Online ISSN: 2249-4626
Print ISSN: 0975-5896

GLOBAL JOURNAL OF SCIENCE FRONTIER RESEARCH: A

Physics and Space Science

Highlights

SK Box Manoeuvres

Optimization Control SK Box

Uhf Wave Propagation

Oscillating Theory of The Universe

Discovering Thoughts, Inventing Future

VOLUME 15 ISSUE 7 VERSION 1.0

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Global Journal of Science Frontier Research: A
Physics & Space Science

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Physics & Space Science

Volume 15 Issue 7 (Ver. 1.0)

Open Association of Research Society

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Contents of the Issue

Global Journal of Science Frontier Research: A
Physics and Space Science
Volume 15 Issue 7 Version 1.0 Year 2015
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Presentation of Strong Candidates for Dark Matter

By Koshun Suto
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Abstract- This paper presents atoms and molecules incorporating hydrogen at ultra-low energy levels as a strong candidate for Dark Matter. The existence of electrons at these energy levels can be demonstrated by changing the interpretation of triplet production. The radius of this undiscovered hydrogen atom is extremely small. The radius is about 1.331×10^{-5} the radius of an ordinary hydrogen atom in the 1s state. If many of these atoms or molecules are collected together, a state with extremely high density will be realized. This paper predicts that, in addition to such hydrogen, diverse types of atoms and various types of molecules comprised of diverse types of atoms, can also be candidates for Dark Matter.

Keywords: *dark matter, dark hydrogen, ultra-low energy levels, triplet production, einstein's energy-momentum relationship, proton radius.*

GJSFR-A Classification : *PACS code: 95.35.+d, 31.10.+z, 31.30.jc, 42.50.Xa*

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Presentation of Strong Candidates for Dark Matter

Koshun Suto

Abstract- This paper presents atoms and molecules incorporating hydrogen at ultra-low energy levels as a strong candidate for Dark Matter. The existence of electrons at these energy levels can be demonstrated by changing the interpretation of triplet production. The radius of this undiscovered hydrogen atom is extremely small. The radius is about 1.331×10^{-5} the radius of an ordinary hydrogen atom in the 1s state. If many of these atoms or molecules are collected together, a state with extremely high density will be realized. This paper predicts that, in addition to such hydrogen, diverse types of atoms and various types of molecules comprised of diverse types of atoms, can also be candidates for Dark Matter.

Keywords: dark matter, dark hydrogen, ultra-low energy levels, triplet production, einstein's energy-momentum relationship, proton radius.

I. Introduction

It is well-known that the existence of Dark Matter (DM) was first pointed out by F. Zwicky in 1933.[1] Zwicky was investigating the dispersion velocity of galaxies in the Coma Cluster, but that velocity was so large that it could not be explained with classical mechanics. Therefore, Zwicky posited the existence of an unknown form of matter to explain the reason for that velocity.

Furthermore, in the latter half of the 1970s, it was discovered that DM also exists in galaxies, and since then it has been revealed by a variety of observations. As a result, the existence of DM is supported by many scientists today. This unknown form of matter is thought to have the following characteristics:

(1) It is widely present in galactic systems.
(2) It is electrically neutral.
(3) It has considerable mass.
(4) It cannot be observed optically (it does not emit light).
(5) It exhibits almost no interaction with matter.
(6) It moves at a speed far slower than light.

DM candidates can be roughly divided into two types: elementary particle candidates and astrophysical candidates. The leading elementary particle candidate is a Weakly Interacting Massive Particle (WIMP).

The Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU) has investigated the distribution of DM using observation data for 50 galactic clusters photographed with the Subaru Telescope. As a result, they announced that the results agreed with a theory called Cold Dark Matter (CDM).[2]

In addition, a new theory was announced this year which posits another force dominating the world of the extremely small, and the existence of a Strongly Interacting Massive Particle (SIMP).[3]

At present, the CDM scenario is thought to have the advantage, but the fact that the candidate particle has not been discovered is regarded as a weak point.

Matter with the six characteristics given above does not exist among the elementary particles we currently know of.

The simplest model assumes one type of particle is involved in DM. However, since the 1990s various experiments have attempted to directly detect WIMPs, but no definitive signs suggesting the existence of WIMPs have been found. Therefore, some scientists have doubts about the current theory, and have begun to also consider models of DM comprised of multiple particles.[4,5]

This paper believes that DM does not necessary have to be elementary particle. Last year, the author published a paper predicting the existence of hydrogen atoms at ultra-low energy levels.[6] This paper examines whether such hydrogen atoms can be candidates for DM.

