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Physics and Space Science

Highlights

- Unitary Quantum Theory
- Semi-Closed Friedman Model
- Emitting Gravitational Wave
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Discovering Thoughts, Inventing Future

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On Asteroid Engineering

By Olaf Lechtenfeld
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Abstract- I pose the question of maximal Newtonian surface gravity on a homogeneous body of a given mass and volume but with variable shape. In other words, given an amount of malleable material of uniform density, how should one shape it in order for a microscopic creature on its surface to experience the largest possible weight? After evaluating the weight on an arbitrary cylinder, at the axis and at the equator and comparing it to that on a spherical ball, I solve the variational problem to obtain the shape which optimizes the surface gravity in some location. The boundary curve of the corresponding solid of revolution is given by $(x^2 + z^2)^3 - (4\,z)^2 = 0$ or $r(\theta) = 2\sqrt{\cos\theta}$, and the maximal weight (at $x = z = 0$) exceeds that on a solid sphere by a factor of $35\sqrt{3}\,5$, which is an increment of 2.6%. Finally, the values and the achievable maxima are computed for three other families of shapes.

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Olaf Lechtenfeld

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I. Introduction

In the spring of 1996 I was visiting the City College of New York for a month, in order to pursue a research project with Stuart Samuel, who was a professor at City University of New York at the time, and to run in the 100th Boston marathon. Several evenings and part of weekends I'd spend with our mutual friend Pascal Gharemani, a tennis coach and instructor at Trinity School (a private high school on West 91st Street in Manhattan). Typically we would go dining, visit places or fly kites. Pascal had an Iranian background but grew up in Versailles near Paris before moving to the US. My wife and I had come to know him during my postdoc years at City College (1987–90), when we would meet weekly at various restaurants in the Columbia University neighborhood for an evening of French conversation. He was important for our socialization in Manhattan and had grown into a good friend. Pascal was a very curious individual, with a great sense of humor and always ready to engage in discussions about savoir vivre, philosophy, and the natural sciences. Regarding the latter, he regularly pondered phenomena and questions which involved physics. Lacking a formal science training, he would go to great lengths and try his physicist friends for explanations.

So one evening in 1996 he shared his musings about the gravitational force of a long and homogeneous rod, as it is felt by a (say, minuscule) creature crawling on its surface. Clearly, the mass points in its neighborhood are mainly responsible for creating the force. On one hand, at the end of the rod, the nearby mass is fewer than elsewhere, but it is all pulling roughly in the same direction. On the other hand, around the middle part of the rod, twice as much mass points are located near the creature, yet their gravitational forces point to almost opposing directions and hence tend to cancel each other out. So which location gives more weight to the mini-bug? Where along the rod is its surface gravity largest?

This was a typical 'Pascal question', and my immediate response was: "That's an easy one. Let me just compute it." Well, easier said then done. For the mid-rod position the resulting integrals were too tough to perform on the back of an envelope. To simplify my life, I persuaded Pascal to modify the problem. Let us vary not the position of the bug but the geometry of its planet: keep the bug sitting on the top of a cylinder, and compare a long rod with a slim disk of the same volume and mass. Then it was not too hard to calculate the surface gravity as a function of the ratio of the cylinder's diameter to its length. To our surprise, in a narrow window of this parameter the weight of the bug exceeds the value for a spherical ball made from the same material. This finding inspired us to generalize the question to another level: Given a bunch of homogeneous material (fixed volume and density, hence total mass), for which shape is the gravitational force somewhere on its surface maximized? Thus, the idea of "asteroid engineering" was born.

After solving the problem and comparing the result with a few other geometries, I put the calculations aside and forgot about them. Four years later, when teaching Mathematical Methods for physics freshmen, I was looking for a good student exercise in variational calculus. Coming across my notes from 1996, I realized they can be turned into an unorthodox, charming and slightly challenging homework problem. And so I did, posing the challenge in the summer of 2000 [1] and again in 2009 [2], admittedly with mixed success.[1] But let the reader decide!

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[1] In 2002, the problem also occurred in a physics quizz page [3] and later in the textbook [4]. For a similar recent treatment, see [5].

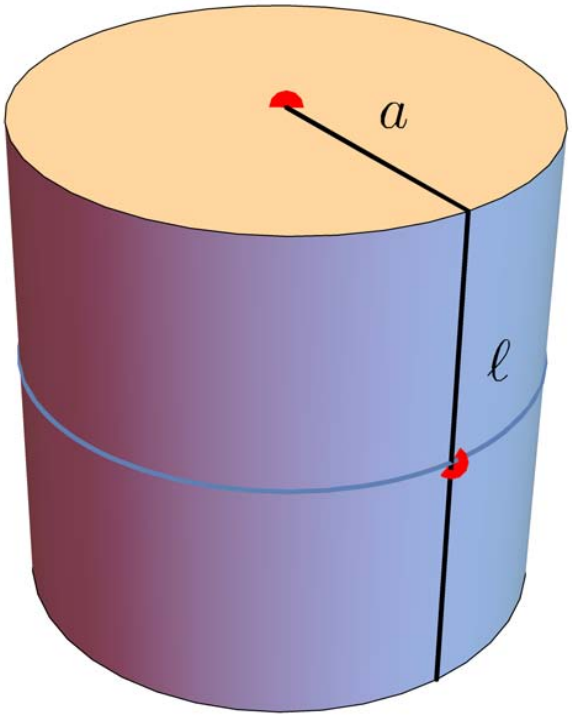


Figure 1 : Geometry of massive cylinder

II. Surface Gravity of a Homogeneous Massive Cylinder

It is textbook material how to compute the Newtonian gravitational field $\vec{G}(\vec{r})$ generated by a given three-dimensional static mass distribution $\rho(\vec{r}\,')$. In the absence of symmetry arguments, it involves a three-dimensional integral collecting the contributions

$$\mathrm{d}\vec{G}(\vec{r},\vec{r}\,') \;=\; \gamma\,\rho(\vec{r}\,')\,\frac{\vec{r}\,'-\vec{r}}{|\vec{r}\,'-\vec{r}|^3}\,\mathrm{d}^3\vec{r}\,' \qquad (2.1)$$

produced by the masses at positions $\vec{r}\,'$, with γ denoting the gravitational constant. For the case of a solid homogeneous body B of volume V and total mass M, clearly $\rho(\vec{r}\,') = M/V$ is constant, and one gets

$$\vec{G}(\vec{r}) \;=\; \gamma\,\tfrac{M}{V}\int_B \mathrm{d}^3\vec{r}\,'\,\frac{\vec{e}_{\vec{r}\,'-\vec{r}}}{(\vec{r}\,'-\vec{r})^2}\;, \qquad (2.2)$$

where $\vec{e}_{\vec{r}\,'-\vec{r}}$ is the unit vector pointing from the observer (at $\vec{r}$) to the mass point at $\vec{r}\,'$. The surface gravity (specific weight of a probe) located somewhere on the surface ∂B of my solid is obtained by simply restricting $\vec{r}$ to ∂B.

One might think of simplifying the task by computing the gravitational potential rather than the field, since the corresponding integral is scalar and appears to be easier. However, evaluating the surface gravity then requires taking a gradient in the end and thus keeping at least an infinitesimal dependence on a coordinate normal to the surface. Retaining this additional parameter until finally computing the derivative of the potential with respect to it before setting it to zero yields no calculational gain over a direct computation of $\vec{G}$.

The original question of Pascal concerned a cylindrical rod, whose length and radius I denote by ℓ and a, respectively, so that $V = \pi a^2\ell$. The integral above has dimension of length, and I shall scale out a factor of ℓ to pass to dimensionless quantities. For the remaining dimensionless parameter I choose the ratio of diameter to length of the cylinder, $t := 2a/\ell$, see Fig. 1. I shall frequently have to express some of the four quantities a, ℓ, t and V in terms of a pair of the others, so let me display the complete table of the relations,

$$\begin{aligned}
a \;&=\; \ell\,t/2 \;=\; \sqrt{V/(\pi\ell)} \;=\; \sqrt[3]{V\,t/(2\pi)}\\
\ell \;&=\; 2a/t \;=\; V/(\pi a^2) \;=\; \sqrt[3]{4V/(\pi t^2)}\\
t \;&=\; 2a/\ell \;=\; 2\pi a^3/V \;=\; \sqrt{4\,V/(\pi\ell^3)}\\
V \;&=\; \pi a^2\ell \;=\; 2\pi a^3/t \;=\; \pi\ell^3 t^2/4\;. \qquad (2.3)
\end{aligned}$$

Pascal's problem was to compare for this cylinder the surface gravity at the symmetry axis point to the one at a point on the mid-circumference or equator. Let me treat both cases in turn.

a) Surface gravity at the axis

Naturally I employ cylindrical coordinates (z,ρ,ϕ) for $\vec{r}\,'$ and put the symmetry axis point in the origin. With $\vec{r}$ = 0 the expression (2.2) then becomes

$$\vec{G}(0) \;=\; \gamma\,\tfrac{M}{V}\int_0^\ell \mathrm{d}z \int_0^a \mathrm{d}\rho\,\rho \int_0^{2\pi} \mathrm{d}\phi\;(z^2+\rho^2)^{-3/2}\begin{pmatrix}\rho\cos\phi\\ \rho\sin\phi\\ -z\end{pmatrix}$$

$$=\; -2\pi\,\gamma\,\tfrac{M}{V}\int_0^\ell \mathrm{d}z \int_0^a \mathrm{d}\rho\;\frac{\rho\,z}{(z^2+\rho^2)^{3/2}}\;\vec{e}_z \;=:\; -G_a\,\vec{e}_z\;. \tag{2.4}$$

The ρ and z integrals are elementary,

$$G_a \;=\; 2\pi\gamma\,\tfrac{M}{V}\int_0^\ell \mathrm{d}z \int_0^a \mathrm{d}\rho\;\frac{\rho\,z}{(z^2+\rho^2)^{3/2}} \;=\; 2\pi\gamma\,\tfrac{M}{V}\int_0^\ell \mathrm{d}z\;\left[\frac{z}{\sqrt{z^2+\rho^2}}\right]_0^a$$

$$=\; 2\pi\gamma\,\tfrac{M}{V}\int_0^\ell \mathrm{d}z\;\left\{1-\frac{z}{\sqrt{z^2+a^2}}\right\} \;=\; 2\pi\gamma\,\tfrac{M}{V}\left[z-\sqrt{z^2+a^2}\right]_0^\ell \tag{2.5}$$

$$=\; 2\pi\gamma\,\tfrac{M}{V}\left\{\ell+a-\sqrt{\ell^2+a^2}\right\} \;=\; 2\pi\gamma\,\tfrac{M}{V}\,\ell\left\{1+\tfrac{t}{2}-\sqrt{1+\tfrac{t^2}{4}}\right\}.$$

It is a bit curious that the result is symmetric under the exchange of ℓ and a, and so in the thin rod ($a \to 0$) and thin disk ($\ell \to 0$) limits one finds that

$$G_a \;=\; 2\pi\gamma\,\tfrac{M}{V}\,a\left\{1-\tfrac{a}{2\ell}+\ldots\right\} \qquad \text{and} \qquad G_a \;=\; 2\pi\gamma\,\tfrac{M}{V}\,\ell\left\{1-\tfrac{\ell}{2a}+\ldots\right\}, \tag{2.6}$$

respectively, with $a^2\ell = V/\pi$ fixed of course.

Apart from the linear dependence on the gravitational constant γ and the mass density $\frac{M}{V}$, the surface gravity must carry a dimensional length factor, which choose to be the cylinder length ℓ. However, ℓ, t and $V$are obviously related, and for comparing different shapes of the same mass and volume it is preferable to eliminate ℓ in favor of $V$and t. The resulting expression for the surface gravity has the universal form

$$G \;=\; (\text{numerical factor})\;\times\;\gamma\,M\,V^{-2/3}\,(\text{shape function})\,, \tag{2.7}$$

where the shape function depends on dimensionless parameters like t only. For the case at hand, I obtain

$$G_a \;=\; 2^{5/3}\pi^{2/3}\,\gamma\,M\,V^{-2/3}\,t^{-2/3}\left\{1+\tfrac{t}{2}-\sqrt{1+\tfrac{t^2}{4}}\right\}. \tag{2.8}$$

The asymptotic behavior for a thin rod ($t \to 0$) and for a thin disk ($t \to \infty$) takes the form

$$G_a \;=\; 2^{5/3}\pi^{2/3}\,\gamma\,M\,V^{-2/3}\;\times\;\begin{cases}\frac{1}{2}t^{1/3}-\frac{1}{8}t^{4/3}+\frac{1}{128}t^{10/3}+O(t^{16/3}) & \text{for}\quad t\to 0\\ t^{-2/3}-t^{-5/3}+t^{-11/3}+O(t^{-17/3}) & \text{for}\quad t\to\infty\end{cases}. \tag{2.9}$$

b) Surface gravity at the equator

This is the harder case, as it lacks the cylindrical symmetry. Naturally putting the origin of the cylindrical coordinate system at the cylinder's center of mass, hence $\vec{r} = (a,0,0)^\top$, the surface gravity integral (2.2) reads

$$\vec{G}(a) \;=\; \gamma\,\tfrac{M}{V}\int_{-\ell/2}^{\ell/2} \mathrm{d}z \int_0^a \mathrm{d}\rho\,\rho \int_0^{2\pi} \mathrm{d}\phi\;\big([\rho\cos\phi-a]^2+[\rho\sin\phi]^2+z^2\big)^{-3/2}\begin{pmatrix}\rho\cos\phi-a\\ \rho\sin\phi\\ z\end{pmatrix}$$

$$= \gamma \tfrac{M}{V} \int_{-\ell/2}^{\ell/2} \mathrm{d}z \int_0^a \mathrm{d}\rho\, \rho \int_0^{2\pi} \mathrm{d}\phi\, \frac{\rho\cos\phi - a}{(z^2+a^2+\rho^2-2\,a\rho\cos\phi)^{3/2}}\, \vec{e}_x$$

$$= 2\,\gamma \tfrac{M}{V}\,\ell \int_0^{1/2} \mathrm{d}u \int_0^1 \mathrm{d}v \int_0^{2\pi} \mathrm{d}\phi\, \frac{v\,(v\cos\phi - 1)}{u^2\ell^2/a^2 + 1 + v^2 - 2\,v\cos\phi)^{3/2}}\, \vec{e}_x \;=:\; -G_m\,\vec{e}_x\ , \tag{2.10}$$

where I employed the $z \leftrightarrow -z$ symmetry and substituted $z = u\,\ell$ and $\rho = v\,a$ for a dimensionless integral. The u integration is elementary,

$$G_m = \gamma \tfrac{M}{V}\,\ell \int_0^1 \mathrm{d}v \int_0^{2\pi} \mathrm{d}\phi\, \frac{v\,(1 - v\cos\phi)/(1+v^2-2\,v\cos\phi)}{\sqrt{\ell^2/(4a^2) + 1 + v^2 - 2\,v\cos\phi}}$$

$$= 2\,\gamma \tfrac{M}{V}\,\ell \int_0^1 \mathrm{d}v \int_{-1}^1 \mathrm{d}w\, \frac{v\,(1 - v\,w)/(1+v^2-2\,v\,w)}{\sqrt{(1-w^2)(t^{-2}+1+v^2-2\,v\,w)}}\ , \tag{2.11}$$

after substituting $\cos\phi = w$ and using the definition $2a/\ell = t$.

The remaining double integrals leads to lengthy expressions in terms of complete elliptic integrals, which I do not display here. For $t \to \infty$ it diverges logarithmically. It is possible, however, to extract the limiting behavior for $t \to 0$ as

$$G_m = 2\pi\,\gamma \tfrac{M}{V}\,a\left\{1 - O(\tfrac{a}{\ell})\right\}\ , \tag{2.12}$$

which in leading order surprisingly agrees with that of G_a.

