# Quantisation of the Auxiliary Gravitational Field in Astronomical Systems

R. Wayte

29 Audley Way, Ascot, Berks, SL5 8EE, England, UK

e-mail: rwayte@googlemail.com

**Research article. Submitted to vixra.org     11 January 2011**

**Abstract:** A quantisation-field model has been developed to explain the general dependence of angular momentum on mass squared of astronomical bodies. The gravito-cordic field is proposed as a real controlling force acting azimuthally, in harmony with normal gravity acting radially, to encourage long-term stability of astronomical systems. The quantisation of the field involves a gravitational de Broglie wavelength and associated force, which organises material into stable orbits. Optimum coupling between the field and orbiting material occurs for a specific velocity and spatial dimensions, as derived by way of electromagnetic theory. For every system, the atomic fine structure constant $(\alpha \approx 1/137)$ has appeared as the major factor.

**Keywords:** stellar dynamics, galaxy dynamics, quantum gravity

**PACS Codes:** 04.60.Bc, 98.62.Dm

## 1. Introduction

It will be shown that numerical commensurabilities can be generated in astronomical systems if we assume that a quantising gravito-cordic field is emitted by orbiting and rotating masses. The original derivation of this field (Wayte 2010, hereinafter Paper 1) [1], described how it propagates around orbits, contributing to the binding and long-term stability of rotating systems. The quantised field model is a mathematical analogy to the Bohr model of the atom, and we shall see the frequent appearance of the inverse atomic fine structure constant $(\alpha^{-1} \approx 137)$, which suggests a deep connection between electromagnetism and gravity. Detailed explanation of quantisation in terms of electromagnetic theory is to be given in Section 3, but practical inferences will be applied first to the observations in Section 2. Several aspects have already been given in Paper 1 for galactic spirals and rings. Logically, quantisation itself implies that material was moved forcibly into certain orbits and held there against the perturbing forces which must have existed during the creation period. Thus the infinite variety of spins and orbits and classes available according to Newtonian theory was reduced to those which obey a few rules extrapolated from atomic theory.

## 2. The J proportional to $M^2$ law

Figure 1, taken from Paper 1, shows how galaxy-clusters, spiral galaxies, globular clusters, binary stars, main sequence stars and planetary bodies fit the J proportional to $M^2$ law. Although all these individual classes do not lie on the main line, they each have their own *parallel* line, signifying a special proportionality constant. We shall try to account for this observed degree of order in each astronomical class by proposing that they have a quantisation-field which governs their angular momentum. It also accounts for the conspicuous absence of objects between the classes. The field is therefore proposed as a real controlling force, acting in addition to normal gravity.

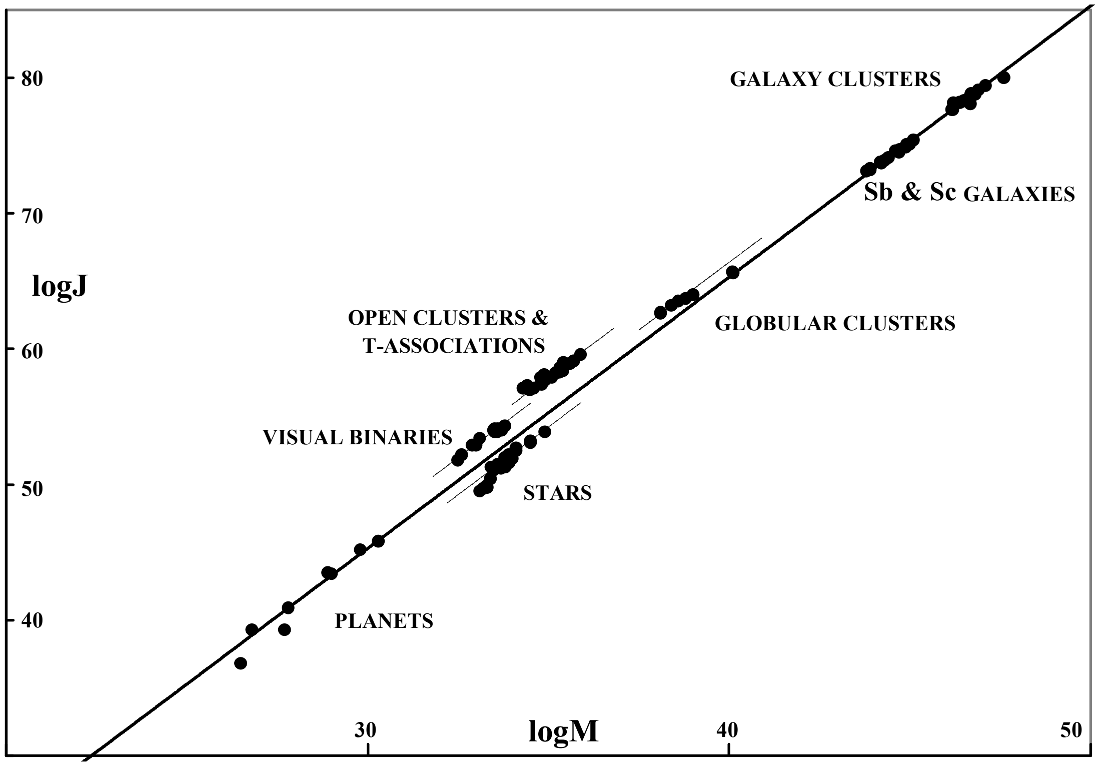


Fig.1 The angular momentum versus mass relationship for various astronomical bodies, showing a theoretical average line for J = 2.00 x $10^{-15}$ $M^2$ over 40 decades. Data taken from Allen (1973) [3].