Prior to that, Sec. II explains the equations which are the departure point when deriving the equation for the ultra-low energy levels of the hydrogen atom. Sec. III actually derives the unknown energy levels from those equations. Sec. IV presents the experimental grounding demonstrating the existence of those energy levels.

II. Equation Serving as the Basis for Deriving Ultra-Low Energy Levels of the Hydrogen Atom

One of the most important relationships in the special theory of relativity is as follows:

$$\left(mc^2\right)^2 = \boldsymbol{p}^2c^2 + \left(m_0c^2\right)^2. \tag{1}$$

Here, m_0c^2 is the rest mass energy of an object or a particle, and mc^2 is the relativistic energy. Eq. (1) can also be applied to the electron, but in that case it becomes as follows:

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$$\left(mc^2\right)^2 = \boldsymbol{p}^2c^2 + \left(m_e c^2\right)^2. \tag{2}$$

Here, $m_e c^2$ is the rest mass energy of an electron.

However, since Eq. (2) does not include the potential energy of the electron, this equation cannot be applied to the electron in the hydrogen atom.

Incidentally, in the classical quantum theory of Bohr, the energy eigenvalues of the hydrogen atom can be expressed with the following equation:

$$E_{B,n} = -\frac{1}{2}\left(\frac{1}{4\pi\varepsilon_0}\right)^2 \frac{m_e e^4}{\hbar^2}\frac{1}{n^2} = -\frac{\alpha^2 m_e c^2}{2n^2}, \qquad n = 1, 2, \cdots. \tag{3}$$

Here, the B in E_B indicates the equation derived by Bohr. In this case, the total mechanical energy of the electron has a negative value.

However, according to quantum mechanics, the energy eigenvalues of a hydrogen atom as obtained from the Dirac relativistic wave equation are as follows.[7]

$$E = m_e c^2\left[1 - \frac{\gamma^2}{2n^2} - \frac{\gamma^4}{2n^4}\left(\frac{n}{|k|} - \frac{3}{4}\right)\right]. \tag{4}$$

γ matches with the fine structure constant α. That is:

$$\alpha = \frac{e^2}{4\pi\varepsilon_0 \hbar c} = 7.2974\times 10^{-3}. \tag{5}$$

If we ignore for the third term of this equation, Eq. (4) can be written as follows.

$$E_{D,n} = m_e c^2 - \frac{1}{2}\left(\frac{1}{4\pi\varepsilon_0}\right)^2 \frac{m_e e^4}{\hbar^2}\frac{1}{n^2} \tag{6a}$$

$$= m_e c^2 + E_n. \tag{6b}$$

Here, the D in E_D indicates the equation derived by Dirac. $E_{D,n}$ of Eq. (6) expresses the remaining amount of rest mass energy of the electron. Even if we place an electron at rest an infinite distance from its nucleus, the relativistic energy of the electron is not zero.

Taking these facts into account, the relativistic energy $E_{re,n}$ of the electron is defined as follows.[8]

$$E_{re,n} = m_e c^2 + E_n, \qquad n = 1, 2, \cdots. \tag{7}$$

Also, the author has derived an energy-momentum relationship applicable to the electron in a hydrogen atom by referring to the reasoning Einstein used when deriving Eq. (2).[8] That is,

$$E_{re,n}^2 + \boldsymbol{p}_n^2 c^2 = \left(m_e c^2\right)^2. \tag{8}$$

In addition, Eq. (8) was verified in that paper.

III. Derivation of Ultra-Low Energy Levels of the Hydrogen Atom

Dirac showed that the energy in Eq. (2) has the following positive and negative values.[9]

$$E = \pm c\left(m_e^2 c^2 + p^2\right)^{1/2}. \tag{9}$$

Here, the following inequality holds for the negative energy.

$$E < -m_e c^2. \tag{10}$$

If Eq. (8) is solved by following Dirac, the following solution is obtained.

$$E_{re,n} = \pm c\left(m_e^2 c^2 - p_n^2\right)^{1/2}. \tag{11}$$

The range of values that can be assumed by $E_{re,n}$, obtained from this equation, is as follows.

$$m_e c^2 > E_{re,n} > -m_e c^2. \tag{12}$$

For this reason, it is theoretically possible for an energy level satisfying the condition $0 \geq E_{re,n} > -m_e c^2$ to exist.

