 a_2 k_2 m dt$$

and (10m)

$$\frac{d\hat{s}_3}{d\tau_3} = v_3 \quad \Rightarrow \quad d\hat{s}_3 = v_3 a_3 k_3 m dt$$

The spatial and temporal subspaces $(s, \hat{s}_2, \hat{s}_3), (t, \tau_2, \tau_3)$ are respectively real Euclidean isomorphic vector spaces. The element of length in our 6 dimensional model, buttressed by

Newtonian physics is given by,

$$d\Sigma^2 = ds^2 + d\hat{s}_2{}^2 + d\hat{s}_3{}^2 + c^2(dt^2 + d\tau_2^2 + d\tau_3^2)$$
$$= (ds^2 + c^2 dt^2) + (d\hat{s}_2^2 + c^2 d\tau_2^2) + (d\hat{s}_3^2 + c^2 d\tau_3^2) \qquad (10n)$$

the constant c being introduced for purposes of dimensional compatibility. Each of the terms within the 3 parenthesis in (10n) corresponds to a 2 dimensional Euclidean subspace.
As a light ray propagates along the s –direction, its constituents the photons also travel along the positive s –direction. In the
temporal subspace the time t increases along the axis of the cone (10h, 10i). Because of the isomorphism of the subspaces, we from (10h) that as the (τ_2, τ_3) vector describes a circle the photons will trace a helix in the $(s, \hat{s}_2, \hat{s}_3)$ space.
The bending of a ray of light in the presence of a mass m in the (t, t_2) plane is,

$$\tan\alpha_2 = \frac{1}{c}\frac{d\hat{s}_2}{dt} = \frac{v_2}{c} a_2 k_2 m \approx 1.83\times10^4 a_2 m \;;\quad \frac{v_2}{c} \approx 1 \qquad (10o)$$

Similarly in the (t, τ_3), the bending of a light ray is given by,

$$\tan\alpha_3 = \frac{1}{c}\frac{d\hat{s}_3}{dt} = \frac{v_3}{c} a_3 k_3 m \approx 1.83\times10^4 a_3 m \;;\quad \frac{v_3}{c} \approx 1 \qquad (10p)$$

To determine the values of the constants (a_2, a_3) we need to calibrate the above equations by for example measuring the bending of light during a total eclipse of the sun. It is expected that $a_2 \approx a_3$. For example in the case of the sun,

$$m \approx 2\times10^{33} \qquad (10q)$$

Therefore from (10n, 10o) for small α_2, α_3

$$\alpha_2 = \alpha_3 = 1.75'' = \frac{\pi}{180}\times\frac{1.75}{3600} \text{ radians} = 8.484\times10^{-6} \qquad (10r)$$

$$a_2 \approx a_3 = 22.9\times10^{-44} \qquad (10s)$$

According to the theory of the big-bang, the present age of the universe is estimated at around 14 billion years, but recently distant galaxies have been observed that appear to be much older. Our hypothesis of virtual particles might be a possible explanation within the constraints of the big-bang theory. The virtual particles in the (τ_2, τ_3) subspace are subject to Heisenberg's Uncertainty Principle, with the uncertainty in time being given by (10h),

$$\Delta\mathrm{T} = \sqrt{\tau_2^2 + \tau_3^2} = \sqrt{\frac{Gm^2}{hc}(a_2^2 + a_3^2)t^2} \tag{10s}$$

Therefore the uncertainty of the energy of these particles is determined by,

$$\Delta E \Delta T \approx h \tag{10t}$$

$$\therefore \qquad \Delta E = \frac{1}{mt}\sqrt{\frac{h^3 c}{G(a_2^2 + a_3^2)}} \tag{10u}$$

From (10f, 10g, 10r)

$$\tau_2 = \tau_3 = 41.9 \times 10^{-40} mt \tag{10v}$$

In the absence of matter, *m=0* and from (10v) $\tau_2 = \tau_3 = 0$. We see that the triad of time coordinates reduce to, *(t,0,0)*, which corresponds to Newtonian 4 space-time and from (10n)

$$d\Sigma^2 = ds^2 + c^2 dt^2 = dx^2 + dy^2 + dz^2 c^2 dt^2 \tag{10w}$$

Again from (10o, 10p, 10s),

$$\tan\alpha_2 = \tan\alpha_3 \approx 42 \times 10^{-40} m \tag{10x}$$

$$\text{For,} \qquad m \approx 10^{40} \text{ gm}, \ \alpha_2, \alpha_3 \approx 90^0 \tag{10y}$$