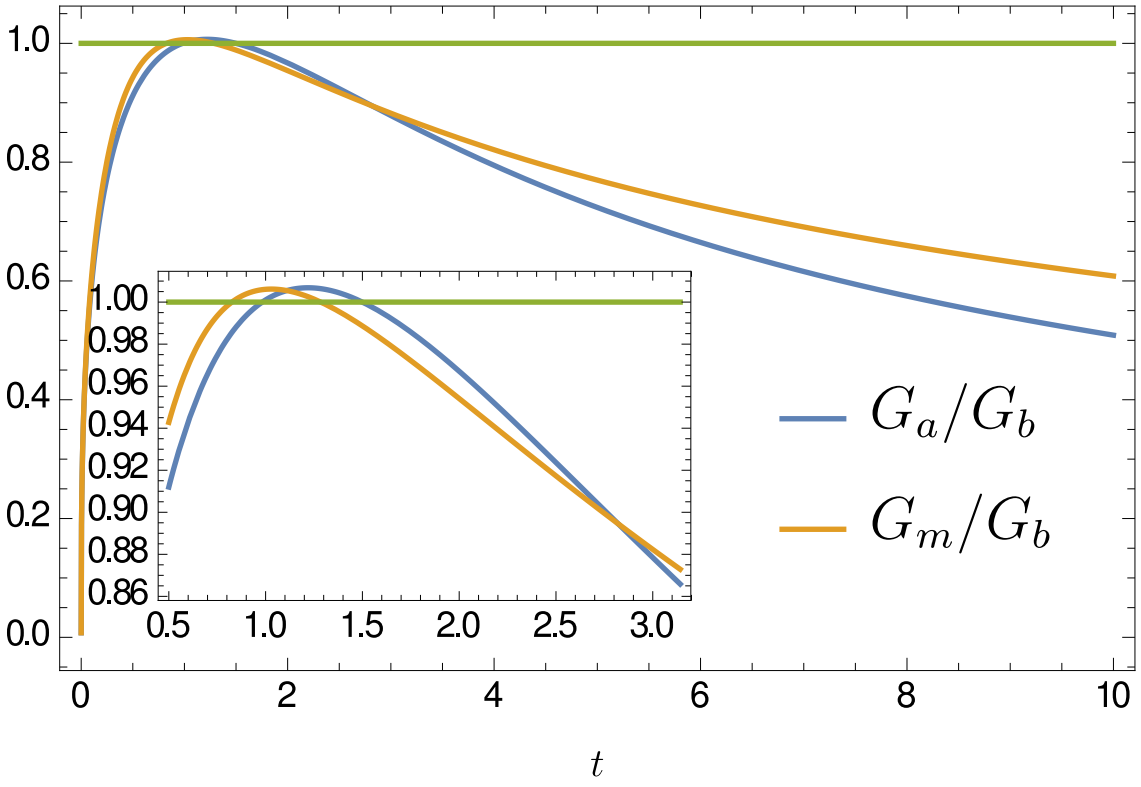


Figure 2 : Cylinder surface gravity on symmetry axis and mid-circumference

c) Comparison with a spherical ball

To get a feeling for these results, it is natural to compare them with the surface gravity of a homogeneous ball of the same mass M and density, thus of radius

$$r_b \;=\; \left(\tfrac{4\pi}{3}\right)^{-1/3} V^{1/3}\,. \tag{2.13}$$

The surface gravity $\vec{G}(r_b) = -G_b\,\vec{e}_r$ of the latter is well known,

$$G_b \;=\; \gamma\, M/r_b^2 \;=\; \gamma\,\tfrac{M}{V}\,\tfrac{4\pi}{3}\,r_b \;=\; \left(\tfrac{4\pi}{3}\right)^{2/3}\gamma\, M\, V^{-2/3}\,. \tag{2.14}$$

Hence, the relation of the cylindrical to the spherical surface gravity is

$$\frac{G_a}{G_b} \;=\; 2\pi\left(\tfrac{\pi}{4}\right)^{-1/3} t^{-2/3}\left\{1+\tfrac{t}{2}-\sqrt{1+\tfrac{t^2}{4}}\right\}\Big/\left(\tfrac{4\pi}{3}\right)^{2/3} \;=\; \sqrt[3]{18}\;t^{-2/3}\left\{1+\tfrac{t}{2}-\sqrt{1+\tfrac{t^2}{4}}\right\}, \tag{2.15}$$

for the axis position, see Fig. 2. Surprisingly, in the interval

$$t \;\in\; \left[\tfrac{4}{9}(2\sqrt{13}-5)\;,\;\tfrac{3}{2}\right] \;\approx\; \left[0.98271\;,\;1.50000\right] \tag{2.16}$$

the weight on the cyclinder's axis exceeds that on the reference ball! Indeed, its maximal value is attained at

$$t_a \;=\; \tfrac{1}{4}(9-\sqrt{17}) \;\approx\; 1.21922 \qquad\Rightarrow\qquad \tfrac{G_a}{G_b}\Big|_{\max} \;=\; \tfrac{G_a}{G_b}(t_a) \;\approx\; 1.00682\,. \tag{2.17}$$

The asymptotic behavior is easily deduced to be

$$\frac{G_a}{G_b} \;=\; \sqrt[3]{\tfrac{9\pi}{2}}\,\frac{a}{V^{1/3}}\left(1-O\big(\tfrac{a^3}{V}\big)\right) \qquad\text{and}\qquad \frac{G_a}{G_b} \;=\; \sqrt[3]{\tfrac{9\pi}{2}}\,\frac{\ell}{V^{1/3}}\left(1-O\big(\sqrt{\tfrac{\ell^3}{V}}\big)\right), \tag{2.18}$$

for $a \to 0$ and $\ell \to 0$, respectively.

For the equatorial position's surface gravity I do not have an analytic expression, only its limiting forms

$$\frac{G_m}{G_b} \;\sim\; \sqrt[3]{\tfrac{9\pi}{2}}\,\frac{a}{V^{1/3}} \;\approx\; 2.41799\,\frac{a}{V^{1/3}} \qquad\text{and}\qquad \frac{G_m}{G_b} \;\sim\; 0.36813\,\frac{\ell}{V^{1/3}}\left|\log\frac{\ell}{V^{1/3}}\right| \tag{2.19}$$

for $a \to 0$ and $\ell \to 0$, respectively. Numerical analysis shows that G_m/G_b (see Fig. 2) attains a maximum at

$$t_m \;\approx\; 1.02928 \qquad\Rightarrow\qquad \tfrac{G_m}{G_b}\Big|_{\max} \;\approx\; 1.00619\,. \tag{2.20}$$

Furthermore, for any given shape in an asymptotic regime, the equatorial position is superior to the axis one. Only in the interval $1.10948 \lesssim t \lesssim 2.82154$ is our mini-bug heavier on the axis.

III. Which Shape Maximizes the Surface Gravity?

This finding suggests the question: Can one do better than the cylinder with a clever choice of shape? It turns the problem into a variational one. Suppose I have by some means discovered the homogeneous body $\bar{B}$ which, for fixed mass and volume, yields the maximally possible gravitational pull in some location on its surface. Without loss of generality I can put this point to the origin of my coordinate system and orient the solid in such a way that its outward normal in this point aims in the positive z direction, so gravity pulls downwards as is customary.

Expressing the surface gravity at this position for an arbitrary body B as a functional of its shape, then $\bar{B}$ must maximize this functional, under the constraint of fixed mass and volume. The following three features of the optimal shape are evident:

- It does not have any holes, so has just a single boundary component
- It is convex
- It is rotationally symmetric about the normal at the origin
  These facts imply that the surface ∂B may be parametrized as in Fig. 3,

$$\partial B \;=\; \left\{ R(\theta)(\sin\theta\cos\phi, \sin\theta\sin\phi, -\cos\theta)^{\top} \;\middle|\; 0 \le \theta \le \tfrac{\pi}{2}\,,\; 0 \le \phi < 2\pi \right\}\,, \tag{3.1}$$

with $R(\theta) \geq 0$ and $R(\frac{\pi}{2}) = 0$. The function $R(\theta)$ (which may be extended via $R(-\theta) = R(\theta)$) completely describes the shape of the solid of revolution B. It may be viewed as the boundary curve of the intersection of B with the xz plane. Its convexity implies the condition

$$\left(\tfrac{1}{R(\theta)}\right)'' + \tfrac{1}{R(\theta)} \;\geq\; 0\,. \tag{3.2}$$

Employing the symmetry under reflection on the rotational axis,

$$S\,:\;(\theta,\phi)\;\mapsto\;(\theta,\phi{+}\pi)\;\sim\;(-\theta,\phi)\,, \tag{3.3}$$

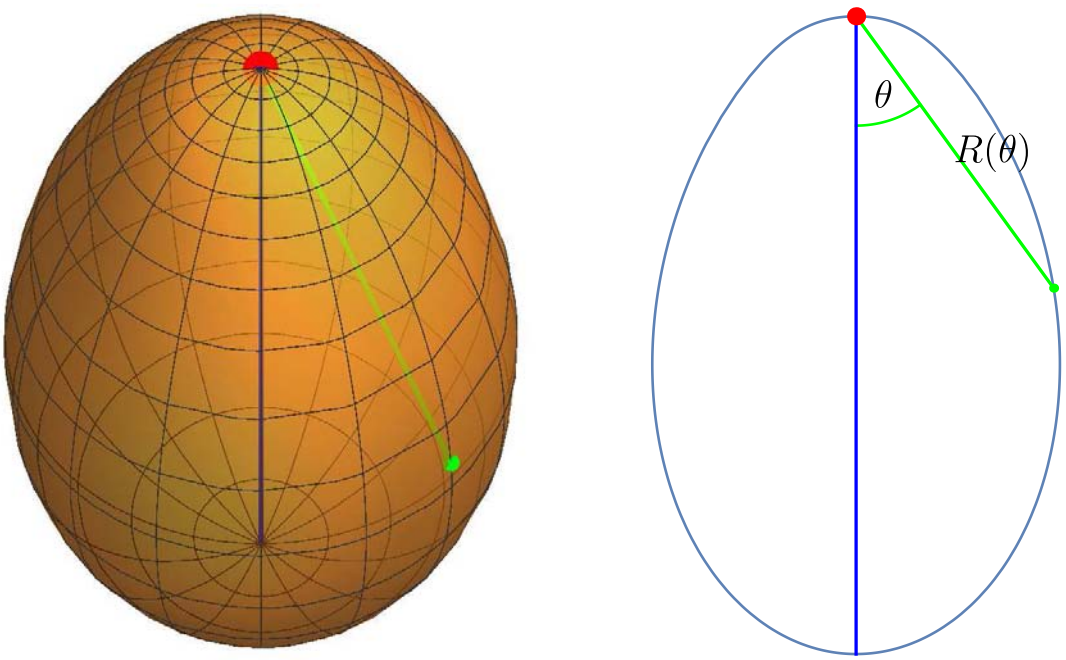


Figure 3 : Parametrization of surface of revolution ∂B

the surface gravity functional (2.2) then reads

$$\vec{G}[R] \;=\; \gamma\,\tfrac{M}{V}\int_B \frac{\mathrm{d}^3\vec{r}}{r^2}\;\tfrac{1}{2}(\vec{e}_{\vec{r}} + S\vec{e}_{\vec{r}}) \;=:\; -G[R]\,\vec{e}_z\,, \tag{3.4}$$

$$G[R] \;=\; 2\pi\,\gamma\,\tfrac{M}{V}\int_0^1 \mathrm{d}\cos\theta\int_0^{R(\theta)}\mathrm{d}r\;\cos\theta \;=\; 2\pi\,\gamma\,\tfrac{M}{V}\int_0^1 \mathrm{d}\cos\theta\;R(\theta)\cos\theta\,. \tag{3.5}$$

It is to be maximized with the mass (and thus the volume) kept fixed,

$$M[R] \;=\; \tfrac{M}{V}\int_B \mathrm{d}^3\vec{r} \;=\; 2\pi\,\tfrac{M}{V}\int_0^1 \mathrm{d}\cos\theta \int_0^{R(\theta)} r^2\mathrm{d}r \;=\; \tfrac{2\pi}{3}\,\tfrac{M}{V}\int_0^1 \mathrm{d}\cos\theta\; R(\theta)^3 \;\stackrel{!}{=}\; M\;. \qquad (3.6)$$

Such constrained variations are best treated by the method of Lagrange multipliers, which here instructs me to combine the two functionals to

$$2\pi\,\tfrac{M}{V}\,U[R,\lambda] \;=\; G[R] \;-\; \lambda\big(M[R]-M\big)\;, \qquad (3.7)$$

introducing a Lagrange multiplier λ (a real parameter to be fixed subsequently). More explicitly,

$$U[R,\lambda] \;=\int_0^1 \mathrm{d}\cos\theta\;\big[\gamma\,R(\theta)\cos\theta \;-\; \tfrac{1}{3}\lambda\,R(\theta)^3\big] \;-\; \lambda\,\tfrac{V}{2\pi}\;, \qquad (3.8)$$

so $\partial_\lambda U = 0$ clearly fixes the volume of B to be equal to V. Demanding that, for λ fixed but arbitrary, U is stationary under any variation of the boundary curve, $R \mapsto R+\delta R$, determines $R = R_\lambda$:

$$0 \;=\; \delta U[R_\lambda,\lambda] \;=\; \int_0^1 \mathrm{d}\cos\theta\;\delta R(\theta)\;\big[\gamma\,\cos\theta \;-\; \lambda\,R_\lambda(\theta)^2\big]\;, \qquad (3.9)$$

so I immediately read off

$$R_\lambda(\theta) \;=\; \sqrt{\tfrac{\gamma}{\lambda}\,\cos\theta}\;. \qquad (3.10)$$

It remains to compute the value $\bar{\lambda}$ of the Lagrange multiplier by inserting the solution R_λ into the constraint (3.6),

$$M \;\stackrel{!}{=}\; M[R_{\bar\lambda}] \;=\; \tfrac{2\pi}{3}\,\tfrac{M}{V}\int_0^1 \mathrm{d}\cos\theta\;\big(\tfrac{\gamma}{\lambda}\,\cos\theta\big)^{3/2} \;=\; \tfrac{4\pi}{15}\,\tfrac{M}{V}\,\big(\tfrac{\gamma}{\lambda}\big)^{3/2}\;, \qquad (3.11)$$

yielding $\bar{\lambda} = \big(\frac{4\pi}{15\,V}\big)^{2/3}\gamma$ and hence the complete solution as displayed in Fig. 4,

$$\bar{R}(\theta) \;:=\; R_{\bar\lambda}(\theta) \;=\; 2\,R_0\,\sqrt{\cos\theta} \qquad \text{with} \qquad (2\,R_0)^3 \;=\; \tfrac{15}{4\pi}\,V\;. \qquad (3.12)$$

What does this curve look like? Let me pass to Cartesian coordinates in the xz plane,

$$\bar{R}^2 \;=\; (2\,R_0)^2\,\cos\theta \;=\; x^2+z^2 \qquad \text{and} \qquad \cos\theta \;=\; \tfrac{z}{\sqrt{x^2+z^2}}\;, \qquad (3.13)$$

which yields the sextic curve (cubic in squares)

$$(x^2+z^2)^3 \;=\; (2\,R_0)^4\,z^2 \qquad \text{with} \qquad R_0^3 \;=\; \tfrac{15}{32\pi}\,V\;. \qquad (3.14)$$

The parameter R_0 only takes care of the physical dimensions and determines the overall size of the solid. In dimensionless coordinates it may be put to unity, which fixes the vertical diameter to be equal to 2 and allows for a comparison of my optimal curve with the unit circle,

$$r(z) \;=\; 2\,|z|^{1/3} \qquad \text{versus} \qquad r(z) \;=\; 2\,|z|^{1/2} \qquad \text{for} \quad r(z)^2 \;=\; x^2+z^2\;, \qquad (3.15)$$

with $-z \in [0,2]$ and $r(z) \in [0,2]$. Since $|z|^{1/3} \geq |z|^{1/2}$ in the interval of question, my curve lies entirely outside the reference circle, touching it only twice on the z axis. (Note that $R_0 \neq r_b$ so the corresponding volumes differ.) Other than the sphere, my curve has a critical point: Due to $z \sim x^3$ near the origin, the curvature vanishes there. Clearly, the vertical extension of $\bar{B}$ is $\Delta z = 2R_0$ while its width is easily computed to be

$$\Delta x \;=\; 2\,\sqrt[4]{\tfrac{4}{27}}\,2R_0 \;\approx\; 2.48161\,R_0 \qquad \text{at} \qquad z_0 \;=\; -\sqrt[4]{\tfrac{1}{27}}\,2R_0 \;\approx\; -0.87738\,R_0\;. \tag{3.16}$$

The shape of my optimal body $\bar{B}$ vaguely resembles an apple, with the flatter side up.