Within each of these classes the angular momentum is proportional to mass squared, for no known classical reason. The constant of proportionality varies from class to class, and will be found to correspond to a *preferred* quantisation wavelength in each case. Then the number of wavelengths around a given body has a characteristic value or increases monotonically with body size. That is,

$$2\pi r = N\lambda = N(h / m_j v) \quad , \qquad (2.1)$$

where N is usually an integer, $m_j$ is an effective mass characteristic of the quantisation species (electron, meson, proton, hydrogen-electron) to be derived, h is Planck's constant; therefore $\lambda$ is the gravitational de Broglie wavelength for $m_j$ travelling at velocity v. This explanation is unique in establishing some control in the creation of astronomical bodies as a whole. The quantisation force appears relatively weak and is easily destroyed by turbulence, which results in a scatter range of sizes in each class. However, for the larger systems, the ratio ($2\pi r_{max} / \lambda$) only varies by a factor of 3 from the mean value. Definite gaps exist between the classes because suitable quantisation rules cannot be established there. Again, no classical explanations exist for these gaps, nor for the particular sizes of bodies. Characteristic features of galaxies and galaxy-clusters have already been covered in Paper 1, so the remaining classes will be analysed here.

A little preliminary theory, common to these classes, will be developed first. We wish to relate the angular momentum to the square of the body mass through some quantisation law. If angular momentum and mass are approximately conserved during the formation of the body, any law derived for present day bodies must reflect some conditions in the original gas clouds. Let those conditions be:

$$GM = V^2R \quad \text{, and} \quad J = (3/5)MVR = p'M^2 \quad , \tag{2.2}$$

where V is the rotational velocity at radius R, and p′ is a constant. Immediately, it follows that V must have been a *preferred* ideally constant velocity in each class. This will be interpreted to imply that there was a particular gravitational de Broglie wavelength, defined as:

$$\lambda_G = \frac{h}{m_s V} \times \left( \frac{e^2}{Gm^2} \right)^{1/2} = \frac{h}{m_j V} \quad , \tag{2.3}$$

where $m_j = m_s(e^2/Gm^2)^{-1/2}$ is a *characteristic* mass of the real source particle mass $m_s$ emitting the gravito-cordic field. $h$ is Planck's constant and $(e^2/Gm^2)$ is the electronic ratio of electric/gravitational force. Then an expression which describes the practical influence of $\lambda_G$ on the orbit is:

$$\frac{2\pi R}{\lambda_G} = K \left[ \frac{GMm_j}{\hbar c} \right] \quad , \tag{2.4}$$

where $(GMm_j/\hbar c)$ is the effective gravitational strength constant, analogous to the electromagnetic strength constant $(e^2/\hbar c = 1/137)$; and $K = c/V$ is a constant for each particular class of object, when V is the preferred velocity. On Fig.1, the main line corresponds to a preferred velocity of $[201\text{kms}^{-1} = (4\pi/137^2)c]$ as described in Paper 1. The analogous equation in the first Bohr orbit of hydrogen is of course:

$$\frac{2\pi r_1}{\lambda_1} = 137 \left( \frac{e^2}{\hbar c} \right) = 1 \quad . \tag{2.5}$$

## *2.1 Stars*

Let us consider normal dwarf and giant stars as a function of spectral class with regard to mass M, radius R and rotation as listed by [3]. For the best fit, the proton mass will be introduced for $m_j$ in Eq.(2.3), where:

$$m_{jp} = m_p(e^2/Gm^2)^{-1/2} \quad . \tag{2.6}$$

Then Table 1 lists $(2\pi R/\ \lambda_{Gp})$ spanning unity, and $(GMm_{jp}\ /\hbar c)$ spanning 1/137. The cross-over points are at spectral type A8.5 for dwarfs and F7.5 for giants, whereupon:

$$\frac{2\pi R}{\lambda_{Gp}} \approx 1 \approx 137\left(\frac{GMm_{jp}}{\hbar c}\right) \quad . \tag{2.7}$$

The fact that $(GMm_{jp}\ /\hbar c \approx 1/137)$ for the proton/star entity, is exceptional evidence for the electromagnetic nature of gravitation. Equation (2.7) is directly analogous to the first Bohr orbit in the hydrogen atom; although stars are now in *hydrostatic* equilibrium.

**Table 1**. Quantisation values for dwarf and giant stars.

| **Dwarf stars** Type | Ratio $2\pi R/\lambda_{Gp}$ | Strength factor $GMm_{jp}/\hbar c$ | **Giant stars** | Ratio $2\pi R/\lambda_{Gp}$ | Strength factor $GMm_{jp}/\hbar c$ |
|---|---|---|---|---|---|
| O5 | 18.26 | 18.74/137 | B0 | 8.14 | 7.99/137 |
| B0 | 8.20 | 7.99 /137 | B5 | 6.49 | 3.33/137 |
| B5 | 4.52 | 3.33 /137 | A0 | 4.78 | 1.67/137 |
| A0 | 2.70 | 1.67 /137 | A5 | 3.31 | 1.03/137 |
| A5 | 1.54 | 1.03 /137 | F0 | 2.34 | 0.84/137 |
| F0 | 0.69 | 0.84 /137 | F5 | 1.29 | 0.66/137 |
| F5 | 0.16 | 0.665/137 | G0 | 0.68 | 1.18/137 |
| G0 | 0.068 | 0.505/137 | G5 | 0.65 | 1.49/137 |
| G5 | 0.061 | 0.439/137 | K0 | 1.03 | 1.87/137 |
| K0 | 0.055 | 0.38 /137 | K5 | 1.63 | 2.36/137 |
| K5 | 0.048 | 0.33 /137 | | | |

It is interesting to note that if there was an original cloud of uniform density which condensed into many stars, then the many protostellar cloud circumferences would have varied either side of the mean value by less than a factor 2, from stellar type O5 to K5. This could signify effective control that the quantisation field had during the star formation period.