For large m such as a neutron star or a black hole, the flow of time stops and in its place we have ghost particles associated with virtual time components (See Section 11). As the time, $t \to \infty$, it is assumed that the universe has an increased probability of disorder (entropy) according to the laws of thermodynamics. This means that ΔE will increase, with time. From (10u), for consistency we need to have either G or m or both tend to zero. In the 1930s, Dirac proposed that the gravitational constant G may in fact decrease with time. This would imply that the sun was significantly brighter in the remote past, since it is gravitational compression that heats the interior, which in turn increases the temperatures at the core of the sun enabling nuclear fusion to occur. In addition, Hoyle & Narlikar, propose that the mass of the elementary particles depend on the local mass distribution.

11. Virtual Galaxies

From (10s, 10v), the uncertainty in the virtual time components (τ_2, τ_3) is given by

$$\Delta T = 59.3 \times 10^{-40}\ mt \qquad (11)$$

Therefore for large masses of order given by (10y) or greater, the time uncertainty (11) will tend to ∞ as the Newtonian time $t \to \infty$, unless $t=0$ always in the presence of very large masses.. This is consistent with the spread in the energy spectrum given by (10u). An additional point to keep in mind is the laws of physics are not well understood as they operate in the presence of massive celestial objects such as a black hole.
Most of the previous analysis has predicated on the assumption, $v_2, v_3 \approx c$. For the more general situation, we have from (10m, 10f, 10s),

$$\frac{d\hat{s}_2}{d\tau_2} = \frac{1}{a_2 m}\sqrt{\frac{hc}{G}}\,\frac{d\hat{s}_2}{dt} = v_2 = H(t)\hat{s}_2$$

$$\therefore \quad \hat{s}_2(t) = \hat{s}_2(0)\exp\left(42 \times 10^{-40}\, m \int_0^t H(t)\,dt\right) \qquad (11a)$$

where $H(t)$ is Hubble's function. Equation (11a) connects gravitation (G), electromagnetism and quantum theory(h, c) and cosmology ($H(t)$).

similarly, $$\hat{s}_3(t) = \hat{s}_3(0)\exp\left(42\times10^{-40}\,m\int_0^t H(t)dt\right) \qquad (11b)$$

from (11a, 11b), $$\hat{s}_2 = \kappa\hat{s}_3 \qquad (11c)$$

where,

$$\kappa = \frac{\hat{s}_2(0)}{\hat{s}_3(0)} \qquad (11d)$$

Assuming the present value of H,

$$H^{-1} \approx 10^{17} \quad \text{sec} \qquad (11e)$$

using (11e) as the function for $H(t)$ in (11a, 11b) we have,

$$\hat{s}_2(t) = \hat{s}_2(0)\exp\left(42\times10^{-57}\,mt\right) \qquad (11f)$$

$$\hat{s}_3(t) = \hat{s}_3(0)\exp\left(42\times10^{-57}\,mt\right) \qquad (11g)$$

12. ***8-Dimensional Spinors***

The solutions of the relativistic wave equation, assuming the monopoles are ½ spin particles we have,

$$\left\{c(\vec{\alpha}_2 \bullet \hat{\vec{p}}_2 + \alpha_{0,2}mc^2)\right\}\hat{\psi}_2 = \hat{E}_2\hat{\psi}_2 \qquad (12)$$

$$\left\{c(\vec{\alpha}_3 \bullet \hat{\vec{p}}_3 + \alpha_{0,3}mc^2)\right\}\hat{\psi}_3 = \hat{E}_3\hat{\psi}_3 \qquad (12a)$$

where the plane wave solutions,

$$\hat{\psi}_2 = \hat{u}_2 \exp i\{(\hat{\vec{p}}_2 \bullet \hat{\vec{r}}_2 - \hat{E}_2\tau_2)\}/\hbar \qquad (12b)$$

$$\hat{\psi}_2 = \hat{u}_3 \exp i\{(\hat{\vec{p}}_3 \bullet \hat{\vec{r}}_3 - \hat{E}_3\tau_3)\}/\hbar \qquad (12c)$$