My final goal is to calculate the maximal possible weight $G_{\max}$, or

$$G[\bar{R}] \;=\; 2\pi\,\gamma\,\tfrac{M}{V}\,2R_0\int_0^1 \mathrm{d}\cos\theta\,\big(\cos\theta\big)^{3/2} \;=\; 2\pi\,\gamma\,\tfrac{M}{V}\,\sqrt[3]{\tfrac{15\,V}{4\pi}}\,\tfrac{2}{5} \;=\; \big(\tfrac{4\pi\sqrt{3}}{5}\big)^{2/3}\gamma\,M\,V^{-2/3}\;. \tag{3.17}$$

Comparing with the spherical shape,

$$\frac{G[\bar{R}]}{G_b} \;=\; 3\cdot 5^{-2/3} \;=\; \tfrac{3}{5}\sqrt[3]{5} \;\approx\; 1.02599\;. \tag{3.18}$$

I conclude that by homogeneous reshaping it is possible to increase the surface gravity of a spherical ball by at most 2.6% !

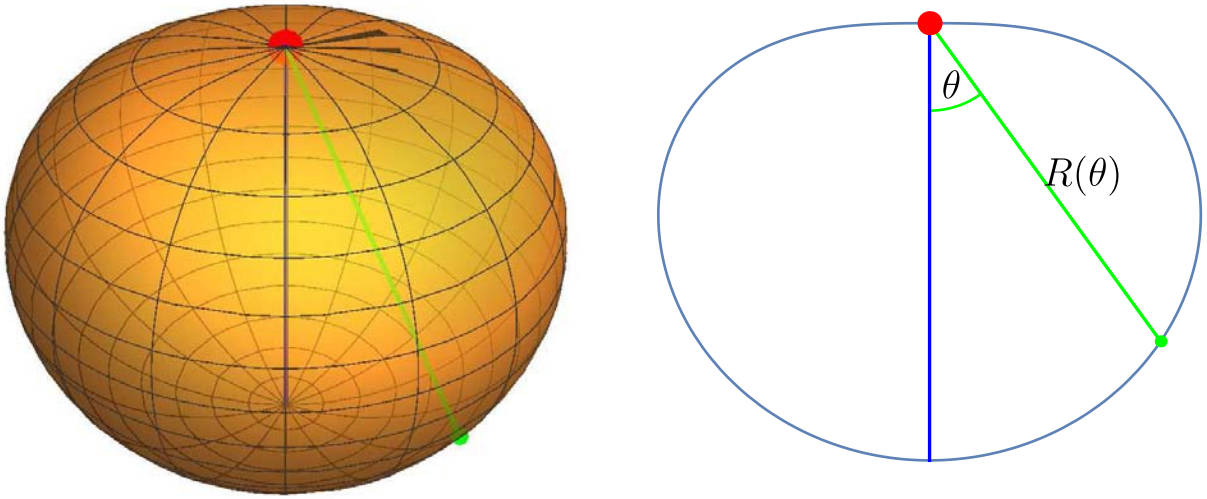


Figure 4 : Optimal asteroid surface $\partial\bar{B}$

IV. Other Shapes

Since the cylinder shape is already superior to the spherical one for maximizing surface gravity, it is interesting to explore a few other more or less regular bodies, to see how close they can get to the optimal value of $\frac{3}{5}\sqrt[3]{5}\approx 1.02599$. Let me discuss three cases which are fairly easy to parametrize in the cylindrical coordinates chosen.

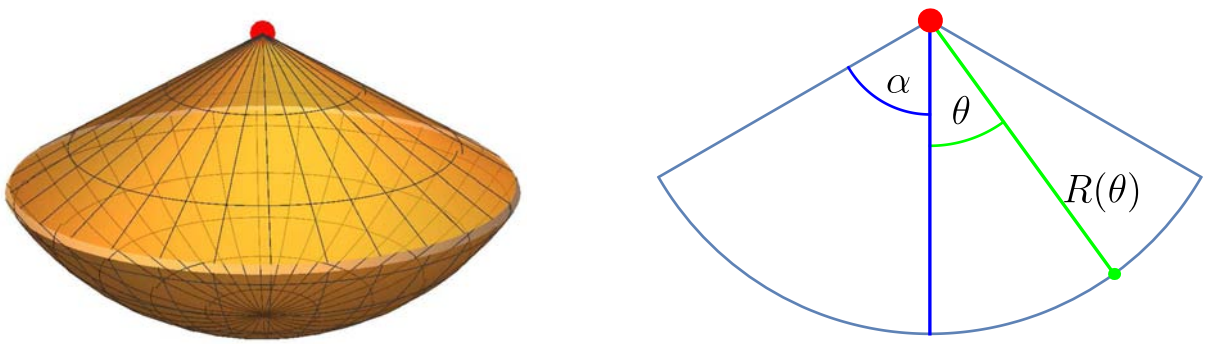


Figure 5 : Conical segment of a spherical ball

First, I consider a conical segment of a spherical ball centered in the origin, with opening angle $2\alpha < \pi$ and radius r_c, see Fig. 5. Here, one simply has

$$0 \leq \theta \leq \alpha \quad \text{and} \quad R_c(\theta) \;=\; r_c \;, \tag{4.1}$$

thus the surface gravity (3.5) reduces to

$$G_c \;=\; 2\pi\,\gamma\,\tfrac{M}{V}\int_{\cos\alpha}^{1} \mathrm{d}\cos\theta \int_0^{r_c} \mathrm{d}r\;\cos\theta \;=\; 2\pi\,\gamma\,\tfrac{M}{V}\,r_c\,\tfrac{1}{2}(1-\cos^2\alpha)\;. \tag{4.2}$$

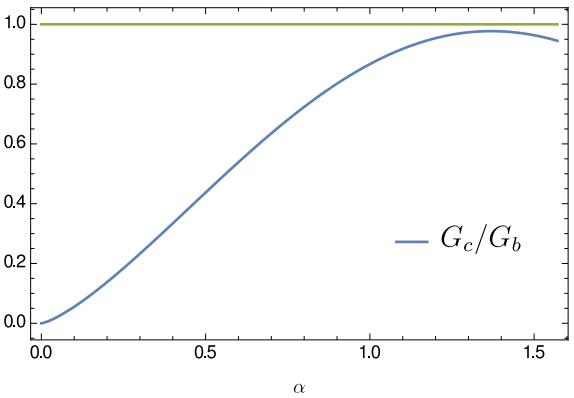


Figure 6 : Surface gravity on the apex of a conical segment of a spherical ball

Since at the same time,

$$M \;=\; 2\pi\,\tfrac{M}{V}\int_{\cos\alpha}^{1} \mathrm{d}\cos\theta \int_0^{r_c} r^2\mathrm{d}r \;=\; 2\pi\,\tfrac{M}{V}\,\tfrac{1}{3}r_c^3\,(1-\cos\alpha)\;, \tag{4.3}$$

one gets

$$G_c \;=\; \left(\tfrac{\sqrt{3}\pi}{\sqrt{2}}\right)^{2/3}\gamma\,M\,V^{-2/3}\,(1-\cos^2\alpha)\,(1-\cos\alpha)^{-1/3}\;, \tag{4.4}$$

leading to the curve in Fig. 6,

$$\frac{G_c}{G_b} \;=\; \tfrac{3}{4}\sqrt[3]{2}\,(1-\cos^2\alpha)\,(1-\cos\alpha)^{-1/3}\;. \tag{4.5}$$

The best opening angle occurs at an angle of about 78.5°,

$$\cos\alpha \;=\; \tfrac{1}{5} \;\approx\; 1.36944 \qquad \Rightarrow \qquad \left.\frac{G_c}{G_b}\right|_{\max} \;=\; 2^{2/3}\cdot 9\cdot 5^{-5/3} \;\approx\; 0.97719\;. \tag{4.6}$$

Clearly, the spherical ball beats any cone. The value $\alpha = \frac{\pi}{2}$ describes a semi-ball, which yields

$$\left.\frac{G_c}{G_b}\right|_{\alpha=\pi/2} \;=\; 2^{-8/3}\cdot 3 \;\approx\; 0.94494\;. \tag{4.7}$$

Second, let me try out the radius function $R(\theta)$ being an arbitrary power n of cos θ,

$$R_n(\theta) \;=\; 2\,r_n\,(\cos\theta)^n \qquad \text{with} \qquad n>0\;, \tag{4.8}$$

displayed in Fig. 7 for n=2. This produces

$$G_n \;=\; 2\pi\,\gamma\,\tfrac{M}{V}\,2r_n\int_0^1 \mathrm{d}\cos\theta\;(\cos\theta)^{n+1} \;=\; 2\pi\,\gamma\,\tfrac{M}{V}\,2r_n\,\tfrac{1}{n+2}\;. \tag{4.9}$$

The special value of $n=1$ yields a spherical ball, which separates squashed forms ($n<1$) from elongate ones ($n>1$). With

$$M \;=\; \tfrac{2\pi}{3}\,\tfrac{M}{V}\int_0^1 \mathrm{d}\cos\theta\,\left(2r_n\,(\cos\theta)^n\right)^3 \;=\; \tfrac{2\pi}{3}\,\tfrac{M}{V}\,(2r_n)^3\,\tfrac{1}{3n+1} \tag{4.10}$$

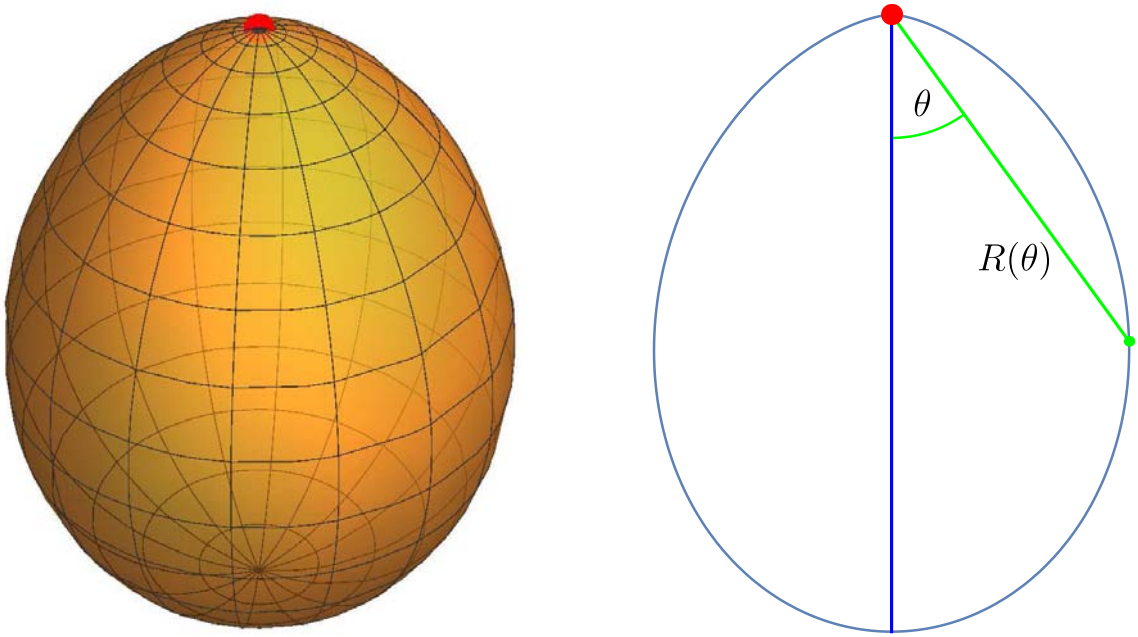


Figure 7 : Shape for radius function $R(\theta) \sim \cos^2\theta$

I can eliminate r_n and find

$$\frac{G_n}{G_b} \;=\; 3\left(\tfrac{1}{4}(3n+1)\right)^{1/3}\!/(n+2)\;, \tag{4.11}$$

which is shown in Fig. 8. This is indeed maximized for

$$n=\tfrac{1}{2} \qquad \Rightarrow \qquad \tfrac{G_{1/2}}{G_b} \;=\; 3\cdot 5^{-2/3}\;, \tag{4.12}$$

as was already found in (3.12) and (3.18). It exceeds unity in the interval $0.17424 \lesssim n < 1$.