Given that a star's equatorial orbit is being considered stabilised in the above analysis, it is possible that the star's bulk may also be stabilised. Bulk mixing would probably be impeded to some extent, so evolution of the star might be slower.

### *2.2 Planets*

In the case of planetary spins, π-mesons of approximately 250 electron masses will be taken as the source of the quantisation field, so mass $m_j$ in Eq.(2.3) is to be given by:

$$m_{j\pi} \approx m_\pi (e^2/Gm^2)^{-1/2} \quad . \tag{2.8}$$

**Table 2**. Quantisation values for the planets.

| **Planet** | Ratio $2\pi R/\lambda_{CG\pi}$ | Strength factor $GMm_{j\pi}/\hbar V_s$ |
|---|---|---|
| Mercury | 0.77≈3/4 | 1.05/137 |
| Venus | 1.93≈2 | 26.5/137 |
| Earth | 2.02≈2 | 0.13/137 |
| Mars | 1.08≈1 | 0.026/137 |
| Jupiter | 22.6 | 1.47/137 |
| Saturn | 19.1 | 0.55/137 |
| Uranus | 7.80 | 0.21/137 |
| Neptune | 8.00 | 0.36/137 |
| Pluto | 1.02≈1 | 0.24/137 |

However, because the gravitational de Broglie wavelength, ($\lambda_{G\pi} = h/m_{j\pi}V_s$), is large compared with the planetary circumference, the gravitational Compton wavelength ($\lambda_{CG\pi} = h/m_{j\pi}c$) will be used instead; see $2\pi R/\lambda_{CG\pi}$ in Table 2. For rotational stability, this quotient should ideally be an integer or simple fraction, and follows from modifying Eq.(2.4):

$$\frac{2\pi R}{\lambda_{CG\pi}} = K_\pi \left( \frac{GMm_{j\pi}}{\hbar V_s} \right) \quad . \tag{2.9}$$

Here the gravitational strength factor normalised for spin velocity ($GMm_{j\pi}/\hbar V_s$) is seen to be clustered around 1/137, for no known classical reason given that the planets are now either solid or in hydrostatic equilibrium. It is possible that quantisation fields helped produce the present Solar System from a gaseous nebula and continue to stabilise the orbiting planets, see Wayte (1982) [2]. Binary stars and clusters also obey the equations of quantisation as follows.

## *2.3 Binary stars*

Many stars are members of binary systems, so it is interesting to know how these are stabilised in orbit by a quantised gravito-cordic field. Table 3 lists the relevant parameters derived from [3] for visual and eclipsing binaries. For orbiting bodies, the quantisation law changes from Eq.(2.4) to:

$$\left(\frac{M_1}{M}\right)\left(\frac{2\pi R_1}{\lambda_{G1}}\right)+\left(\frac{M_2}{M}\right)\left(\frac{2\pi R_2}{\lambda_{G2}}\right)=K'\left(\frac{GMm_j}{\hbar c}\right) \quad , \qquad (2.10)$$

where $M=(M_1 + M_2)$, $\lambda_{G1,2} = h / m_j V_{1,2}$ , and $K' = p'c /G$. The meson and proton masses have been used for $m_j$ in eclipsing and visual binaries respectively, as they give the best values for the strength factor ($GMm_j /\hbar c \sim 1/137$), and orbit fitting ($2\pi R/\lambda_G$). Average radii in elliptical orbits have been used.

**Table 3.** Quantisation values for eclipsing and visual binaries.

| **Eclipsing binary** | Ratio $\frac{2\pi R_1}{\lambda_{G\pi 1}}$ | Ratio $\frac{2\pi R_2}{\lambda_{G\pi 2}}$ | Strength factor $\frac{GMm_{j\pi}}{\hbar c}$ |
|---|---|---|---|
| σAq1 | 0.864 | 1.369 | 0.79/137 |
| WW Aur | 0.515 | 0.526 | 0.25 " |
| AR Aur | 0.703 | 0.864 | 0.31 " |
| β Aur | 0.704 | 0.755 | 0.30 " |
| yz Cas | 0.339 | 1.440 | 0.32 " |
| AR Cas | 0.305 | 4.800 | 0.97 " |
| AH Cep | 1.593 | 2.151 | 2.00 " |
| αCrB | 0.263 | 2.074 | 0.22 " |
| AR Lac | 0.394 | 0.400 | 0.17 " |
| U Oph | 0.803 | 1.043 | 0.65 " |
| VV Ori | 0.415 | 3.613 | 1.56 " |
| AF Per | 0.811 | 1.042 | 0.62 " |
| ξ Phe | 0.383 | 0.781 | 0.33 " |
| RS Sgr | 0.256 | 0.569 | 0.15 " |
| R CMa | 0.016 | 0.073 | 0.039 " |
| RZ Cas | 0.085 | 0.695 | 0.16 " |
| U Cep | 0.255 | 1.093 | 0.28 " |
| U Her | 0.283 | 2.256 | 0.69 " |
| δ Lib | 0.192 | 1.075 | 0.24 " |
| β Per | 0.086 | 2.270 | 0.40 " |
| V Pup | 0.940 | 2.700 | 1.71 " |
| U Sge | 0.224 | 2.514 | 0.57 " |
| V356 Sgr | 0.710 | 4.625 | 1.08 " |
| V505 Sgr | 0.194 | 0.718 | 0.23 " |
| μ´ Sco | 0.957 | 2.217 | 1.50 " |
| λ Tau | 0.202 | 1.263 | 0.21 " |
| TX UMa | 0.125 | 1.361 | 0.24 " |
| RS Vul | 0.200 | 2.160 | 0.39 " |
| Averages | 0.458 | 1.659 | 0.58/137 |