the usual spinor solutions are,

$$\hat{\psi}_2 = \left\{\begin{matrix} 1 \\ 0 \\ \dfrac{c\hat{p}_{2,z}}{mc^2 + \hat{E}_{2,+}} \\ 0 \end{matrix}\right\} , \left\{\begin{matrix} 0 \\ 1 \\ 0 \\ -\dfrac{c\hat{p}_{2,z}}{mc^2 + \hat{E}_{2,+}} \end{matrix}\right\} , \left\{\begin{matrix} -\dfrac{c\hat{p}_{2,z}}{mc^2 - \hat{E}_{2,-}} \\ 0 \\ 1 \\ 0 \end{matrix}\right\} ,$$

$$\left\{\begin{matrix} 0 \\ \dfrac{c\hat{p}_{2,z}}{mc^2 - \hat{E}_{2,-}} \\ 0 \\ 1 \end{matrix}\right\} \tag{12d}$$

and,

$$\hat{\psi}_3 = \left\{\begin{matrix} 1 \\ 0 \\ \dfrac{c\hat{p}_{3,z}}{mc^2 + \hat{E}_{3,+}} \\ 0 \end{matrix}\right\} , \left\{\begin{matrix} 0 \\ 1 \\ 0 \\ -\dfrac{c\hat{p}_{3,z}}{mc^2 + \hat{E}_{3,+}} \end{matrix}\right\} , \left\{\begin{matrix} -\dfrac{c\hat{p}_{3,z}}{mc^2 - \hat{E}_{3,-}} \\ 0 \\ 1 \\ 0 \end{matrix}\right\} ,$$

$$\left\{\begin{matrix} 0 \\ \dfrac{c\hat{p}_{3,z}}{mc^2 - \hat{E}_{3,-}} \\ 0 \\ 1 \end{matrix}\right\} \tag{12e}$$

These expressions have been derived on the assumption that the virtual particles are moving in the global z-direction. In addition, (τ_2, τ_3) are functions of time *t*- as shown by equation (10g). Therefore, the wave function for the virtual particles in the $(\tau_2, \tau_3; \hat{s}_2, \hat{s}_3)$ subspace is,

$$\hat{\psi} = \left(\hat{\psi}_2 \mid \hat{\psi}_3\right)^T \tag{12f}$$

The energy is given by,

$$\hat{E}_{2,+} = +\sqrt{m^2c^4 + c^2\hat{p}_{2,z}^2} \;,\hat{E}_{2,-} = -\sqrt{m^2c^4 + c^2\hat{p}_{2,z}^2} \tag{12g}$$

$$\hat{E}_{3,+} = +\sqrt{m^2c^4 + c^2\hat{p}_{3,z}^2} \;,\hat{E}_{3,-} = -\sqrt{m^2c^4 + c^2\hat{p}_{3,z}^2} \tag{12h}$$

The total energy in the above subspace is given by the 6 combinations,

$$\hat{E} = \hat{E}_{2,+} + \hat{E}_{2,-} \quad \text{or} \quad \hat{E} = \hat{E}_{2,+} + \hat{E}_{3,-} \quad \text{or} \quad \hat{E} = \hat{E}_{2,+} + \hat{E}_{3,+} \quad \text{or}$$

$$\hat{E} = \hat{E}_{3,+} + \hat{E}_{2,-} \quad \text{or} \quad \hat{E} = \hat{E}_{3,-} + \hat{E}_{2,-} \quad \text{or} \quad \hat{E} = \hat{E}_{3,+} + \hat{E}_{3,-} \tag{12i}$$

On the assumption, $\hat{p}_{2,z} = \hat{p}_{3,z} = \hat{p}_z$ (12j)

the distinct nonzero values of the energy associated with the the virtual particles is given by,

$$\hat{E} = \pm\sqrt{m^2c^4 + c^2\hat{p}_z^2} \tag{12k}$$

for this energy spectrum to be measurable we have from (10u),

$$\hat{E} >> \Delta E \tag{12l}$$

$$\therefore \sqrt{m^2c^4 + c^2\hat{p}_z^2} >> \frac{1}{mt}\sqrt{\frac{h^3c}{G(a_2^2 + a_3^2)}} \tag{12m}$$

i.e. $$t >> \frac{h\sqrt{hc}}{mc\sqrt{G(a_2^2 + a_3^2)(m^2c^2 + \hat{p}_z^2)}} \tag{12n}$$