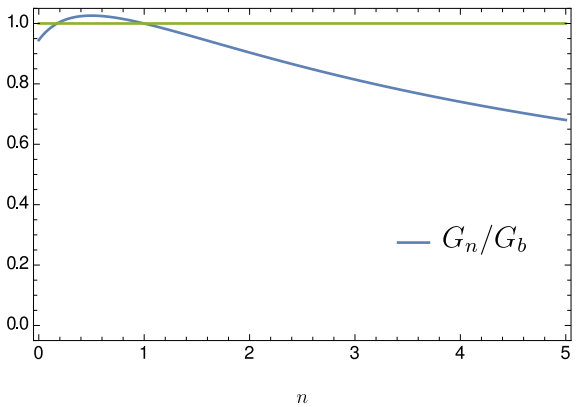


Figure 8 : Surface gravity on a body with radius function $R(\theta) \sim \cos^n\theta$

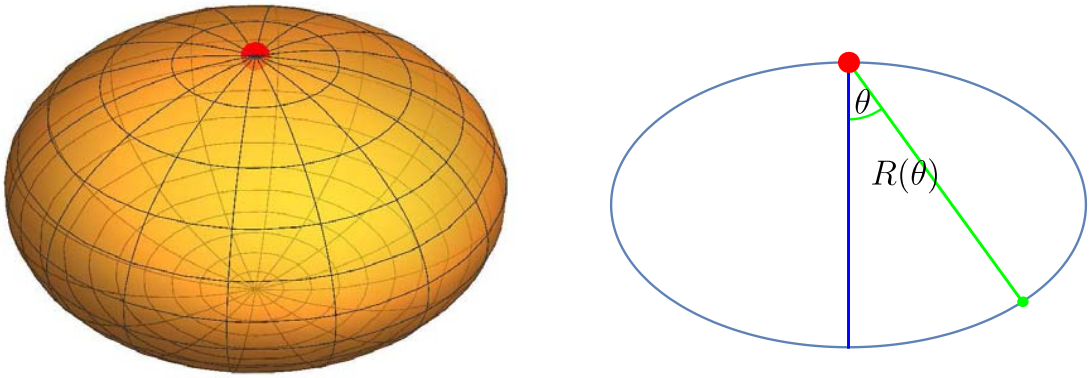


Figure 9 : Oblate ellipsoid with eccentricity $\epsilon = 0.8$

Third, I look at an oblate ellipsoid of revolution with minor semi-axis length r_e and eccentricity ϵ, see Fig. 9. In this case,

$$R_e(\theta) \;=\; \frac{2\,r_e\,\cos\theta}{1-\epsilon^2\sin^2\theta} \;=\; \frac{2\,r_e\,\cos\theta}{1-\epsilon^2+\epsilon^2\cos^2\theta} \qquad \text{with} \quad \epsilon\in[0,1)\;, \tag{4.13}$$

which includes the sphere for ϵ=0. (The prolate case corresponds to imaginary ϵ.) The surface gravity and mass integrals then become

$$G_e \;=\; 2\pi\,\gamma\,\tfrac{M}{V}\,2r_e\int_0^1 \mathrm{d}y\;\frac{y^2}{1-\epsilon^2+\epsilon^2y^2} \;=\; 2\pi\,\gamma\,\tfrac{M}{V}\,2r_e\,\frac{1}{\epsilon^2}\Big(1-\sqrt{\tfrac{1-\epsilon^2}{\epsilon^2}}\,\arctan\sqrt{\tfrac{\epsilon^2}{1-\epsilon^2}}\Big)\;, \tag{4.14}$$

$$M \;=\; \tfrac{2\pi}{3}\,\tfrac{M}{V}\,(2r_e)^3\int_0^1 \mathrm{d}y\;\frac{y^3}{(1-\epsilon^2+\epsilon^2y^2)^3} \;=\; \tfrac{2\pi}{3}\,\tfrac{M}{V}\,(2r_e)^3\,\frac{1}{4(1-\epsilon^2)}\;, \tag{4.15}$$

respectively. From this I conclude that

$$\frac{G_e}{G_b} \;=\; 3\,(1-\epsilon^2)^{1/3}\,\frac{1}{\epsilon^2}\Big(1-\sqrt{\tfrac{1-\epsilon^2}{\epsilon^2}}\,\arctan\sqrt{\tfrac{\epsilon^2}{1-\epsilon^2}}\Big)\;, \tag{4.16}$$

shown in Fig. 10. This is larger than one for $\epsilon \lesssim 0.85780$ and is maximized numerically at

$$\epsilon \approx 0.69446 \;\Rightarrow\; \frac{G_e}{G_b}\bigg|_{\max} \;\approx\; 1.02204\;. \tag{4.17}$$

Hence, I can come to within less than 0.4% of the optimal surface gravity by engineering an appropriate ellipsoid.

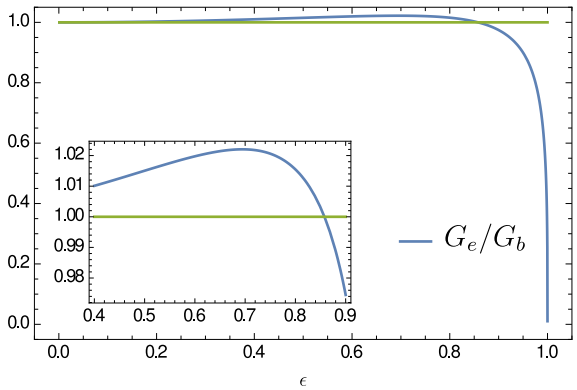


Figure 10 : Surface gravity on an ellipsoid with eccentricity ϵ

V. Conclusions

The main result of this short paper is a universal sixth-order planar curve,

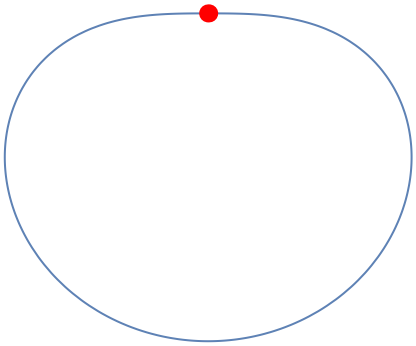
$$\mathcal{C}_{\rm Gh}: \quad (x^2+z^2)^3-(4\,z)^2 \;=\; 0 \qquad \Leftrightarrow \qquad r(\theta) \;=\; 2\sqrt{\cos\theta}\;, \tag{5.1}$$

which characterizes the shape of the homogeneous body admitting the maximal possible surface gravity in a given point, for unit mass density and volume. It is amusing to speculate about its use for asteroid engineering in an advanced civilization or our own future. This curve seems not yet to have occurred in the literature, and so I choose to name it "Gharemani curve" after my deceased friend who initiated the whole enterprise.

The maximally achievable weight on bodies of various shapes is listed in the following table. It occurs at the intersection of the rotational symmetry axis with the body's surface and is normalized to the value on the spherical ball.

shape	cone	ball	cylinder	ellipsoid	Gharemani
maximum of G/G_b	0.97719	1.00000	1.00682	1.02204	1.02599

It can pay off to get inspired by the curiosity of your non-scientist friends. The result is a lot of fun and may even lead to new science!



VI. Acknowledgments

I thank Michael Flohr for help with Mathematica and the integral (2.11).

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The Mass Spectrum of Elementary Particles in Unitary Quantum Theory and Standard Model

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Abstract- The particle is represented by the wave packet in nonlinear space-time continuum. Due of dispersion, the packet periodically appears and disappears in movement and the envelope of the process coincides with the wave function. It was considered that the partial differential equation of telegraph-type describes the motion of such wave packet in spherical coordinate space (r,θ,φ). Also the analytical solution $u(r,\theta,\varphi)$ of this equation was constructed and it was supposed that the integral over all space of $\left|\mathrm{grad}|u|^2\right|^2$ was equal to the mass of the particle identified with the wave packet. As the solution $u(r,\theta,\varphi)$ depends on two parameters L,m being positive integer, it is possible to calculate our theoretical particle masses M_{Lm} for different L,m. Thus, we have obtained the theoretical mass spectrum of elementary particles. In comparison with known experimental mass spectrum it shows that our calculated theoretical mass spectrum is sufficiently verisimilar. In this article we discuss the problems of standard SM-model, supersymmetry and string theory, compare the possibility to predict in UQT and SM and show that Standard Model has left unsettled a lot of fundamental problems solved by UQT.

Keywords: *unitary quantum theory, mass spectrum of elementary particles, standard model, wave packet, string theory, supersymmetry.*

GJSFR-A Classification : *FOR Code: 029999*

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Leo G. Sapogin [α] & Yu. A. Ryabov [σ]

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In fact we have now to distinguish "the substance" and "fields" although we can hope that future generation will overcome this dualistic interpretation and will replace it by general idea as Field theory of our days has been vainly trying to do.
Albert Einstein (back translation).

Keywords: unitary quantum theory, mass spectrum of elementary particles, standard model, wave packet, string theory, supersymmetry.

I. Introduction

In SM a particle is represented **as a point that is the source of a field, but cannot be reduced to the field itself** and nothing can be said about its "structure" except with these vague words. In the standard quantum theory, a micro particle is described with the help of a wave function with a probabilistic interpretation. This does not follow from the strict mathematical formalism of the nonrelativistic quantum theory, but is simply postulated. At the same time in UQT the probabilistic version of the wave function appears during the study of the process particle and macrodevice interaction.

This dualism is absolutely unsatisfactory as the two substances have been introduced, that is, both the points and the fields. The points are like the sources of a field, but they do not driven to the field. Presence of a both points and fields at the same time is not satisfactory from general philosophical positions - razors of Ockama. Besides that, the presence of the points leads to non-convergences, which are eliminated by various methods, including the introduction of a re-normalization group that is declined by many mathematicians and physicists.

We shall not criticize such normalized theories here; however, to quote P. A. M. Dirac*: *"…most physicists are completely satisfied with the existing situation. They consider relativistic quantum field theory and electrodynamics to be quite perfect theories and it is not necessary to be anxious about the situation. I should say that I do not like that at all, because according to such 'perfect' theory we have to neglect, without any reason, infinities that appear in the equations. It is just mathematical nonsense. Usually in mathematics the value can be rejected only in the case it were too small, but not because it is infinitely big and someone would like to get rid of it."*

Modern quantum field theory cannot even formulate the problem of a mass spectrum finding. The original idea of Schrödinger was to represent a particle as a wave packet of de Broglie waves. As he wrote in one of his letters, he "*was happy for three months*" before British mathematician Darwin showed that the packet quickly and steadily dissipates and disappears. So, it turns out that this beautiful and unique idea to represent a particle as a portion of a field is not realizable in the context of wave packets of de Broglie waves. It was proved [1] by V.E. Lyamov and L.G Sapogin in 1968 that every wave packet constructed from de Broglie waves with the spectrum $a(k)$ satisfying the condition of Viner-Pely (the condition for the existence of localized wave packets).

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$$\int_{-\infty}^{\infty} \frac{\left|\ln(a(k))\right|}{1+k^2} \geq 0$$

becomes blurred in every case. Later, de Broglie tried to save this idea by introducing nonlinearity for the rest of his life, but wasn't able to obtain significant results.

The trouble with the numerous previous field unification attempts was in trying to construct a particle model from classical de Broglie waves, whose dispersion is such that the wave packet becomes blurred and spreads out over the whole of space. The introduction of nonlinearity greatly complicated the task but did not lead to a proper solution of the problem.

II. Unitary Quantum Approach

There is a school in physics, going back to William Clifford, Albert Einstein, Erwin Schrödinger and Louis de Broglie, where a particle is represented as a cluster or packet of waves in a certain unified field. According to Max Jammer's classification, this is a "*unitary approach*". The essence of this paradigm is clearly expressed by Albert Einstein's own words:

"We could regard substance as those areas of space where a field is immense. From this point of view, a thrown stone is an area of immense field intensity moving at the stone's speed. In such new physics there would be no place for substance and field, since field would be the only reality . . . and the laws of movement would automatically ensue from the laws of field."

However, its realization appeared to be possible only in the context of the Unitary Quantum Theory (UQT) within last two decades. It is impressive, that the problem of mass spectrum has been reduced to exact analytical solution of a nonlinear integro-differential equation [2-8]. In UQT the quantization of particles on masses appears as a subtle consequence of a balance between dispersion and nonlinearity, and the particle represents something like a very small apple shape toroid, the contour of which is the density of energy.

The Unitary Quantum Theory (UQT) represents a particle as a bunched field (cluster) or a packet of partial waves with linear dispersion [4-11]. Dispersion is chosen in such a way that the wave packet would periodically disappear and appear in movement, and the envelope of the process would coincide with the wave function. Based on this idea, the relativistic-invariant model of such unitary quantum field theory was built.

The principal nonlinear relativistic invariant equation is following [4-7,15]:

$$i\lambda^{\mu}\frac{\partial\Phi}{\partial x^{\mu}} - \frac{c\Phi}{\hbar}\int\left(\bar{\Phi}\lambda_1 u^{\mu}\frac{\partial\Phi}{\partial x^{\mu}} - u^{\mu}\frac{\partial\bar{\Phi}}{\partial x^{\mu}}\lambda_1\Phi\right)\frac{dV}{\gamma} = 0, \qquad (1)$$

where $x^{\mu} = (ct, x)$,

$$u^{\mu} = \left(\frac{1}{\gamma}, \frac{v}{\gamma}\right)$$

is the four-velocity of the particle, matrices $\lambda^{\mu}(32\times 32)$ satisfy the commutation relations

$$\lambda^{\mu}\lambda^{\nu} + \lambda^{\nu}\lambda^{\mu} = 2g^{\mu\nu}I\,,\ \mu,\nu = 0,1,2,3,$$

and $g^{\mu\nu}$ is the metrical tensor. This fundamental equation of UQT describes, in our opinion, all properties of elementary particles and even of gravitation. It is possible to derive from (1) the Dirac equation and also the relativistic invariant Hamilton – Jacoby equation [4-7,12-14]. We have succeeded in solving only the simplified scalar variant of eq. (1). However, the obtained solution has allowed to determine theoretically the elementary electrical charge and the fine-structure constant α with high precision (our theoretical value $\alpha = 1/137.962$, the known experimental value $\alpha = 1/137.03552$). Probably the slight discrepancy between theory and experimental data are caused by screening of electric charge value by vacuum fluctuations [4-7, 11-14]. Our efforts to find more complete solution of eq.(1) were unsuccessful. Note, our approach based on Unitary Quantum Theory has nothing in common with Standard Model of Elementary Particles - SM.

Nevertheless, our idea to consider a particle as some moving wave packet which periodically disappears and appears in movement, has allowed to arrive to the conclusion [4-7,16] that such particle may be described by the common telegraph – type equation of second order. In one-dimension case this equation is following:

$$\frac{1}{v^2}\frac{\partial^2 F(x,t)}{\partial t^2} - \frac{\partial^2 F(x,t)}{\partial x^2} - \frac{2imc^2\sqrt{1-\frac{v^2}{c^2}}}{\hbar v^2}\frac{\partial F(x,t)}{\partial t} - \frac{m^2c^4}{\hbar^2 v^2}\left(1-\frac{v^2}{c^2}\right)F(x,t) = 0 \qquad (2)$$

Note, this equation would be relativistic invariant if the root $\sqrt{1-v^2/c^2}$ would be placed in denominator. Equation (2) is satisfied exactly by relativistic invariant solutions in the form of a standard planar quantum-mechanical wave and also in the form of disappearing and appearing wave-packet, viz.,

$$F(x,t)=\exp\left(\frac{i}{\hbar}\frac{mc^2t-mvx}{\sqrt{1-\frac{v^2}{c^2}}}\right) \tag{3}$$

or

$$F(x,t)=\exp\left(\frac{i}{\hbar}\frac{mc^2t-mvx}{\sqrt{1-\frac{v^2}{c^2}}}\right)\varphi(x-vt)\,, \tag{4}$$

where φ is an arbitrary scalar function of its argument $x-vt.$

At terms v<<c Schrodinger equation [5-7,16] can be easily obtained from equation (2), by replacement of velocity via energy and potential, while the exact equation (2) can be deduced from Maxwell equations, and that was done by Heaviside.

III. Calculation of the Spectrum of Possible Wave Packets using Telegraph-Type Equation

We imagine the wave packet, while spreading in a media with dispersion and nonlinearity, should not only appear and disappear at the length de Broglier wave, but also keep its individuality. So, we are looking for exact class of solution for nonlinear integro-differential equation. Nonlinearity in equation will appear after replacement of mass by integral over the total volume of solution gradient square.