| **Visual binary** | Ratio $\frac{2\pi R_1}{\lambda_{Gp1}}$ | Ratio $\frac{2\pi R_2}{\lambda_{Gp2}}$ | Strength factor $\frac{GMm_{jp}}{\hbar c}$ |
|---|---|---|---|
| ηCas | 1.52x137 | 4.00x137 | 0.715/137 |
| O2 EriBc | 0.485 " | 2.22 " | 0.311/137 |
| ξBoo | 1.61 " | 2.06 " | 0.753/137 |
| 70 Oph | 1.06 " | 2.03 " | 0.730/137 |
| αCenAB | 1.37 " | 2.07 " | 0.923/137 |
| Sirius | 0.739 " | 4.00 " | 1.53 /137 |
| Kru60 | 0.234 " | 0.811 " | 0.202/137 |
| Procyon | 0.455 " | 3.33 " | 1.13 /137 |
| ζHer | 0.880 " | 1.65 " | 0.871/137 |
| 85Peg | 1.01 " | 1.06 " | 0.763/137 |
| Ross614AB | 0.123 " | 0.378 " | 0.104/137 |
| Fu46 | 0.322 " | 0.496 " | 0.264/137 |
| Averages | 0.817x137 | 2.01x137 | 0.692/137 |

It can be seen that the visual binaries differ as a group from the eclipsing binaries in that the orbit length relative to the gravitational de Broglie wavelength is consistently around 137 times larger. On Fig.1, the short line through the visual binaries corresponds to a preferred nominal velocity of $c/(4x137^2)$ in Eq.(2.2). Several of the ratios $2\pi R/\lambda_{G\pi}$ for the eclipsing binaries are small, such that a proton mass instead of a meson mass for $m_j$ would be much better suited (x7) to bring the ratio near to unity. Both mesons and protons could assist in the quantisation process, at the same time.

From Table 3 it is plain that the various ratios of orbit length to gravitational de Broglie wavelength are around unity or 137, and the strength factors around 1/137; so the quantisation phenomenon must have selected these from the continuum of classical dimensions.

## *2.4 Globular clusters, open clusters and T-associations.*

Globular cluster dimensions fit the gravitational de Broglie wavelength emitted by the bound electron within the hydrogen atom. This wavelength is defined as:

$$\lambda_{GH} = 137\left(\frac{h}{m_{je}V}\right) , \qquad (2.11)$$

where $m_{je} = m(e^2/Gm^2)^{-1/2}$, for electron mass m. Table 4 lists the relevant parameters of several globular clusters derived from [3]. The ratio of the cluster circumference $2\pi R$ to the wavelength $\lambda_{GH}$ is scattered around 137, and the gravitational strength factor is of the order 1/137. It therefore looks as though the quantisation field from hydrogen governed the size of the globular clusters at some stage. On Fig.1, the short line for globular clusters corresponds to a preferred velocity of $c/(137^2)$ in Eq.(2.2).

The long-term stability of globular clusters may be assisted by detailed control of stars throughout the body. Given the average result ($2\pi R/\lambda_{GH}$ ~137), then around 137 quantised interior orbits will also exist due to hydrogen-electrons.

**Table 4.** Quantisation values for some globular clusters, open clusters and T-associations.

| **Globular clusters** | Ratio $\frac{2\pi R}{\lambda_{GH}}$ | Strength factor $\frac{GMm_{je}/137}{\hbar c}$ | **Open clusters** | Ratio $\frac{2\pi R}{\lambda_{GH}}$ | Strength factor $\frac{GMm_{je}/137}{\hbar c}$ |
|---|---|---|---|---|---|
| M3 | 0.53x137 | 0.39/137 | M103 | 0.54 | $1.05/137^3$ |
| M5 | 0.27 " | 0.11 " | N752 | 0.76 | 2.10 " |
| M4 | 0.24 " | 0.11 " | hPer | 3.06 | 10.5 " |
| M13 | 0.58 " | 0.56 " | XPer | 2.56 | 8.43 " |
| M92 | 0.38 " | 0.26 " | Stock2 | 1.08 | 4.21 " |
| M22 | 2.56 " | 13.1 " | M34 | 0.68 | 2.10 " |
| M15 | 2.62 " | 11.2 " | Perseus | 1.37 | 2.81 " |
| N104 | 0.74 " | 0.99 " | Pleiades | 0.97 | 4.21 " |
| Averages | 0.99x137 | 3.34/137 | Hyades | 0.99 | 3.51 " |
| | | | M38 | 1.17 | 3.51 " |
| | | | M36 | 0.76 | 1.76 " |
| | | | M37 | 1.76 | 7.01 " |
| | | | SMon | 0.84 | 2.10 " |
| **T-associations** | Ratio $\frac{2\pi R}{\lambda_{GH}}$ | Strength factor $\frac{GMm_{je}/137}{\hbar c}$ | τCMa | 0.42 | 1.05 " |
| | | | Praesepe | 0.88 | 3.51 " |
| | | | oVel | 0.24 | 0.52 " |
| | | | M67 | 0.79 | 2.81 " |
| Tau T1 | 0.46 | $0.42/137^3$ | θCar | 0.38 | 0.88 " |
| Tau T2 | 0.56 | 0.35 " | N3532 | 1.33 | 4.54 " |
| Aur T1 | 0.71 | 0.45 " | Sco-Cen | 4.64 | 3.86 " |
| Ori T1 | 1.62 | 1.40 " | Coma | 0.74 | 1.40 " |
| Ori T2 | 4.83 | 14.0 " | KCru | 0.48 | 1.05 " |
| Mon T | 13.38 | 4.90 " | Ursa Maj | 1.17 | 3.51 " |
| Ori T3 | 2.21 | 3.15 " | M21 | 0.56 | 1.40 " |
| Sco T1 | 1.41 | 1.05 " | M16 | 0.62 | 1.40 " |
| Del T1 | 1.58 | 0.87 " | M11 | 0.97 | 2.81 " |
| Per T2 | 0.31 | 0.56 " | M39 | 0.28 | 0.70 " |
| Averages | 2.71 | $2.72/137^3$ | Averages | 1.11 | $3.06/137^3$ |

Open clusters and T-associations have diameters about half that of globular clusters, with masses $137^2$ times less on average. Nevertheless, the gravitational de Broglie wavelengths of the hydrogen-electron give very good fits to cluster circumferences, see $2\pi R/\lambda_{GH}$ in Table 4. The corresponding gravitational strength factor is $137^2$ times less typically. It is possible that the definite step in ($2\pi R/ \lambda_{GH}$), from 1 in open clusters to 137 in globular clusters, accounts for the dearth of intermediate-sized bodies. According to Newtonian theory, there is no reason for two such definite star cluster species to exist within an infinite continuum of sizes. On Fig.1, the short line for open clusters corresponds to a preferred velocity of $c(4/137^3)$ in Eq.(2.2).