introducing the numerical values for *G, h, c* from just above equation (10f) and (10s), we have from (12n),

$$t >> 2.64 \times 10^{9} \frac{1}{m\sqrt{m^{2}c^{2} + \hat{p}_{z}^{2}}} \qquad (12o)$$

since, $\hat{p} \le mc$ we have from (12o),

$$t >> \frac{8.7 \times 10^{-10}}{m^{2}} \qquad (12p)$$

Assuming an age of the universe of about 18 billion years we can estimate a mass m for a monopole as,

$$m \approx 4.6 \times 10^{-18} \quad \text{gm} \qquad (12q)$$

From (11f, 11g, 10v)

$$\hat{s}_2(t) = \hat{s}_2(0)\exp\left(42 \times 10^{-57} mt\right) \rightarrow \hat{s}_2(\tau_2) = \hat{s}_2(0)\exp(10^{-17}\tau_2)$$
$$\hat{s}_3(t) = \hat{s}_3(0)\exp\left(42 \times 10^{-57} mt\right) \rightarrow \hat{s}_3(\tau_3) = \hat{s}_3(0)\exp(10^{-17}\tau_3)$$

(12r)

From (12r) we see the trajectories of all particles are independent of mass in the alternate universe spanned by $(\tau_2, \tau_3; \hat{s}_2, \hat{s}_3)$. However in terms of standard time t, we see From (10h, 10s),

$$\tau_2^2 + \tau_3^2 = 3.519 \times 10^{-77} m^2 t^2 \qquad (12s)$$

For a monopole (12q),

$$\tau_2^2 + \tau_3^2 = 7.4 \times 10^{-252} t^2 \qquad (12t)$$

Therefore, as time t increases in the alternate universe $(\hat{s}_2, \hat{s}_3)$ the particle is a straight line for

$$\tau_2, \tau_3 \le 2.7 \times 10^{-126} \qquad (12u)$$

13. Magnetohydrodynamics

The equation of motion of a monopole plasma is given by,

$$\rho \frac{d\vec{u}}{dt} = \frac{1}{c}\vec{j} \times \vec{H} - \nabla p + \rho \vec{F} \tag{13}$$

where $\vec{F}$ is the gravitational contribution per unit mass, which we assume is derivable from a potential function,

$$\vec{F} = -\nabla \Xi \tag{13a}$$

For stationary states as they may prevail in the ether,

$$\frac{1}{c}\vec{j} \times \vec{H} - \nabla p - \rho \nabla \Xi = 0 \tag{13b}$$

From (1a, 1b),

$$\frac{1}{4\pi}(\vec{\nabla} \wedge \vec{H}) \wedge \vec{H} + \frac{1}{c^2}\frac{\partial \vec{j}_m}{\partial t} + \frac{1}{4\pi c^2}\frac{\partial^2 \vec{H}}{\partial t^2} - \nabla p - \rho \nabla \Xi = 0 \tag{13c}$$

further simplification gives,

$$-\nabla\left(\frac{H^2}{8\pi} + p + \int \rho d\Xi\right) + \frac{1}{c^2}\frac{\partial \vec{j}_m}{\partial t} + \frac{1}{4\pi c^2}\frac{\partial^2 \vec{H}}{\partial t^2} = 0 \tag{13d}$$

In addition, further simplification using (1h, 1j)

$$\nabla\left(\frac{H^2}{8\pi} + p + \int \rho d\Xi - \frac{1}{4\pi c^2}\int \frac{1}{|\vec{r} - \vec{r}\,'|}\frac{\partial^2 \rho_m}{\partial t^2} d^3\vec{r}\,'\right) - \frac{1}{4\pi c^2}\frac{\partial^2 \vec{H}}{\partial t^2} = 0 \tag{13e}$$

This equation determines the intrinsic magnetic field H in the ether, for a given distribution of magnetic monopoles ρ_m. From (4c, 4f) for a continuous distribution of monopoles, we have

$$\Xi = -\frac{\lambda}{6}\int \rho \vec{r}^{\,2} d^3 r - G\iint \frac{\rho(\vec{r})\rho(\vec{r}\,')}{|\vec{r}-\vec{r}\,'|} d^3\vec{r}\, d^3\vec{r}\,' \qquad \text{(13f)}$$