We will show that eq. (2) (considered in the case of 3-dimension coordinate space (r,θ,φ)) allows, namely, to determine theoretically the mass spectrum of elementary particles. Such equation for the function $u=u(r,\theta,\varphi)$ is following:

$$\frac{1}{v^2}\frac{\partial^2u}{\partial t^2}-\frac{1}{r^2\sin\theta}\left(2r\sin\theta\frac{\partial u}{\partial r}+r^2\sin\theta\frac{\partial^2u}{\partial r^2}+\cos\theta\frac{\partial u}{\partial\theta}+\sin\theta\frac{\partial^2u}{\partial\theta^2}+\frac{1}{\sin\theta}\frac{\partial^2u}{\partial\varphi^2}\right)-\frac{2iMc^2\sqrt{1-\frac{v^2}{c^2}}}{v^2\hbar}\frac{\partial u}{\partial t}-$$

$$-\frac{M^2c^4}{v^2\hbar^2}(1-\frac{v^2}{c^2})u=0\,, \tag{5}$$

(the symbol *m* is replaced by *M*). We will use the natural system of units and put $\hbar=1,c=1$, and will seek the solution of eq. (5) in the following form:

$$u=\frac{f}{r}\exp\left(\frac{iMt}{\sqrt{1-v^2}}-\frac{iMvr}{\sqrt{1-v^2}}\right)\,, \tag{6}$$

where $f=f(r,\theta,\varphi)$ is some function not depending on t. This function represents as hardened wave packet in coordinate space $(r,\theta,\varphi).$ Substituting (6) in eq. (5), we get

$$2iMvr^2\cos^2\theta\frac{\partial f}{\partial r}-2iMvr^2\frac{\partial f}{\partial r}+r^2\sqrt{1-v^2}\frac{\partial^2f}{\partial r^2}\sin^2\theta+\sqrt{1-v^2}\frac{\partial^2f}{\partial\theta^2}\sin^2\theta+$$

$$+\sqrt{1-v^2}\left(\frac{\partial^2 f}{\partial\varphi^2}+\sin\theta\cos\theta\frac{\partial f}{\partial\theta}\right)=0. \tag{7}$$

We will seek the solution of eq. (7) in form:

$$f = R(r)Y_{Lm}(\theta,\varphi), \tag{8}$$

where

$$Y_{Lm}(\theta,\varphi)=\frac{\sqrt{(2L+1)(L-m)!}}{2\sqrt{\pi(L+m)!}}P_L^m(\cos\theta)\exp(\pm im\varphi), \tag{8`}$$

$P_L^m(\cos\theta)$ is the Legendre function, $Y_{Lm}(\theta,\varphi)$ is the spherical harmonic and L,m are nonnegative integers L=0,1,2,3,…, $m=0\pm1\pm2\pm3..$ besides $m\le L.$ Substituting (8) in eq. (7), we come to the following equation with respect to the function $R(r)$:

$$\left(\frac{d^2R(r)}{dr^2}r^2\sqrt{1-v^2}-2i\frac{dR(r)}{dr}Mvr^2\right)-R(r)L^2\sqrt{1-v^2}-R(r)L\sqrt{1-v^2}=0 \tag{9}$$

The solution $R(r)=R_L(r)$ of this equation depends on parameter L and we obtain the family of solutions $u_{Lm}(r,\theta,\varphi,t)$ of equation (5) depending on parameters $L,m.$ It is natural to suppose that every solution u_{Lm} of our equation (5) describes the amplitude of the partial world unitary potential Φ_{Lm} determined by partial wave packet and the potential itself is represented by the quadrate of amplitude modulus, i.e.

$$\Phi_{Lm}=|u_{Lm}|^2=\left|\frac{R_L(r)}{r}Y_{Lm}(\theta,\varphi)\right|^2. \tag{10}$$

Further, we consider the gradient of this potential as the tension of corresponding field (it is the custom in electrodynamics) of the partial wave packet and consider the quadrate of the tension as the density W_{Lm} of the energy or of the wave packet's mass distributed continuously in space. If we consider eq. (9) in some fixed spherical zone Q_r with radius r, where the corresponding part of our hardened wave packet is placed, then it is natural to consider $M=M_{Lm}$ as the mass of this part of the partial wave packet, i.e. as the integral of density W_{Lm} over given spherical zone. Such approach allows to replace the mass M in (9) by integral

$$M=\iiint_{Q_r}W_{Lm}r^2\sin(\theta)drd\theta d\varphi, \tag{11}$$

where $W_{Lm}=|\mathrm{grad}\,\Phi_{Lm}|^2.$ So, we will consider eq. (9) as the integro-differential equation with respect to the function $R(r)=R_L(r)$. For the sake of simplicity; we will use the following expression for M (after discarding the members which depend on θ,φ and omitting index L):

$$M=\int_0^r\left|\frac{d}{dr}\left(\frac{R(r)^2}{r^2}\right)\right|^2r^2dr. \tag{12}$$

We will use the following way to solve our integro-differential eq. (9). Viz., at first, we rewrite this equation in form

$$2ivM=\frac{1}{r^2R'(r)}(R''(r)r^2-L(L+1)R(r))\sqrt{1-v^2},\ \ (`=\frac{d}{dr}). \tag{13}$$

At second, we substitute integral (12) for M and differentiate left- and right-hand sides with respect to $r.$ We obtain

$$2iv\left[\frac{d}{dr}\left(\frac{R^2}{r^2}\right)\right]^2r^2=\frac{d}{dr}\left[\frac{1}{r^2R'}(R''r^2-L(L+1)R)\right]\sqrt{1-v^2}. \tag{13'}$$

At the third step, we set $v=0$ in (13'). The grounds are following. The solution of this equation depends on parameter v (the velocity of our particle). It is natural to suppose that the potential Φ describe processes which are continuous with respect to v (in any case, if v is less, than light velocity c), i.e. $\lim R(r,v)=R(r,v^*)$ if $v\to v^*$ and it is valid if $v^*=0.$ Besides, we want to determine the inner (proper) characteristic of our wave packet not depending on the velocity of its movement. We consider the mass of the wave packet as its inner (proper) characteristic not depending on the velocity of its movement. Now, suppose $v=0$ and after integration obtain the following differential equation for $R(r)$:

$$R''-\frac{L(L+1)}{r^2}R=CR',$$

where *C* is some constant. This equation possesses the analytical general solution:

$$R=C_1\exp(\frac{C}{2}r)\sqrt{r}\,\mathrm{J}(L+\frac{1}{2},\frac{1}{2}\sqrt{-C^2}r)+C_2\exp(\frac{C}{2}r)\sqrt{r}\,\mathrm{Y}(L+\frac{1}{2},\frac{1}{2}\sqrt{-C^2}r) \tag{14}$$

where C, C_1, C_2 arbitrary constants and J and Y are are the Bessel functions. Since we seek the finite solution R for $r\to 0, r\to\infty$ and tending to zero for, $r\to\infty$ we set $C_2=0$ and can set some positive value for C_1 and some negative value for the constant *C* in eq. (13). The calculations show the choice of these constants has influence only on the absolute value of the masses calculated below but the ratios of these masses remain the same. We have chosen the simplest values

$$C_1=1, C=-2$$

and have obtained following solution

$$R(r)=\sqrt{r}\exp(-r)\,\mathrm{J}(L+\frac{1}{2},ir)), \tag{15}$$

where $\mathrm{J}(L+\frac{1}{2},ir)$ is the Bessel function of the first kind with imaginary argument, or

$$R(r)=i^{L+\frac{1}{2}}\sqrt{r}\exp(-r)\mathrm{I}(L+\frac{1}{2},r), \tag{16}$$

where $\mathrm{I}(L+\frac{1}{2},r)$ is the modified Bessel function of the first kind.

Radial part of amplitude of world potential for any integral positive *L* is a complex value.

So, we obtain the following expression for the partial world unitary potential Φ_{Lm} (taking into consideration (6, 8, 8', 10) :

$$\Phi_{Lm}=\frac{e^{-2r}}{4\pi r}\left|\frac{(2L+1)(L-m)!\mathrm{I}(L+\frac{1}{2},r)^2\,\mathrm{P}_L^m(\cos\theta)^2}{(L+m)!}\right| \tag{17}$$

Now, we form $\mathrm{grad}\,\Phi_{Lm}$ considered as the tension of the world unitary field and form also the quadrate of its modulus considered as the mass density W_{Lm}. We obtain:

$$W_{Lm}=2e^{-4r}\left(\frac{(L-m)!^2\,\mathrm{I}(L+\frac{1}{2},r)^2\left((L+r+1)\,\mathrm{I}(L+\frac{1}{2},r)-r\,\mathrm{I}(L-\frac{1}{2},r)\right)^2\mathrm{P}_\mathrm{L}^\mathrm{m}(\cos\theta)^4(L+\frac{1}{2})^2}{\pi^2r^4(L+m)!^2}+\right.$$

$$\left.+\frac{(L+\frac{1}{2})^2\mathrm{I}(L+\frac{1}{2},r)^4(L-m)!^2\,\mathrm{P}_\mathrm{L}^\mathrm{m}(\cos\theta)^2\left((m-L-1)\,\mathrm{P}_{L+1}^\mathrm{m}(\cos\theta)+(L+1)\cos\theta\,\mathrm{P}_\mathrm{L}^\mathrm{m}(\cos\theta)\right)^2}{\pi^2r^4(L+m)!^2\sin^2\theta}\right) \tag{18}$$

The integrals of W_{Lm} overall spherical space (r,θ,φ) for different $L=0,1,2,...$ and $m=0,\pm1,\pm2,...,m\le L$ is equal to required different masses M_{Lm} of elementary particles, i.e.

$$M_{Lm} = \int_0^{\infty}\int_0^{\pi}\int_0^{2\pi} W_{Lm} r^2 \sin(\theta) dr d\theta d\varphi \tag{19}$$

Since W_{Lm} do not depend on φ and the Legendre functions in expressions of W_{Lm} may be integrated analytically, we calculated, at first, analytically (with help of *Mathematica-9*) the integrals

$$U_{Lm} = \int_0^{\pi} W r^2 \sin(\theta) d\theta \int_0^{2\pi} d\varphi = 2\pi \int_0^{\pi} W r^2 \sin(\theta) d\theta \tag{20}$$

and then calculated numerically (with the help of *Mathematica-9*) the integrals

$$M_{Lm} = \int_0^{\infty} U_{Lm} dr \tag{21}$$

For example, we have obtained for $L=0$ и $m=0$ (with help of *Mathematica*-9):

$$U_{00} = \frac{8e^{-4r}\sinh(r)^2}{\pi^3 r^4}\left\{(r^2+\frac{1}{2}+r)\cosh(r)^2 - r(1+r)\sinh(r)\cosh(r) - \frac{(1+r)^2}{2}\right\}$$

and

$$M_{00} = \int_0^{\infty} U_{00} dr = 0.003944364169$$

For $L=1, m=1$, we have obtained (with help of *Mathematica-9*)

$$U_{11} = \frac{8e^{-4r}}{\pi^3 r^8}\left[\left(r^6+5r^5+\frac{93}{8}r^4+13r^3+\frac{61}{4}r^2+2r+\frac{17}{8}\right)\cosh^4 r - \right.$$

$$- r\sinh r\cosh^3\left(r^5+5r^4+11r^3+\frac{33}{2}r^2+8r+\frac{17}{2}\right) -$$

$$- \cosh^2 r\left(\frac{1}{2}r^6+3r^5+10r^4+14r^3+\frac{71}{4}r^2+4r+\frac{17}{4}\right) +$$

$$\left. + r\sinh r\cosh r\left(r^4+3r^3+8r^2+8r+\frac{17}{2}\right)+\frac{1}{2}r^4+r^3+\frac{5}{2}r^2+2r+\frac{17}{8}\right]$$

and

$$M_{11} = 0.00006798678730.$$

The calculations for small values of L are sufficiently simple. But for large L, the quantities U_{Lm} are represented by long polynomials in r and $\cosh(r), \sinh(r)$ with enormous numerical coefficients and the integration of these polynomials meets serious technical difficulties. The same computations have been made with the help of *Maple-18* program, it's faster than *Mathematica-9* integrates with the respect to angle, but slower integrates in number with respect to radius. The results totally coincide. It's amazing but for the difficult non-linear integro-differential equation UQT managed to obtain the exact analytical solution. It can be considered as a gift of Fortune. The Standard Quantum Theory has only one similar gift – analytical solution for the atom of Hydrogen.

We consider the ensemble $L+1$ particles (masses) with given L and $m=0...\pm L$ to be one family and we will use the notations

$M_{L,0}, M_{L,1}, ..., M_{L,L}$ for particles (masses) of the family with given L. We have calculated and analyzed in full the masses of 49 families ($L = 0,...,48$), i.e. of 1225 particles. Our PC with $3GHz, RAM = 32GB$ has required for these calculations nearly 3 weeks of computing time.

We have compared our theoretical spectrum for 1225 masses with known experimental spectrum for elementary particles measured in *MeV*. The zero-point for the matching of both spectra was required. We have taken for such matching the quotient of the muon mass to the electron mass. As we know, this quotient for observed muons and electrons is measured straight experimentally [17] with the most precision and is equal 206.768283(10). Each our calculated mass was divided consecutively by all other 1224 masses and the resulting quotients were compared with the mentioned number. It turned out that the quotient of our masses $M_{16,10} / M_{48,45}$ is equal to 206.7607796 (with relative divergence 0.0039%) and we have taken our mass $M_{48,45}$ equal to $0.2894982442536304 \cdot 10^{-10}$ for zero-point, i.e. for our electron mass. Then we have divided all other 1224 masses $M_{L,m}$ by $M_{48,45}$ and we have obtained our theoretical spectrum in electron masses which may be compared (after expressing in *MeV*) with known experimental masses. Here is the table 1 with our masses M_{Lm} for 38 cases of the well coincidence with well known experimental values (relative errors are less than 1% in 35 cases and between 1.3% and 1.8% in three cases):

Among these calculated masses all of known leptons and quarks are presented. Note, the ratio of our proton mass $M_{12,1}$ and our electron mass $M_{48,45}$ is equal 1832.355 with relative error 0.207% in comparison with well known experimental ratio 1836.152167. Our calculated spectrum containing 169 masses from muon to the heaviest mass approximates also others well known particles and, although the coincidences with experimental data are worse but quite acceptable (with relative divergences not more than several per cent). The mass values for negative m coincides with the mass valued for positive m (antiparticles?).

We do not analyze mass spectrum for neutrino because of numerous experimental mistakes. On the whole, this table shows the striking coincidence of our theoretical values with essential quantity of the known experimental masses and, by no means, such coincidence may be called occasional. The probability of such occasional coincidence is less 10^{-60}. Note, the choice of the nominee for the electron's mass is not unique and may be further calculations of families with $L = 60....100$ would allow to obtain the better result. Our calculated theoretical spectrum contains also the values near to the masses of quarks. In UQT there is no firm belief that quarks exist at all and this question will be discussed further. The experimental data for quarks are not so precise and are determined in an indirect way. We give the separate table 2 with the calculated and experimental quark masses (*MeV*).

We have carried out also the series of calculation M_{Lm} for L exceeding 48 including $L = 60$. The ratio of maximal $M_{00} = 0.0039443641689$ to minimal $M_{60,60} = 0.3909395521 \cdot 10^{-11}$ is of order 10^9. The ratio of maximal M_{00} to the mass $M_{12,1} = 0.5304640719 \cdot 10^{-7}$ of proton is equal 74400. This number does not contradict the known the experimental data.

Note, the radial function $U_{Lm}(r)$ being the density mass as function of r, is equal zero always for r=0 and for all L, m, and, at first, increases very swiftly on the right from for r=0 and then very swiftly decreases. The plot of $U_{Lm}(r)$ reminds for large L quasi delta-function approaching to coordinates origin as L increases (very simplified analogy is shown on Fig.1.

All particles look like bubbles cut by spherical harmonic but button wall itself at other values of L and m has numerous oscillations. Curious, such model, namely, was considered by A. Poincare [18]. And that mass spectrum was very identical to experimental data. It was so because all components of tensor fields contributed to energy in the process of scalar equation solution and to get more precise details of the particles' structure the integro-differential equation (1) should be solved, but the authors failed to do it because the mathematical trick used earlier has not work more. The particles' masses decrease with the growth of L and m and in theory the foot of the spectrum is infinite and gradually after mass of electron approaches to the quasi-continuous vacuum fluctuations.

Certainly, we do not intend to assert that our results are adequate in full to the known experimental mass spectrum of elementary particles. The divergences are present. Our theoretical spectrum contains the large quantity (1053) of masses between electron mass and muon mass but such real particles have not been observed till now. Our spectrum contains many light particles $M_{L,m}(L > 48)$ with masses differing extremely little one from another. Somebody may suppose the existence of quasi-continuous distribution of lightest particles not affirmed till now by experiments. We suppose that this region of our calculated spectrum contains also the values corresponding to masses of all 6 neutrinos, and it will be

possible to discover their theoretical masses after sufficiently precise experimental determination of their masses.