## 3. Theory of quantisation of the gravito-cordic field

The previous section has shown that some astronomical phenomena may be explained by proposing the existence of a quantising gravito-cordic field. This field is emitted around orbits by the orbiting material, serving to increase the overall radial binding force and also to organise material and encourage long-term stability in preferred orbits. Astronomical features explained so far are: flat rotation curves in disc galaxies, creation and maintenance of bar and spiral structures, rings of stars within the discs, the universal angular momentum / mass squared relationship, and the general masses and segregation of objects.

The problem is to see how the gravito-cordic field generates a real ponderomotive force, which is physically capable of coercing material into specific orbits and velocities. Rules covering the quantisation aspect of the field will be based upon the Bohr atom and de Broglie hypothesis. The effective wavelength of the field is actually to be the gravitational equivalent of the atomic de Broglie wavelength:

$$\lambda_G = \left(\frac{h}{m_s v}\right) \times \left(\frac{e^2}{Gm^2}\right)^{1/2} . \tag{3.1}$$

Here, $m_s$ is the mass of the emission source particle which couples best to the size of the astronomical object; for example, proton for stars, pion for binaries, electron for globular clusters and galaxies. *h* is Planck's constant, v is the orbital velocity, and $(e^2/Gm^2)$ is the electronic ratio of electromagnetic to gravitational force. The quantisation field can be optimised around galactic orbits for a particular material velocity. This will appear to be equivalent to tuning a waveguide system to match a microwave source. Various properties of the field, which were arbitrarily introduced into the Paper 1, will now be derived in detail.

By analogy with the Compton wavelength in electromagnetic theory it is proposed that the gravito-cordic field quanta emitted from particles of mass $m_o$ have a gravitational wavelength:

$$\lambda_{CGo} = \frac{h}{m_o c} \times \left(\frac{e^2}{Gm^2}\right)^{1/2} = \frac{h}{m_{jo} c} \quad , \tag{3.2}$$

where $m_{jo} = m_o(Gm^2/e^2)^{1/2}$ acts like a characteristic mass, but is not an actual particle mass. The wave amplitude at the particle, as seen by a local observer may be expressed as:

$$y = y_o \exp[-i2\pi\nu_o t_o] \qquad , \tag{3.3}$$

where frequency $\nu_o = c/\lambda_{CGo}$. If, however, the particle has a velocity v in the x direction relative to a coordinate observer, the wave amplitude at the particle as seen by the coordinate observer is, by application of the Lorentz transformation:

$$y' = y'_o \exp\frac{-i2\pi\nu_o\left(t - vx/c^2\right)}{\left(1 - v^2/c^2\right)^{1/2}} \quad . \tag{3.4a}$$

This may be written as:

$$y' = y'_o \exp[-i2\pi(\nu' t - \tilde{\upsilon}x)] \qquad , \tag{3.4b}$$

where $\nu' = \nu_o\left(1 - v^2/c^2\right)^{-1/2}$ and $\tilde{\upsilon} = \nu' v/c^2$ .

A Compton gravitational quantum emitted by a particle in the direction of motion in a circular orbit would be measured by a stationary coordinate observer as having a Doppler-frequency $\nu'(1 + v/c)$. Alternatively, a quantum emitted backwards would have a coordinate Doppler-frequency $\nu'(1 - v/c)$. Since these two quanta travel around the circular orbit and may interfere, the net amplitude at distance x from any designated origin on the orbit could be given as:

$$\begin{aligned} y &= y_o \exp[-i2\pi\{(\nu' t - x/\lambda')(1 + v/c)\}] + y_o \exp[-i2\pi\{(\nu' t + x/\lambda')(1 - v/c)\}] \\ &= 2y_o \cos[2\pi\{\nu'(v/c)t - x/\lambda'\}]\exp[-i2\pi\{\nu' t - \tilde{\upsilon}x\}] \quad . \end{aligned} \tag{3.5}$$

Here $\lambda' = c/\nu'$, and t starts from zero as the particle crosses the origin. This is a circularly polarised wave of fundamental frequency in the exponential term:

$$\nu' = \left[m_{jo}\left(1 - v^2/c^2\right)^{-1/2} c^2/h\right] = \left(m_j c^2/h\right) \qquad , \tag{3.6}$$

where $m_j = m_{jo}(1-v^2/c^2)^{-1/2}$ is the increased relativistic mass. In the cosine term, the beat frequency is $\nu'(v/c)$, and the beat wavelength is therefore:

$$\lambda = c/(\nu' v/c) = 1/\tilde{\upsilon} = h/m_j v = \lambda_G \qquad , \tag{3.7a}$$

which is the *gravitational de Broglie* wavelength. Hence, by superimposing or interfering two Doppler-shifted Compton quanta in a circular orbit, we get a standing wave pattern rotating around the orbit with the particle, and a simple interpretation of the de Broglie wavelength $\lambda_G = 1/\tilde{\upsilon}$. The individual Compton quanta propagate around the orbit at the velocity of light but we can show that the beats naturally stay fixed relative to the orbiting particle source, as follows. From Eq.(3.5) the condition for a beat maximum, for a given beat number s, is:

$$2\pi\{\nu'(v/c)t - x/\lambda'\} = s\pi \quad . \tag{3.7b}$$

Hence by differentiation, the beat envelope velocity is:

$$dx/dt = \lambda'\nu'(v/c) = v \quad . \tag{3.8}$$

At an anti-node, a particle receives the two Compton quanta in phase with its emission so there is resonance at the particle. All particles around the orbit would like to align themselves so as to emit coherently because this is a lowest energy state. Furthermore, the amplitude Eq.(3.5) will be single-valued when $c/v = \lambda_G/\lambda'$ = integer n, if the orbit circumference is an integral number of de Broglie wavelengths. Then the amplitude repeats itself spatially every distance $\lambda_G$.