Equation (13e), in conjunction with (4c, 4f) or (13f) is to be solved as described below. From (13e) we have a generalized Bernoulli equation of the form,

$$\left(\frac{H^2}{8\pi} + p + \int \rho dV - \frac{1}{4\pi c^2}\int \frac{1}{|\vec{r}-\vec{r}\,'|}\frac{\partial^2 \rho_m}{\partial t^2} d^3\vec{r}\,'\right) - \frac{1}{4\pi c^2}\frac{\partial^2}{\partial t^2}\int \vec{H}\bullet d\vec{r}\,' = const$$

(13g)

Particular Solutions of MHD Equations

For ρ, ρ_m constant, we have integrating (13f)

$$\Xi = -\frac{2\pi}{3}\Re^5\left(\frac{\lambda\rho_0}{5} + 4\pi G\rho_0^2\right) \qquad \text{(13h)}$$

where $\Re$ is the radius of the universe. Bernoulli's equation (13g) becomes with $\rho = \rho_0$,

$$\left[\frac{H^2}{8\pi} + p - \frac{2\pi\rho_0\Re^5}{3}\left(\frac{\lambda\rho_0}{5} + 4\pi G\rho_0^2\right)\right] - \frac{1}{4\pi c^2}\frac{\partial^2}{\partial t^2}\int \vec{H}\bullet d\vec{r}\,' = const$$

(13i)

From (3e), we see that for a particular magnetic field distribution,

$$H = H_0\vec{r} \quad , \quad \Rightarrow \quad \rho_m = \frac{H_0}{4\pi} = \text{constant} \qquad \text{(13j)}$$

where H_0 is a constant to be determined. If the background magnetic field in deep space is $\tilde{H}$, then $H_0 = \frac{\tilde{H}}{\Re}$. From (2h) the pressure is given by,

$$p \approx \frac{3kTn}{4\pi\Re^3} \tag{13l}$$

Substituting the expressions (13j, 13l) in (13i),

$$\left[\frac{H_0^2\Re^2}{8\pi} + \frac{3kTn}{4\pi\Re^3} - \frac{2\pi\rho_0\Re^5}{3}\left(\frac{\lambda\rho_0}{5} + 4\pi G\rho_0^2\right)\right] - \frac{H_0}{8\pi c^2}\frac{\partial^2\Re^2}{\partial t^2} = const$$

(13m)

This equation describes the variation of the size of the universe $\Re$ with time . To solve this differential equation, put,

$$\aleph = \frac{\partial\Re}{\partial t} \tag{13n}$$

Then from (13m),

$$\left[\frac{H_0^2\Re^2}{8\pi} + \frac{3kTn}{4\pi\Re^3} - \frac{2\pi\rho_0\Re^5}{3}\left(\frac{\lambda\rho_0}{5} + 4\pi G\rho_0^2\right)\right] - \frac{H_0}{8\pi c^2}\aleph\frac{d\aleph}{d\Re} = \mathrm{C}$$

where C is a constant, the right hand side of equation (13m). integrating,

$$-\frac{H_0}{16\pi c^2}\aleph^2 = C_0 + C\Re - \left[\frac{H_0^2\Re^3}{24\pi} - \frac{3kTn}{8\pi\Re^2} - \frac{\pi\rho_0\Re^6}{9}\left(\frac{\lambda\rho_0}{5} + 4\pi G\rho_0^2\right)\right] \tag{13o}$$

using (13n) in (13o) and simplifying,

$$\left(\frac{\partial\Re}{\partial t}\right)^2 =$$

$$c_0 + c_1\Re + \frac{2H_0c^2}{3}\Re^3 - \frac{6kTnc^2}{H_0\Re^2} - \frac{16\pi^2c^2\rho_0^2}{9H_0}\left(\frac{\lambda\rho_0}{5} + 4\pi G\rho_0^2\right)\Re^6 \tag{13p}$$

Therefore a further integration shows,

$$t =$$

$$\int_0^{\Re} \frac{d\Re}{\sqrt{c_0 + c_1\Re + \frac{2H_0c^2}{3}\Re^3 - \frac{6kTnc^2}{H_0\Re^2} - \frac{16\pi^2c^2\rho_0^2}{9H_0}}} \left(\frac{\lambda\rho_0}{5} + 4\pi G\rho_0^2 \right) \Re^6 \tag{13q}$$

Equation (13q) determines the evolution of the universe from the moment of the big-bang at time *t=0* , to time *t.*

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