Our spectrum contains 169 particles from the muon to the heaviest particle $M_{0,0}$ but we can see the large quantity of particles in this interval with short "life-time" (so called "resonances") of order 10^{-22} sec. These divergences require the further researches. With respect to light particles, it may be supposed the existence of some selection principles (not discovered till now theoretically) for such particles and these principles lead to essential decreasing of particles quantity between muons and electrons. We suppose that such principles arise theoretically from some relations between the tensors of different valences (ranks) and spherical functions for different *L, m* and leave this complicate problem for future researches. May be these light particles constitute the "dark energy".

Now arise the question with respect to the particles with short "life-time": how about to take all these particles for elementary? Our Unitary Quantum Theory allows formulating the following criterion: **If the way which the particle (which we identify with appearing and disappearing wave packet) passes from the moment of its appearing to the moment of its destruction is much longer than de Broglie wave, then such particle may be called elementary.** Have we reason to call "elementary" the particle with life-time of order 10^{-22} sec ?

IV. Calculation of Spectrums of Possible Wave Packets for Schrödinger and Klein-Gordon Equations

Let us point to following essential circumstance. Viz., if we will use the Schrödinger equation in spherical coordinates (relativistic-noninvariant) or Klein—Gordon equation (relativistic-invariant) instead our initial equation (5), then we will come to the same theoretical mass spectrum. Really, the above mentioned Schrödinger equation is following:

$$\frac{\hbar^2}{2}\frac{\left(2r\sin\theta\frac{\partial u}{\partial r}+r^2\sin\theta\frac{\partial^2 u}{\partial r^2}+\cos\theta\frac{\partial u}{\partial\theta}+\sin\theta\frac{\partial^2 u}{\partial\theta^2}+\frac{1}{\sin\theta}\frac{\partial^2 u}{\partial\varphi^2}\right)}{Mr^2\sin\theta}+i\hbar\frac{\partial u}{\partial t}=0\,, \tag{22}$$

where *M* is the particle's mass. We will seek the solution of this equation in form of unitary wave packet f :

$$u=\frac{f}{r}\exp(-i\frac{Mv^2}{2\hbar}t+i\frac{Mv}{\hbar}r) \tag{23}$$

where $f=f(r,\theta,\varphi)$ is the function of coordinates and does not depend on the time. The function u is considered as the amplitude of the world unitary potential Φ. Substituting (23) in (22), we obtain (after simplification) the following equation

$$\hbar r^2\sin^2\theta\frac{\partial^2 f}{\partial r^2}-2iMvr^2\sin^2\theta\frac{\partial f}{\partial r}+\frac{\hbar}{2}\sin 2\theta\frac{\partial f}{\partial\theta}+\hbar\sin^2\theta\frac{\partial^2 f}{\partial\theta^2}+\hbar\frac{\partial^2 f}{\partial\varphi^2}=0\,. \tag{24}$$

This equation coincides with our equation (7) if we put $\sqrt{1-v^2}$ instead $\hbar$. The further study described above remains unchanged.

Let us consider Klein—Gordon equation in spherical coordinates and in natural units system $c=1$, $\hbar=1$

$$\frac{\left(2r\sin\theta\frac{\partial u}{\partial r}+r^2\sin\theta\frac{\partial^2 u}{\partial r^2}+\cos\theta\frac{\partial u}{\partial\theta}+\sin\theta\frac{\partial^2 u}{\partial\theta^2}+\frac{1}{\sin\theta}\frac{\partial^2 u}{\partial\varphi^2}\right)}{r^2\sin\theta}-\frac{\partial^2 u}{\partial t^2}-M^2u=0\,, \tag{25}$$

where *M* is the particle's mass. We will seek the solution

$$u=\frac{f}{r}\exp\left(\frac{iMt}{\sqrt{1-v^2}}-\frac{iMvr}{\sqrt{1-v^2}}\right)\,, \tag{26}$$

where $f=f(r,\theta,\varphi)$ is the function of coordinates not depending explicitly on *t*. Substituting (26) in (25), we obtain following equation after simplification:

$$r^2\sin^2\theta\sqrt{1-v^2}\frac{\partial^2 f}{\partial r^2}-2ivr^2M\sin^2\theta\frac{\partial f}{\partial r}+\sin^2\theta\sqrt{1-v^2}\frac{\partial^2 f}{\partial\theta^2}+\sqrt{1-v^2}\frac{\partial^2 f}{\partial\varphi^2}+\frac{\sqrt{1-v^2}}{2}\sin 2\theta\frac{\partial f}{\partial\theta}=0 \qquad (27)$$

This equation coincides in full with our equation (7) and we will come to the same results.

So, different initial equations (5), (22), (25) (the last is relativistic invariant and the other two are relativistic non-invariant) lead to the same theoretical mass spectrum. Note the following remarkable fact: the standard theory allowed to detect spectra by using always the quantum equations with outer potential and as corollaries to geometric relations between de Broglie wave length and characteristic dimension of potential function. **The quantum equation of our theory does not contain the outer potential and describes a particle in empty free space; the mass quantization arises owing to the delicate balance of dispersion and non-linearity which provides the stability of some wave packets number.** It is the first case when spectra are detected by using the quantum equations without outer potential.

Here is the table 1 with all our theoretical masses from the muon to the heaviest $M_{0,0}$ (MeV). We should note that data from Table 3 was calculated in 2007 [2,3,6-8] and remained unchanged, and Higgs boson and three pentaquarks were insert in the table 1 after their discovery. We should also note that both elementary electric charge and mass spectrum appear in the result of complex space geometry, while time in UQT becomes Newtonian again.

In view of all above-mentioned we, nevertheless, make bold to say that our results represent the substantial advancement on the way of solution for the extremely complicated theoretical problem of the mass spectrum for elementary particles and to underline that this advancement is owing to our Unitary Quantum Theory. We hope that further analysis with the help of exact equation (1) of our theory will allow to obtain more precise results.

We would like to propose the name "**Dzhan—particle**"- 69.62274 TeV for our heaviest particle $M_{0,0}$ in honor of the kosmonaut V.A. Dzhanibekov, general of RF Air Force. As we know, particles with mass of such order are observed in cosmic rays.

The UQT allows to explain both "dark matter" and "dark energy". The heaviest **Dzhan-particle** should be neutral and pure scalar. As the result it will poorly react with the surrounding particles also due to minimum quantum numbers, and probably this state will be filled as much as possible and is responsible for existence of "dark matter". At the same time numerous light particles with masses less than electron may create vacuum fluctuations with negative pressure – "dark energy".

V. Standard Model, Supersymmetry and Strings

Conventional quantum theory has concepts of the field dualism and the matter, where particle is considered as s point – a source of a field, but UQT was the first to presented it as a field. There is a concept of a standard model (SM) of particle physics, it is often called by mass media as *"theory of nearly everything"*. This modern theory of structure and interaction of elementary particles repeatedly confirmed by experiments allows to predict the properties of different processes of scattering and transformation in the world of elementary particles. Physicists working in the frame of this model stipulate that all their predictions are experimentally confirmed. But this perfect (for lack of something better) model cannot predict even the masses of elementary particles. For example, both Higgs boson mass and recently opened pentaquarks has not been predicted, SM had only rough estimation of the orders of their values, that is why the SM cannot be considered as a final theory of elementary particles.

According to Einstein words used as epigraph to this article the next theory should decrease the number of matters, but SM builds the matter from 12 fundamental "bricks" – six grades of leptons and six grades of quarks. The number of possible combinations made from these bricks is limited, therefore SM leaves no space for the great number of weakly interacting particles that make up 95 % of the University general mass. In addition SM left in deep rear some fundamental quantum questions like corpuscular-wave dualism and uniform explanations of numerous phenomena of chemical catalysis [5-7, 23, 24]. In UQT quantum entanglement of photon and quantum teleportation does not arise as a problem at all [7]. In UQT the possibility to consider the interaction between entangled particles for data communication (seriously discussed by modern science) does not occur at all and even Einstein called this "*interaction illusory*".

Now UQT explains the existents of the low energy nuclear reactions, of other exceptional phenomena and the possibility to create new sources of energy, for example E-cat Andrea Rossi [5-7]. Appearance of quarks with charges of 2/3 and 1/3 is a striking example of a beautiful mathematical fairy tale. As far quarks had not been found it was stipulated aiming the rescue of SM that quarks could not been extracted from "quark bag" in general, even the origin of this "bag" was mysterious also. From UQT point of view the possibility of arising of the particles with charges of 2/3 and 1/3 is beyond understanding because nothing

except π and e in calculation of fine-structure constant are used.

To our regret today this theory cannot compute correctly the masses of elementary particles including the mass of "Higgs boson". More worse that SM contains from 20 to 60 adjust in arbitrary! - parameters (there are different versions of SM). SM does not have theoretically proved algorithm for spectrum mass computation and no ideas how to do it! All these bear strong resemblance to the situation with Ptolemaic models of Solar system before appearance of Kepler`s laws and Newton s mechanics. These earth-centered models of the planets movement in Solar system had required at first introduction of so called epicycles specially selected for the coordination of theoretical forecasts and observations. Its description of planets positions was quite good; but later to increase the forecasts accuracy it had required another bunch of additional epicycles. Good mathematicians know that epicycles are in fact analogues of Fourier coefficients in moment decomposition in accordance with Kepler`s laws; so by adding epicycles the accuracy of the Ptolemaic model can be increased too. However that does not mean that the Ptolemaic model is adequately describing the reality. Quite the contrary... More over SM does not take into account in the computations the gravity and it's beyond the understanding how it can be used at all.

One of the main unsolved problems of SM remains the impossibility to compute the fine-structure constant value $\alpha =$ 1/137 (non-dimensional electric charge in system $\hbar = 1$, c=1). The value $\alpha =$ 1/137 is dimensionless and each extraterrestrial civilization with the highly developed level of science will know tree great constants π, e, α. In UQT it was computed for the first time [7,12-14]. This result is very important. There are some opinions:

"The mystery about α is actually a double mystery. The first mystery – the origin of its numerical value $\alpha \approx$ 1/137 has been recognized and discussed for decades. The second mystery –the range of its domain – is generally unrecognized." —M. H. MacGregor (2007). The Power of Alpha. World Scientific.

"If alpha were bigger than it really is, we should not be able to distinguish matter from ether and our task to disentangle the natural laws would be hopelessly difficult. The fact however that alpha has just its value 1/137 is certainly no chance but itself a law of nature. It is clear that the explanation of this number must be the central problem of natural philosophy". — Max Born, A.I. Miller (2009). Deciphering the Cosmic Number: The Strange Friendship of Wolfgang Pauli and Carl Jung. W. W. Norton & Co.

"*There is a most profound and beautiful question associated with the observed coupling constant, e – the amplitude for a real electron to emit or absorb a real photon. It is a simple number that has been experimentally determined to be close to 0.08542455. (My physicist friends won't recognize this number, because they like to remember it as the inverse of its square: about 137.03597 with about an uncertainty of about 2 in the last decimal place. It has been a mystery ever since it was discovered more than fifty years ago, and all good theoretical physicists put this number up on their wall and worry about it.) Immediately you would like to know where this number for a coupling comes from: is it related to π or perhaps to the base of natural logarithms? Nobody knows. It's one of the greatest damn mysteries of physics: a magic number that comes to us with no understanding by man. You might say the "hand of God" wrote that number, and "we don't know how He pushed his pencil." We know what kind of a dance to do experimentally to measure this number very accurately, but we don't know what kind of dance to do on the computer to make this number come out, without putting it in secretly!*" Richard P. Feynman (1985). "QED: The Strange Theory of Light and Matter", p. 129.

The researches of supersymmetry and strings exist by themselves and look like next beautiful mathematical fairy tales without any experimental confirmation. More over the modern science is based on special and general theory of relativity and relativistic conception of space-time, the UQT has a lot of complaints to [19-22]. In UQT the relativistic correlations between impulse and energy is strictly maintained but the reason of their appearance is absolutely different. The time is Newtonian again, and with the change of gravitational potential (equivalently to acceleration effect) the speeds of all processes change too, at the same time the lines reduction is absent at all [19-22]. The authors realize in full the panic their investigations can create among scientists working in the field of high energy physics. And of course the position of modern science is quite evident: to keep the financing of future projects the UQT should not be noticed at all.

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Table 1 (*MeV*)

$M_{L,m}$	Theory	Experiment	Notation	Error %
$M_{48,45}$	0.51099906	0.51099906	e	--
$M_{16,10}$	105.6545640	105.658387	μ	0.0036
$M_{18,4}$	135.8958708	134.9739	π^0	0.683
$M_{23,0}$	137.2902541	139.5675	π^+, π^-	1.62
$M_{14,1}$	541.7587460	548.86	η	1.29
$M_{7,7}$	894.0806293	891.8	K^{*+}, K^{*0}	0.25
$M_{12,1}$	936.3325942	938.2723	p	0.206
$M_{10,4}$	957.1290490	957.2	ω	0.0083
$M_{9,5}$	1110.473414	1115.63	Λ	0.462
$M_{8,6}$	1224.151552	1233	b_1^0	0.71
$M_{11,1}$	1271.916682	1270	K^*	0.14
$M_{9,4}$	1331.705434	1321.32	Ξ^-	0.78
$M_{10,2}$	1378,127355	1382.8	$\sum^0$	0.33
$M_{12,0}$	1524.617683	1522± 3	θ^+barion	0.29
$M_{8,5}$	1549.444919	1540 ± 5	F_1	0.28
$M_{7,6}$	1595.510637	1594	ω_1	0.094
$M_{9,3}$	1601.282953	1600	ρ'	0.08
$M_{6,6}$	1718.917400	1720	N_0^3	0.06
$M_{10,1}$	1774.917815	1774	K_3^{*+}	0.051
$M_{8,4}$	1906.842877	1905	Δ_5^+	0.096
$M_{9,2}$	1965.115639	1950	Δ_4	0.77
$M_{11,0}$	2092.497779	2100	Λ_4	0.35
$M_{7.5}$	2195.695293	2190	N(2190)	0.25
$M_{7,4}$	2818.645188	2820	η_c	0.048
$M_{10,0}$	2954.549810	2980	η	0.85
$M_{6,5}$	3082.979571	3096	J/ψ	0.42
$M_{7,3}$	3543.664516	3556.3	χ	0.35
$M_{5,5}$	3687.679612	3686.0	ψ'	0.04
$M_{9,0}$	4315.87	4380±86	pentaquark	
$M_{7,2}$	4436.65	4449.8±19	pentaquark	
$M_{7,2}$	4496.650298	4415	ψ'''	1.84
$M_{6,4}$	5642.230394	5629.6	Ξ_b	0.8
$M_{5,3}$	9499.927309	9460.32	Υ`	0.41
$M_{6,1}$	10075.78271	10023.3	Υ``	0.523
$M_{7,0}$	10533.15222	10580	Υ```	0.442
$M_{2,2}$	131517.11	125000-140000	Higgs	
$M_{0,0}$	6962274	?	Dzhan	?

(e – electron, μ - muon, π^0 - π -meson, p – proton etc.)