Now, even if the emission from several particles around an orbit is totally incoherent, the resultant amplitude from q particles will, from Eq.(3.5) be:

$$y_q \approx q^{1/2}\, 2y_o \cos[2\pi\{\nu'(v/c)t - x/\lambda' + \varphi\}]\exp[-i2\pi\{\nu't - \tilde{\upsilon}x\}] \ , \tag{3.9}$$

where $\varphi$ is some arbitrary constant phase, for constant velocity of all the particles. By convenient choice of origin, $\varphi$ may be set to zero. The average intensity $I_q$ of the net quantisation-field due to q incoherent particle emitters is proportional to q, but there will be a superimposed intensity modulation at frequency $(2\nu_G = 2c/\lambda_G)$ proportional to $q^{1/2}$. That is, from Eq.(3.9) we get:

$$\begin{aligned} I_q &= \sum_q \left(2y_o \cos\left[2\pi\left\{\nu'(v/c)t - x/\lambda' + \varphi_q\right\}\right]\right)^2 \\ &\approx q\left(2{y_o}^2\right) + q^{1/2}\left(2{y_o}^2\right)\cos 2\left[2\pi\left\{\nu'(v/c)t - x/\lambda' + \varphi_q\right\}\right] \ . \end{aligned} \tag{3.10}$$

This intensity profile normally travels round the orbit at velocity v. It appears from the galactic bar and spiral pattern data that there are two stable nodes per $\lambda_G$ so this implies that incoherent matter is guided towards the two intensity minima per $\lambda_G$ by some longitudinal radiation pressure gradient of Eq.(3.10). Since the intensity minima are $\lambda_G/2$ apart, and the radiation pressure gradient must change direction across a minimum or across a maximum, the resultant longitudinal force probably has the form:

$$F_{RP} = F_0 \cos 4[2\pi\{\nu'(v/c)t - x/\lambda' + \varphi_f\}] \quad , \qquad (3.11)$$

which exhibits two stable points and metastable points per $\lambda_G$ along the orbit. An estimate of force magnitude could be made by arbitrarily letting it be *proportional* to the gravito-cordic field strength given in Paper 1, Eq.(3.6). The directional nature of quantisation-field emission (see Section 4.4) helps to increase the quantisation force, whatever the degree of coherence.

It is to be noted that the wave phenomenon expressed by Eqs.(3.5) to (3.11) is entirely due to *interference* of real circularly polarised quanta. There is no actual de Broglie-type quantum, although the interference is characterised by the gravitational de Broglie wavelength and propagates at the velocity of light. Gravito-cordic field quanta are emitted by orbiting particles (electrons, for example), and exist as loops of material attached continuously to their particles.

## 4. Matching the gravito-cordic field to orbital parameters

It will be shown that the quantised gravito-cordic field may be optimised in its propagation around galactic orbits for a certain material velocity. This is equivalent to tuning a waveguide system to match a microwave source. In Paper 1 it was shown how orbit lengths in disc galaxies are stable when they satisfy the de Broglie condition for hydrogen-electrons, $(2\pi r = N\lambda_{GH})$; but the actual orbital velocity is also important.

### *4.1 Basic relationships*

The average rotational velocity V for flat rotation curves in Sa,b,c galaxies is of the order of 201kms$^{-1}$. In addition, the universal J proportional to M$^2$ law for astronomical bodies has a slope linked to this velocity; see Paper 1, Section 7. Consequently, this velocity is probably not random, especially as it has a special relationship to the velocity of light:

$$\frac{V_{201}}{c} = \frac{4\pi}{137^2} = 4\pi\alpha^2 \quad , \qquad (4.1)$$

where $(\alpha = e^2/\hbar c = 1/137)$ is the atomic fine structure constant. Given that hydrogen-electrons emit the controlling gravito-cordic field in galaxies, it is appropriate to operate initially in atomic units. Thus, every unit is referred to the hydrogen 1st Bohr orbit such that ($e = m = \hbar = v_1 = r_1 = 1$ and $c = 137v_1$). Then Eq.(4.1) may be expressed:

$$\frac{V_{201}}{v_1} = 4\pi\alpha \quad . \tag{4.2}$$

Now, there is no established interpretation for this formula, but electric *impedance* is inversely proportional to velocity, so this may represent a ratio of impedances. Then the $4\pi\alpha$ term on the right turns out equal to the value in *atomic units* of the characteristic impedance of electromagnetic radiation, (alias impedance of vacuum $Z_0 = 376.73\Omega$; see Glazier and Lamont 1958, p133; [4]). For this interpretation, an atomic unit of resistance is defined as the unit potential ($e/r_1$), divided by the unit of current $e/(r_1/v_1)$, and will be named an *atohm*. That is:

$$\frac{(e/r_1)}{(e/(r_1/v_1))} = \frac{1}{v_1} = 1.0 \text{ atohm} \quad , \tag{4.3a}$$

or in SI units:

$$\left(\frac{e/4\pi\varepsilon_0 r_1}{e/(r_1/v_1)}\right) = 4108 \text{ ohms} \quad . \tag{4.3b}$$

It follows that:

$$4\pi\alpha \text{ atohms} = 376.73 \text{ ohms} = Z_0 \quad , \tag{4.4}$$

All electromagnetic radiation exhibits electric and magnetic fields in the ratio $E/H = Z_0$ ohms. By *inference* then, the controlling gravito-cordic field from hydrogen-electrons is an electromagnetic phenomenon. So Eq.(4.2) is able to relate the de Broglie wavelength of a galactic electron moving at velocity $201\text{kms}^{-1}$ to this most fundamental impedance.

Support for this special velocity-impedance relationship is illustrated in Figure 2 where the hydrogen-electron's orbit around the proton $p^+$ is aligned in the direction of galactic velocity $V_{201}$ so that the electron describes a helix of pitch $V_{201}/v_1$ . Now, *admittance* is by definition the inverse of *impedance* and is equivalent to velocity in Eq.(4.3a); therefore, the admittance of electromagnetic radiation ($Y_0 = 1/Z_0$) is equivalent to a velocity $V_0$ as shown in Figure 2b. It follows that along the helical trajectory we have a rather special arrangement:

$$\tan\theta = \frac{V_{201}}{v_1} = \frac{v_1}{V_0} \quad . \tag{4.5a}$$

Then, in terms of the impedances involved in the real electromagnetic interactions (where $z_1 = 1/v_1$ ), we get:

$$\frac{z_1}{Z_{201}} = \frac{Z_0}{z_1} = 4\pi\alpha \quad . \tag{4.5b}$$

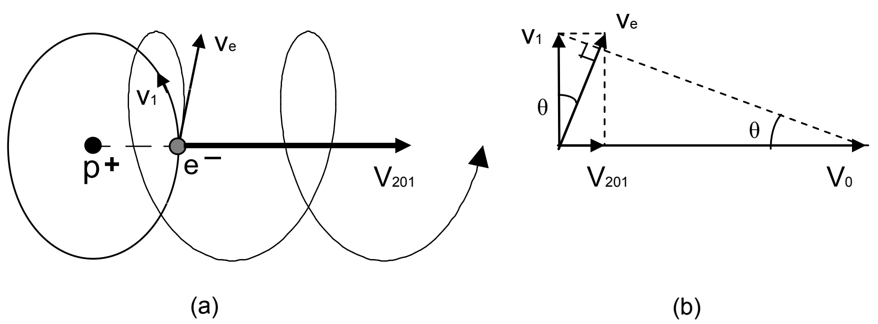


Figure 2 (a) The electron in the first Bohr orbit of a hydrogen atom travelling around the galactic orbit at velocity $V_{201}$ describes a helical trajectory. (b) The instantaneous electron velocity is $v_e$ , with $V_{201}$ and $V_0$ occupying congruent triangles.

To get this result, $V_0$ had to be parallel to $V_{201}$ , which is in the direction of net current flow and gravito-cordic field emission around the galactic orbit. Equation (4.5) is therefore taken to mean that at an orbit velocity of 201kms$^{-1}$, the impedance of electromagnetic radiation is coupled to the hydrogen-electron impedance $z_1$, and this optimises the emission and reception of gravito-cordic field quanta, *analogous to a tuned helical radio antenna.*

## *4.2 Application to galaxies*

The next step is to apply this optimum propagation equation (4.5) directly to galactic structure. Practical units for the gravitational domain must be reinstated by putting $m_{je} = m(e^2/Gm^2)^{-1/2}$: then the gravitational de Broglie wavelength for hydrogen-electrons (see Section 4.5) becomes $\lambda_{GH} = (h/mV_{201})[137\times(e^2/Gm^2)^{1/2}]$, and $r_1$ becomes $r_{GH} = r_1[137\times(e^2/Gm^2)^{1/2}]$. Equation (4.2) with (4.4) may now be written:

$$Z_0 = \left[\frac{r_{GH}}{\lambda_{GH}/2\pi}\right]\left(\frac{1}{v_1}\right) = 4\pi\alpha \text{ atohms.} \tag{4.6}$$

Classical waveguide theory enables us to interpret this equation, (see [4], pp194, 228). For a waveguide of dimensions *a,b* transmitting an $H_{10}$ wave of guidewavelength $\lambda_g$ and free space wavelength $\lambda$, the waveguide impedance is:

$$Z_g = 120\pi\left(\frac{b}{a}\right)\left(\frac{\lambda_g}{\lambda}\right) \quad . \tag{4.7}$$

Thus, for optimum coupling of a gravito-cordic field to such a galactic waveguide, $Z_g$ should probably be equal to $Z_0$ . In the simplest case, let $\lambda_g = \lambda_{GH}/2$ for intensity tuning, and $\lambda = 2\pi r_{GH}$ . As the radial separation of stable galactic orbits is $\lambda_{GH}/2\pi$, (Eq.(7.5) in Paper 1), let this define the waveguide width *a*. It follows that $b = 2r_{GH}$ is to be the effective waveguide height in Eq.(4.7). That is, each stable galactic orbit acts like a waveguide with dimensions defined by the hydrogen first Bohr radius and the gravitational de Broglie wavelength such that the waveguide impedance is optimally matched to $Z_0$ for V = 201kms$^{-1}$. The scatter of velocities around 201kms$^{-1}$ for Sa,b,c galaxies indicates that the quantisation force is not strong enough to coerce the disc matter into perfect agreement with Eq.(4.6), but nevertheless there is no known classical reason why this particular average velocity should exist at all.