Таблица 2. (*MeV*)

$M_{L,m}$	Theory	Experiment	Notation
$M_{13,3}$	4.722547634	4,79±0,07	down
$M_{30,25}$	2.75072130	1.5-3.0	up
$M_{20,4}$	94.4251568	95 ± 25	strange
$M_{11,1}$	1271.9166	1250 ± 90	charm
$M_{6,4}$	4300.86662	4200 ± 70	beaty
$M_{3,0}$	179100	174 200 ± 3300	truth

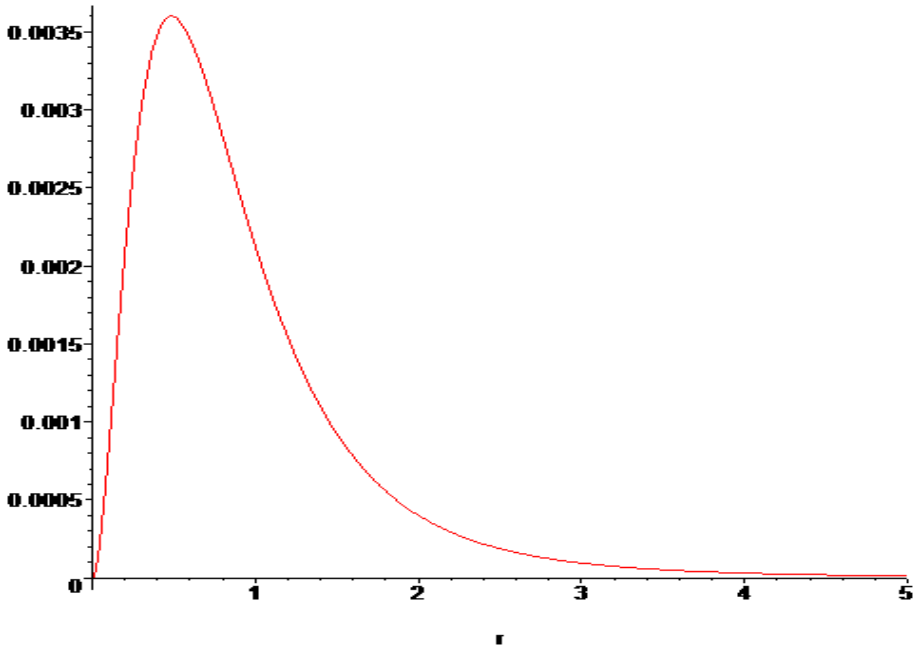

Fig.1 : The plot for $U_{00}(r)$

Table 3 (*MeV*)

105.655, 105.94, 106.241, 108.291, 108.997, 109.597, 110.133, 112.784, 117.054, 118.136, 120.31, 121.826, 122.664, 125.522, 125.71, 127.187, 127.237, 127.306, 131.445, 133.013, 135.896, 137.29, 142.287, 144.326, 145.96, 147.309, 147.698, 149.62, 149.905, 153.765, 153.827, 159.796, 162.135, 162.192, 165.33, 172.249, 177.091, 178.559, 178.758, 180.585, 180.895, 187.69, 192.661, 192.917, 195.832, 199.852, 203.297, 205.588, 209.097, 218.681, 219.639, 221.135, 224.061, 225.089, 231.432, 231.656, 241.805, 249.092, 252.972, 253.184, 269.993, 270.91, 276.443, 280.151, 281.016, 289.488, 300.299, 301.848, 304.024, 314.364, 318.997, 335.848, 339.955, 341.136, 342.52, 349.235, 357.381, 366.838, 373.402, 402.126, 408.316, 423.36, 423.429, 432.83, 445.413, 459.388, 461.593, 472.253, 504.945, 521.772, 529.951, 531.566, 539.326, 541.759, 560.236, 571.51, 606.559, 619.012, 672.537, 686.757, 705.247, 705.477, 730.141, 738.98, 812.354, 828.374, 866.997, 894.081, 897.982, 915.038, 936.333, 957.129, 996.316, 1110.47, 1135.57, 1137.9, 1224.15, 1271.92, 1331.71, 1378.13, 1524.62, 1549.43, 1595.51, 1601.28, 1718.92, 1774.92, 1906.84, 1965.1, 2092.5, 2195.7, 2334.9, 2557.69, 2818.65, 2906.6, 2954.55, 3082.98, 3543.66, 3687.68, 3832.21, 4300.87, 4315.87, 4496.65, 5642.23, 6026.01, 6570.85, 6666.64, 7358.75, 9219.36, 9499.93, 10075.8, 10533.2, 12941.1, 16897., 18035.6, 18261.3, 25000.7, 28935.4, 33698.9, 36955.4, 54518.8, 71060.4, 87704.5, 131517., 179100., 266419., 601983., 1.20005e6 3.4545e6, 6.96227e7.

UQT - Table of the Mass Spectrum of Elementary Particles

MeV	$M_{L,m}$	MeV	$M_{L,m}$	MeV	$M_{L,m}$	MeV	$M_{L,m}$	MeV	$M_{L,m}$	MeV	$M_{L,m}$
0.51099906 electron	48,45 e	2.751 up	30,25	4.722 down	13,3	94.425 strange	20,4	105.655 μ	16,10	105.94	-
106.241	-	108.291	-	108.997	-	109.597	-	110.133	-	112.784	-
117.054	-	118.136	-	120.31	-	121.826	-	122.664	-	125.522	-
125.71	-	127.187	-	127.237	-	127.306	-	131.445	-	133.013	-
135.896 π^0	18,4	137.29 $\pi^+\pi^-$	23,0	142.287	-	144.326	-	145.96	-	147.309	-
147.698	-	149.62	-	149.905	-	153.765	-	153.827	-	159.796	-
162.135	-	162.192	-	165.33	-	172.249	-	177.091	-	178.559	-
178.758	-	180.585	-	180.895	-	187.69	-	192.661	-	192.917	-
195.832	-	199.852	-	203.297	-	205.588	-	209.097	-	218.681	-
219.639	-	221.135	-	224.061	-	225.089	-	231.432	-	231.656	-
241.805	-	249.092	-	252.972	-	253.184	-	269.993	-	270.91	-
276.443	-	280.151	-	281.016	-	289.488	-	300.299	-	301.848	-
304.024	-	314.364	-	318.997	-	335.848	-	339.955	-	341.136	-
342.52	-	349.235	-	357.381	-	366.838	-	373.402	-	402.126	-
408.316	-	423.36	-	423.429	-	432.83	-	445.413	-	459.388	-
461.593	-	472.253	-	504.945	-	521.772	-	529.951	-	531.566	-
539.326	-	541.759 η	14,1	560.236	-	571.51	-	606.559	-	619.012	-
672.537	-	686.757	-	705.247	-	705.477	-	730.141	-	738.98	-
812.354	-	828.374	-	866.997	-	894.081 K^{*+}, K^{*0}	7.7	897.982	-	915.038	-
936.333 p	12,1	957.129 ω	10,4	996.316	-	1110.47 Λ	9,5	1135.57	-	1137.9	-
1224.15 b_1^0	8,6	1271.92 sharm K^*	11,1	1331.71 Ξ^-	9,4	1378.13 Σ^0	10,2	1524.62 barion	12,0	1549.43 F_1	8,5
1595.51 ω_1	7,6	1601.28 ρ'	9,3	1718.92 N_0^3	6,6	1774.92 K_3^{*+}	10,1	1906.84 Δ_5^+	8,4	1965.1 Δ_4	9,2
2092.5 Λ_4	11,0	2195.7 N(2190)	7,5	2334.9	-	2557.69	-	2818.65 η_c	7,4	2906.6	-
2954.55 η	10,0	3082.98 J/ψ	6,5	3543.66 χ	7,3	3687.68 ψ'	5,5	3832.21	-	4300.87 beauty	6,4
4315.87 pentaquark	9,0	4436.65 pentaquark	7,2	4496.65 ψ'''	7,2	5642.23 Ξ_b	6,4	6026.01	-	6570.85	-
6666.64	-	7358.75	-	9219.36	-	9499.93 Υ'	5,3	10075.8 Υ''	6,1	10533.2 Υ'''	7,0
12941.1	-	16897	-	18035.6	-	18261.3	-	25000.7	-	28935.4	-
33698.9	-	36955.4	-	54518.8	-	71060.4	-	87704.5	-	131517 Higgs	2,2
179100 truth	3,0	266419	-	601983	-	1.20005e6	-	3.4545e6	-	6.96227e7 Dzhan	0,0

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Enhancement of Infrared Images using Nonlinear Model

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Abstract- This paper presents a new enhancement approach for infrared images. The idea behind this technique is based on that modifies the local luminance mean of an image and controls the local contrast as a function of the local Luminance mean of the image. The algorithm first separates an image into LPF (low pass filtered) and HPF (high pass filtered) components. The LPF component then controls the amplitude of the HPF component to increase the local contrast. The LPF component is then subjected to a non linearity to modify the local luminance mean of the image and is combined with the processed HPF component. Finally, this approach is enhanced to get an infrared image with better visual details.

Keywords: *nonlinear enhancement model, the proposed enhancement approach and entropy.*

GJSFR-A Classification : *FOR Code: 020199*

Strictly as per the compliance and regulations of :

Enhancement of Infrared Images using Nonlinear Model

H. I. Ashiba [α], H. M. Mansour [σ], M. F. El-Kordy [ρ] & H. M. Ahmed [ω]

Abstract- This paper presents a new enhancement approach for infrared images. The idea behind this technique is based on that modifies the local luminance mean of an image and controls the local contrast as a function of the local Luminance mean of the image. The algorithm first separates an image into LPF (low pass filtered) and HPF (high pass filtered) components. The LPF component then controls the amplitude of the HPF component to increase the local contrast. The LPF component is then subjected to a non linearity to modify the local luminance mean of the image and is combined with the processed HPF component. Finally, this approach is enhanced to get an infrared image with better visual details.

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I. Introduction

Image enhancement is a very popular field in image processing. Enhancement aims at improving the visual quality of an image by reinforcing edges and smoothing flat areas. Several researchers have evaded this field using different approaches such as simple filtering, adaptive filtering, waveletdenoising, homomorphic enhancement and etc, [1-4]. All these approaches concentrate on reinforcing the details of the image to be enhanced.

IR vision is a key technology in a variety of military and civilian applications ranging from night vision to environmental monitoring and biomedical diagnostics devices. Military applications include target acquisition, surveillance, night vision, homing and tracking. Non-military uses include thermal efficiency analysis, remote temperature sensing, short-range wireless communications, spectroscopy, and weather forecasting. IR astronomy uses sensor-equipped telescopes to penetrate dusty regions of space, such as molecular clouds to detect cool objects such as planets, of the and to view highly red-shifted objects from the early days universe[5-8].

They can operate also on infrared images, it is desirable to modify the local contrast and local luminance mean. For example, when an image with a large dynamic range is recorded on a medium with a smaller dynamic range, the details of the image in the very high and/or low luminance regions cannot be well represented. One approach to such a problem is a simultaneous contrast enhancement and dynamic range reduction that can be accomplished by modification of the local contrast and the local luminance mean. In this paper, we develop this model that modifies the local contrast and the local luminance mean in a specific method, and uses it in a lot of application problems.

The rest of the paper is organized as follows : section II explains nonlinear enhancement model . Section III presents the proposed enhancement algorithm. Section IV surveys the entropy. Section V gives the experimental results. Finally, section VI gives the concluding remarks.

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II. Nonlinear Enhancement Model

An image can be used represented as addition of two components as following equation [4, 9] :

$$f(n1,n2)=f_L(n1,n2)+f_H(n1,n2) \quad (1)$$

$f(n1,n2)$ is original infrared image, $f_L(n1,n2)$is local luminance mean,$f_H(n1,n2)$ is local contrast.

To enhancing the image, then, is to increase$f_H(n1,n2)$and decrease $f_L(n1,n2)$. the local luminance mean is modified by a nonlinearity resulted $f'_L(n1,n2)$ and local contrast is modified by multiplication factor $k\,(f_L)$resulted $f'_H(n1,n2)$. The specific functional form of $k\,(f_L)$ depends on the particular application under consideration, and $k\,(f_L)>1$represents the local contrast increase while $k\,(f_L)<1$ representslocal contrast decrease. This modification used as follow takes a larger $k\,(f_L)$and choose the nonlinearity taking into account $f_L(n1,n2)$change and $f_H(n1,n2)$ increase. This approach modifies the local contrast and the local luminance mean in a specific method as shown in Figure1. The results are combined to obtain the enhanced infrared image, $g(n1,n2)$ with more details as in the following equation [9]:

$$g(n1,n2)=f'_L(n1,n2)+f'_H(n1,n2) \quad (2)$$

III. The Proposed Enhancement Approach

In this approach, modifies the local contrast and the local luminance mean in a specific method to reinforce its details. These steps of the proposed

approach can be summarized as follows and are depicted in Fig. (1).

1. Apply the low pass filtering to the original infrared image, $f(n1,n2)$ to getthe local luminance mean $f_L(n1,n2)$.
2. Performa subtraction anoperation $f_L(n1,n2)$ from $f(n1,n2)$to get the local contrast $f_H(n1,n2)$.
3. Modify $f_H(n1,n2)$ by multiplying $f_H(n1,n2)$ with a scalar factor$k(f_L)$, $f'_H(n1,n2)$.
4. Modify $f_L(n1,n2)$ by non linearity function, $f'Ln1,n2$.
5. Combine the modified local contrast and local luminance mean to get the enhanced infrared image$g(n1,n2)$.

IV. Entropy

Entropy is a measure of the average amount of information content of an image. For an 8-bit gray-scale image, the maximum entropy is 8. The entropy of the processed image is defined as follows [10].

$$E = \sum_{i=0}^{255} -p_i \log_2(p_i) \qquad (3)$$

Where p_i is the probability occurrence of pixel in the image having intensity '*i*'. Suppose the number of pixels having intensity '*i*' is n_i and the image contains $n$pixels$p_i = {}^{n_i}/_{n}$. The larger the number of levels in an image, the higher is the entropy.

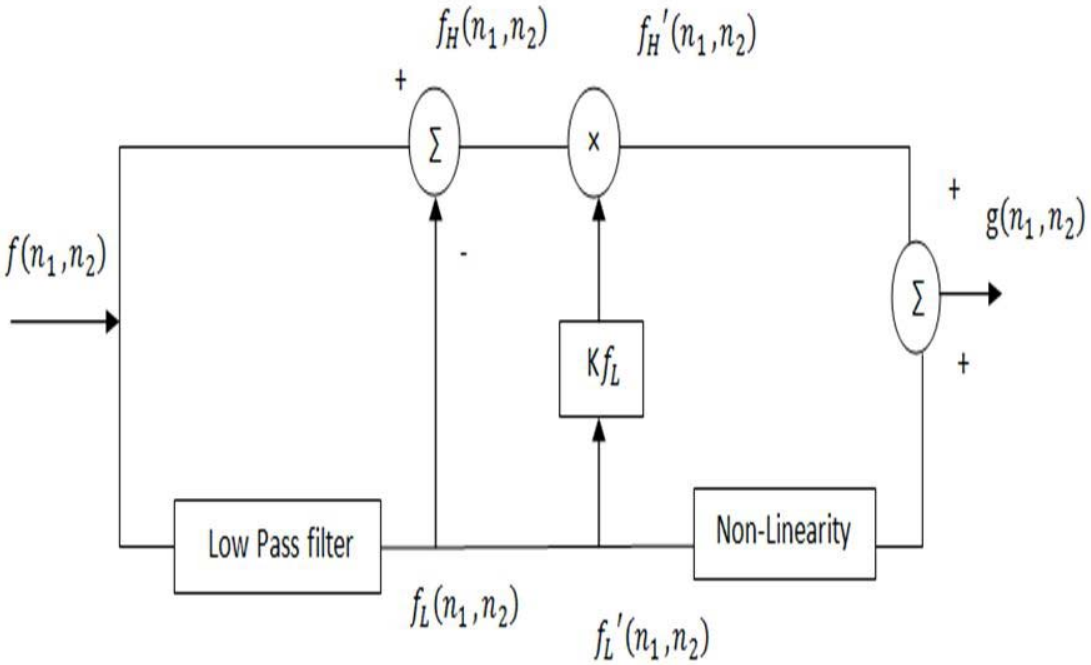


Fig. 1 : Steps of proposed algorithm

V. Experimental Results

In this section, two experiments are performed on two different infrared images to test the performance of the proposed enhancement algorithm. The steps of the algorithm mentioned in section (IV) are performed on these two images. For the purpose of evaluation metric for image quality is the entropy of the image. We use the entropy of the image of both the original infrared image and the enhanced one as an assistance tool with the visual evaluation. The results of the first experiment are shown in Fig. (2).

Part (a) gives the original infrared image of gives the entropy of the original image before processing and Part (b) of the same figure gives the enhanced infrared image.We remark that the entropy of the original infrared image is 1.4605and the entropy of enhanced infrared image is 2.8655.it's clear the entropy of enhanced infrared image is larger than the entropy of the original infrared image.

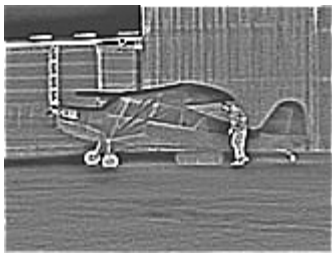
A similar experiment is carried out on another infrared image and the results are given in Fig. (3).From these results, due to the darkness of IR images, it is expected that their entropy will be small and entropy of enhanced image increased with a maximum of 8 bits. The proposed algorithm has enhanced the visual quality of the processed image as well as it's entropy metric.It's shown that this technique has succeeded in the enhancement of the visual quality of that infrared image and more details have been obtained.

(a)Original IR image
E= 1.4605

(a) Enhanced IR image
E= = 2.8655

Fig. (2) : Results of the first experiment

(a)Original IR image
E= 1.4753



(b) Enhanced IR image
E= = 2.8949

Fig. (3) : Results of the second experiment

VI. Conclusion

The paper presents a new approach for infrared image enhancement .This approach modifies the local luminance mean of an image and controls the local contrast as a function of the local luminance mean of the image. This feature of the algorithm is useful in a variety of application problem. For typical infrared images, it is often desirable for visual purposes to increase the local contrast. The results obtained using this algorithm reveals its ability to enhance infrared images.

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Single-Electron Double-Slit Experiment and Semi-Closed Friedman Model of Binary Black Hole Emitting Gravitational Wave

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Abstract- Previous time-symmetric but non-relativistic interpretation of the single-electron double-slit experiment, visualizing the particle-wave dual nature of the electron, is extended to a relativistic interpretation of the singular nature of the electron as a quantum anomaly occurring at Compton scale distances (ultraviolet regions) from the point particle source and the detection point, violating time-symmetry and local causality. The lensing action of the double-slit is next compared to the lensing action of galaxy cluster or black hole in the foreground of a distant extragalactic light source and extended to a semi-closed Friedman model of the recently observed binary back hole emitting a trangent gravitational wave signal. Historical comments are given on the early philosophical notion of the reality of the intermediate states between source and detector.

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GJSFR-A Classification : *FOR Code: 020109*

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Abstract- Previous time-symmetric but non-relativistic interpretation of the single-electron double-slit experiment, visualizing the particle-wave dual nature of the electron, is extended to a relativistic interpretation of the singular nature of the electron as a quantum anomaly occurring at Compton scale distances (ultraviolet regions) from the point particle source and the detection point, violating time-symmetry and local causality. The lensing action of the double-slit is next compared to the lensing action of galaxy cluster or black hole in the foreground of a distant extragalactic light source and extended to a semi-closed Friedman model of the recently observed binary back hole emitting a trangent gravitational wave signal. Historical comments are given on the early philosophical notion of the reality of the intermediate states between source and detector.

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I. Introduction

Since the advent of quantum mechanics in the mid-1920s, there have been recurring interpretational controversies surrounding the standard (time-asymmetric) theory seeking a physical reality in (a Newtonian) causal descriptive order of world processes in an open-ended time. With the development of precise measurements in quantum optics and electronics, semi-and super-conductors and so on, the past decades have seen a growing awareness of time-symmetric approaches [1]-[10] to quantum mechanics, seeking physical reality in (Aristotelian) causation-retrocausation symmetry of elementary quantum processes in closed time intervals. We here extend the previous time-symmetric interpetation of the particle-wave dual nature of the electron [10] to a relativistic interpetation of the the singular nature of the electron as a quantum anomaly in double-slit interference experiment said to contain "the only mystery of quantum mechanics."[9].

II. Intermediate Amplitude of Transition

In the third edition of his book Dirac [2] related the scalar product <initial|final> of initial and final state vectors to the probability amplitude, so that the transition between two quantum states can be visualized in two-dimensional space spanned by two Hilbert space vectors. We here consider a visualization [10] of the particle transition in configuration space between two space-time points, particle source S at (x_0, t_0) and detection point D at $(x_1, t_1 > t)$ by plotting the 2-dimensional image of the (x, t) dependence of the absolute value of the complex valued intermediate amplitude of transition $|<x_0, t_0 \mid x, t><\mathbf{x}, t \mid x_1, t_1>|$ between S and D. From the known retarded and advanced wave solutions of Schrödinger equation:

$$[i\partial/\partial ct + \partial^2/\partial^2 x - (mc/\hbar)^2] < x_1, t_1 \mid x, t > = 0 \qquad (1)$$

for a free electron of mass m:

$$<x_0, t_0 \mid x, t>$$
$$= [m/2i\pi\hbar(t-t_0)]^{3/2} \exp[-im(x-x_0)^2/2\hbar(t- t_0)],$$
$$<x_1, t_1 \mid x, t>$$
$$= [m/2i\pi\hbar(t_1-t)]^{3/2} \exp[im(x_1- x)^2/2\hbar(t_1-t)], \qquad (2)$$

we get

$$< x_0, t_0 \mid x, t><\mathbf{x}, t \mid x_1, t_1>$$
$$= [m/2\pi\hbar\tau]^3 \exp[-im\,(x- z(t))^2/2\hbar\tau]. \qquad (3)$$

Here

$$t(t) = (t_1 - t)(t - t_0)/(t_1-t_0) \qquad (4)$$

is the bi-directional 'local time' of a counter-propagating electron waves increasing from t = 0 at S and D towards $t = (t_1 + t_0)/2$ at an intermediate point $x = (x_0 + x_1)/2$ where the wavelike nature of the electron is maximally enhanced and the doubl-slit is placed in an ideal experiment; $z(t) = v\,(t - t_0) + x_0$ is the classical path and $v(x, t) = (x - x_0)/(t - t_0)$ the particle velocity. Eq.(3) shows that the mean square deviation $(x - z)^2$ of x from z is of the order of the de Broglie wavelength $\hbar/mv$. The bi-directional wave was considerd by Schrödinger [1] in his early attempt to evade the collapse of his wave function at D.

III. Visualizaion of Particle-Wave Duality

Fig.1 shows the video-record of a serial arrival of independent 1, 8. 1600, 8000, electrons

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forming an interference pattern on the detector screen. [11]

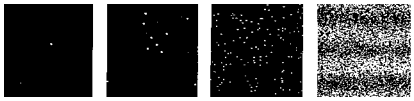


Fig.1 : Accumulation of single electrons on the detector sce

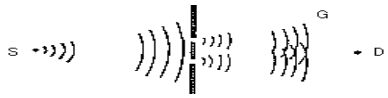
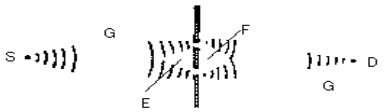


Fig.2 : Expanding wave front G of the retarded wave $<x_0, t_0 \mid x, t>$

Fig.2 shows an expanding wave front of retarded wave $< x_0, t_0 \mid x, t >$ from S, Fig. 3 is an image of the time-symmetric wave $< x_0, t_0 \mid x, t >< \mathbf{x}, t \mid x_1, t_1 >$ standing between S and D, showing an advanced bifurcation, merging and contraction of the retarded wave $< x_0, t_0 \mid x, t >$ towards D, as if guided by the advanced wave $< \mathbf{x}, t \, x_1, t_1 >$ from D, in accordance with Feynman's sum over classical paths construction of the quantum mechanical path between S and D.



Fihg.3 : Time-symmetric wave $< x_0, t_0 \mid x, t >< \mathbf{x}, t \mid x_1, t_1 >$ standing between S and D, showing the particle-wave dual nature of bifurcation and merging of the single electron

Points like E in the shadow of the advanced wave $< x, t \mid x_1, t_1 >$ from D in front of the slit are causally disconneted to D, while points like F in the shadow of the retarded wave $< x_0, t_0 \mid x, t >$ on the rear side of the slit is causally disconnected from S. Points like G are causally and retrocausally unrelated to both S and D, so that the electron wave does not expand beyond these points, as is proved by placing a tiny obstacle at G. By confining a magnetic flux within a slender tube standing perpendicular to the plane of the paper in E and F, the quantized shift of the interference pattern (Aharonov-Bohm effect) was observed by Tonomura and Nori.[12]

Fig.3 also shows the nonlocal EPR (Einstein-Podolsky-Rosen) correlation between bifurcated electron waves as verified by the delayed-choice experiment with one of the two slits equipped with a time-dependent switch which is generally closed but opens after the electron has left the source.

IV. Quantum Teleportation

We note that the wave $< x_0, t_0 \mid x, t >< \mathbf{x}, t \mid x_1, t_1 >$ takes a dumbbell shape in the single-slit experiment. The observed quantum entanglement of spatially separated two states of an electron introduced into a dumbbell shaped silicon cavity [13] could be understood in terms of the electron wave standing between fixed end points. A quantum teleportation of entangled pair of photons could likewise be understood as a W-shaped swapping of the V-shaped EPR pairs in the presence of a spacelike array of deep Coulomb potentials.[14]

V. Ultraviolet Anomaly in Double-Slit Experiment

To see the singular behavior of the electron as a quantum anomaly [15] in leaving the source $S(x_0, t_0)$ and entering the detector $D(x_1, t_1)$ in the double-slit experiment, we extend the Schrödinger equation in relatvistic Klein-Gordon form:

$$[\partial^2/\partial^2 ct - \partial^2/\partial^2 x - (mc/\hbar)^2] < x_0, t_0 \mid x, t > = 0 \qquad (4)$$

and consider the retarded wave solution:

$$< x_0, t_0 \mid x, t > = -(1/4\pi)\delta(s^2)$$

$$+ \; [mc/8\pi\hbar s)]^{3/2} H^{(2)}(mcs/2\hbar). \qquad (5)$$

where $s = [c^2(t-t_0)^2 - (x-x_0)^2]^{1/2}$ is the 4-dimensional distance between S and its neighboring point P(x, t); $H^{(2)}$ is the Hankel function of the second kind.

For $s^2 = 0$ (on the future light cone of S) we have a delta-singularity:

$$< x_0, t_0 \mid x, t > = (1/4\pi)\delta(s^2). \qquad (6)$$

For $s^2 >> 0$ (inside the future light cone of S) we get Schrödinger's wave function in its asymptotic form:

$$< x_0, t_0 \mid x, t > \sim (\lambda/s)^{3/2} \exp(-is/\lambda)$$

$$\rightarrow [\lambda/c(t-t_0)]^{3/2} \exp[-i(t-t_0)/\lambda], \qquad (7)$$

where $\lambda = \hbar/mc$ is the Compton electron wave length. For $s^2 << 0$ (outside the future light cone of S) we have $s = -i|s|$ and find

$$< x_0, t_0 \mid x, t >$$

$$\sim [\lambda/(x-x_0)]^{3/2} \exp(-(x-x_0)/\lambda). \qquad (8)$$

For $s^2 << 0$ (outside the past light cone of D) we have likewise

$$< x, t \mid x_1 - x >$$

$$\sim [\lambda/(x_1-x)]^{3/2} \exp(-(x_1-x)/\lambda) \qquad (9)$$

between D and its neighboring point Q(x, t).

Eqs.(8), (9) show the nonlocal and superluminal connections between S, D and P, Q separated by Compton scale spacelike distances, developing anomal ultraviolet regions [16] outside the future and the past light cones of S, D accumulating delta-singularities on the light cones in early and late stages of the expanding and contracting electron wave, recalling the accumulation of Planck scale black holes outside the event horizons in the inflationary epochs of expanding and contracting semiclosed Friedman model universe.[17],[18]

VI. Gravitational Lensing

Tonomura observed an intereference pattern (Fig.1) in his double-slit experiment using the electron-biprism for lensing action of the double-slit. Recent astronomical observations [19] showed characteristic interference images formed by the lensing action [20] of galaxy cluster or black hole in the foreground of an extragalactic light source using a Hubble telescope. There a double quasistellar objects is interpreted as the images of one and the same quasar, produced by the lensing action of intervening galaxy and a cluster of galaxies. Wheeler [21] proposed to extend a delyed-choice double-slit γ-ray experiment from the laboratory scale of meters to the cosmological scale of billions of light years.

VII. Gravitational Wave from Binary Black Hole

On February 11, 2016 [22] LIGO announced the detection of a trangent gravitational wave signal from a binary black holes at 1.3 billions light years from Earth. The black holes have 29 and 36 solar masses spiralling towards each other until they lose orbital energy, collide and merge into a single spinning black hole having 3 solar masses less than initial 65 solar masses. The 3 solar masses equivalent of energy is emitted as a trangent gravitational wave observed by twin LIGO detectors on September 14, 2015, sweeping upwards in frequency and strength in characteristic faint rising tone, streching the L-shaped arms of the laser interferometer from 4 km to one part in 10^{22}.

VIII. Semiclosed Friedman Model of Binary Black Hole

Friedman universe filled with uniform distribution of dust-like matter having constant density ρ_m is characterized by the density parameter $\Omega_m = \rho_m/\rho_c$, where ρ_c is the critical density for the universe to be closed, so that $\Omega_m = 0$ for empty space and $\Omega_m = 1$ for black hole.

In his seminal paper in 1918 [23] Einstein showed that the dumbbell-lik system rotating about two axes, such as binary stars and supernovas can make wave in space. LIGO image of computer simulations seem to indicate that the binary black hole has evolved from a pair of semiclosed Friedman black holes with $0.5 > \Omega_m > 0$ to a dumbbell shaped pair of black holes spiralling towards each other before merging into an almost closed spinning black hole. Recently updated density parameters [24] are: $\Omega_{atom} = 0.049$ for evolutionarily recent atomic matter, $\Omega_m = 0.266$ for nonrelativistic matter (luminous and dark) and $\Omega_\Lambda = 0.685$ for evolutionarily earlier dark energy of inflationary origin,[24] so that

$$\Omega_{tot} = \Omega_{atom} + \Omega_m + \Omega_\Lambda = 0.965. \quad (10)$$

We note that the observed density parameter $\Omega_m = 0.266$ falls into the range $0.5 > \Omega_m > 1$ in the semiclosed Friedman model.

IX. Historical Comments

At the Tokyo Symposium [21] Wheeler allegorized the single electron in the double-slit experiment as a “smoky dragon” with its mouth biting the detector, leaving its tail at the particle source. The body of the dragon is smoky with double-connected and delayed-choice space time structure, so that nothing can be asked for before measurement.

A similar notion found in Nagarjuna (150-250) in his Middle Way doctrine [25] was translated from Tibetan text into English, restated in today's (quantum physicist's) words as: If, a cause (initial state) having ceased, the effect (final state) were a complete (unitary) transformation of the cause. Then the previously arisen cause would arise again: Reality (of intermediate state) is neither non-existent (virtual) in spacetime, nor permanent (trangent), while Fermat-Huygens exrtremum principle for a photon passing through double- and multi-layered media was known to Helon (100-200) [26]

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Erratum

In ref.[18] the loop integral, $\oint$, is missing in eq.2 defining magnetic monopoles.

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2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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