## *4.3 Realisation of the de Broglie wavelength*

It has now been shown that the quantisation wavelength is matched to the dimensions of the stable orbits, as far as characteristic impedance is concerned. However, it was seen in Section 3 that there are *no real* de Broglie-type quanta, so the question arises as to why the orbital dimensions should match the *interference* wavelength $\lambda_{GH}$. According to Eq.(3.9) the net field amplitude is a circularly polarised wave of frequency $\nu'$ modulated at frequency $\nu'(v/c)$. In order to extract this modulation frequency it is necessary for the wave to interact with a body.

For example, in the static coordinate reference frame there is a field amplitude $y_q$ in Eq.(3.9) acting on particles of internal field Eq.(3.4), so by Lenz's law the interaction force is:

$$
\begin{aligned}
F_c &= -y_q \exp[+i2\pi(\nu' t - \tilde{\upsilon} x)] \\
&= q^{1/2}(2y_o i)\sin[2\pi\{\nu'(v/c)t - x/\lambda'\}]
\end{aligned}
\quad . \tag{4.8}
$$

Thus at any position *x,* the matter is excited by a field oscillating at the de Broglie frequency $\nu'(v/c)$. Now, from scattering theory, (van der Hulst 1957) [5] and radar theory ([4], p.273) it is known that Mie resonance is optimum when the particle is around ($\lambda/2\pi$) in radius; this actually corresponds with the spacing of the galactic orbits, ($\lambda_{GH}/2\pi$). It is suggested therefore that the force Eq.(4.8) causes resonance at the gravitational de Broglie frequency in any orbiting gas clouds with this radius. Given that reception and radiation characteristics of antenae are identical, according to the Reciprocity Theorem, ([4], p.269), then the reception of the interference wave Eq (3.9) is also optimised by matching radiation impedance to the orbital dimensions. Thus, the *interference* field Eq.(3.9) really is capable of exciting resonance through radiation reaction forces, (see Panofsky & Phillips, 1962) [6].

## *4.4 Polar diagram*

It is interesting to calculate the effective polar diagram of the ponderomotive force due to the gravito-cordic field around the orbit. The transverse force field Eq (4.8), vibrating at frequency $\nu'(v/c)$ may be viewed as an equivalent dipole. If there are ($N = 2\pi R/\lambda_{GH}$) (typically several million) gravitational de Broglie wavelengths around an orbit, then there are effectively N dipoles properly phased to enhance one another in the forward direction. Such an assembly of dipoles constitutes an "end-fire" aerial array ([4], p.314). The main lobe total angular width is given by ($\beta = 2\cos^{-1}(1-4/N) \approx (32/N)^{1/2}$), for large N. Therefore the beam width after one revolution is ($\Delta R = 2\pi R\beta = \lambda_{GH}(32N)^{1/2}$), and this corresponds to a spread over $\Delta R/(\lambda_{GH}/2\pi)$ orbits. The total number of nodes in these orbits encompassed by this beam spread is then $2\pi(32N^3)^{1/2}$. Thus, the quantisation force of each orbit extends laterally across a range of orbits and tends to synchronise the de Broglie frequency, thereby encouraging production of *flat rotation curves*. Since, the overall synchronisation force increases with $N^{3/2}$, the larger disc galaxies should show flatter rotation curves, except when turbulence destroys the coherence.

### *4.5 The gravitational de Broglie wavelength emitted by hydrogen-electrons*

According to Eq.(3.7a), *free* electrons would carry a gravitational de Broglie wavelength ($\lambda_{Ge} = h / m_{je}V$). However, in galaxies the quantisation field appears to be emitted from the atomic hydrogen-electron, because the replacement of $\lambda_{Ge}$ by ($\lambda_{GH} = 137\lambda_{Ge}$) fits the galactic parameters better and may be explained as follows.

The hydrogen-electron's motion around the proton in the 1$^{st}$ Bohr orbit of length $2\pi r_1 = 137\lambda_C$ will modulate the gravito-cordic field from the electron itself at 137 times the Compton wavelength. This modulation introduces a factor 137 into Eqs.(3.1) and (3.7a), as was employed in Section 4.2. Orientation of the hydrogen atoms in the galactic orbits will not affect this process, although it was assumed that circularly polarised quanta would be optimum for the analysis in Section 4.1.

## 5. Conclusion

Published astronomical data from a variety of sources [3] have been analysed to reveal significant quantisation of angular momenta and body parameters. Analogy with the Bohr atom is striking and the regular appearance of the fine structure constant implies that gravity is electromagnetic by nature. The gaps between classes may he attributed to a lack of quantisation rules to operate there. One aspect of the results is that the quantisation forces are strong enough to cause approximate quantisation but not so strong as to eliminate variety in each class. A great deal of further evidence for quantisation has already been presented in Paper 1 on the characteristic features of disc galaxies.

The gravitational de Broglie wavelength of the gravito-cordic field emitted by a particle has been calculated from first principles, and then the corresponding ponderomotive force derived. Emission of the gravito-cordic field has been found to be optimum for a particular velocity of 201kms$^{-1}$ because of its dependence upon the characteristic impedance of electromagnetic radiation. This impedance was also found to be matched to galactic orbit dimensions in terms of classical waveguide theory.

Finally, a polar diagram for the gravito-cordic field radiation was calculated, which confirmed that larger disc galaxies should possess flatter rotation curves.

## Acknowledgements

I would like to thank Imperial College Libraries and A. Rutledge for typing.

## References

1. Wayte R: 2010, viXra:1002.0018, (Paper 1).
2. Wayte R: *Moon and the Planets* 1982, **26**:11.
3. Allen CW: *Astrophysical Quantities, 3rd edition* (Athlone Press: London); 1973.
4. Glazier EVD, Lamont HRL: *The Services book of Radio, Vol 5, Transmission & Propagation* HMSO, London; 1958.
5. Van de Hulst HC: *Light scattering by small particles* Wiley, NY; 1957.
6. Panofsky WKH, Phillips M: *Classical Electricity and Magnetism 2nd Edition.* Addison-Wesley, London; 1962.