Incidentally, according to the virial theorem, the following relation holds between K and V:

$$\langle K \rangle = -\frac{1}{2}\langle V \rangle. \tag{13}$$

Here, K is the kinetic energy of the entire system, and V is the potential energy of the entire system.

The average time of K is equal to $-1/2$ the time average of V. Also, the sum of the time average K and the time average of the total mechanical energy E of the entire system becomes 0. That is,

$$\langle K \rangle + \langle E \rangle = 0. \tag{14}$$

Next, if Eqs. (13) and (14) are combined, the result is as follows:

$$\langle E \rangle = -\langle K \rangle = \frac{1}{2}\langle V \rangle. \tag{15}$$

Taking these facts into account, the author presented the following equation as an equation indicating the relationship between the rest mass energy and potential energy of the electron in the electrostatic field of the proton.[10]

$$V(r) = -\Delta m_e c^2. \tag{16}$$

According to this equation, the potential energy corresponds to the reduction in rest mass energy of the electron in the atom. Also, the potential energy of the electron can be expressed with the following equation:

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$$V(r_n) = -\frac{1}{4\pi\varepsilon_0}\frac{e^2}{r_n} \tag{17a}$$

$$= -\frac{\alpha\hbar c}{r_n}. \tag{17b}$$

Here, if Eq. (8) is rewritten taking into account Eq. (15), the following two equations are obtained.

$$\left(m_e c^2 - \frac{\alpha^2 m_e c^2}{2n^2}\right)^2 + p_n^2 c^2 = \left(m_e c^2\right)^2. \tag{18}$$

$$\left(m_e c^2 - \frac{\alpha\hbar c}{2r_n}\right)^2 + p_n^2 c^2 = \left(m_e c^2\right)^2. \tag{19}$$

The following p_n^2 can be found from Eq. (18).

$$p_n^2 = \frac{\alpha^2 m_e^2 c^2}{n^2}\left(1 - \frac{\alpha^2}{4n^2}\right). \tag{20}$$

Expanding and rearranging Eq. (19), it is possible to obtain the following quadratic equation for r_n :

$$p_n^2 r_n^2 - \alpha\hbar m_e c r_n + \frac{\alpha^2\hbar^2}{4} = 0. \tag{21}$$

If the value of Eq. (20) is substituted here for p_n^2, the following solution is obtained:

$$r_n = \frac{\alpha\hbar m_e c \pm \left(\alpha^2\hbar^2 m_e^2 c^2 - p_n^2\alpha^2\hbar^2\right)^{1/2}}{2p_n^2} \tag{22a}$$

$$= \left[r_e \pm r_e\left(1 - \frac{\alpha^2}{2n^2}\right)\right]\frac{n^2}{2\alpha^2}\left(1 - \frac{\alpha^2}{4n^2}\right)^{-1}. \tag{22b}$$

Here, r_e is the classical electron radius as following:

$$r_e = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{m_e c^2}. \tag{23}$$

Here if r_n^+ is taken to be the larger of the two solutions obtained from Eq. (22), and r_n^- the smaller, then r_n^+ and r_n^- are as follows:

$$r_n^+ = \frac{n^2}{\alpha^2} r_e = n^2 a_B, \qquad n = 1, 2, \cdots. \tag{24}$$

$$r_n^- = \frac{r_e}{4}\left(\frac{n^2}{n^2 - \alpha^2/4}\right), \qquad n = 1, 2, \cdots. \tag{25}$$

Here, a_B is the Bohr radius. In Eq. (25) the radius approaches $r_e/4$ with $n \to \infty$. Therefore this paper predicts that $r_e/4$ will be the radius of the atomic nucleus (the proton).

Next, the energy is found when the radius is r_n^+ and r_n^-. Here, E_n in Eq. (3) can be written as follows if Eq. (15) and Eq. (17a) are taken into consideration.

$$E_n = -\frac{1}{2}\frac{1}{4\pi\varepsilon_0}\frac{e^2}{r_n}. \tag{26}$$

Here, if E_n^+ is taken to be the energy obtained by substituting r_n^+ for r_n in Eq. (26), and similarly E_n^- is taken to be the energy obtained by substituting r_n^- for r_n, then E_n^+ and E_n^- are as follows:

$$E_n^+ = E_{B,n} = -\frac{\alpha^2 m_e c^2}{2n^2}, \qquad n = 1, 2, \cdots. \tag{27}$$

$$E_n^- = -2m_e c^2 + \frac{\alpha^2 m_e c^2}{2n^2}, \qquad n = 1, 2, \cdots. \tag{28}$$

If these energies are described on an absolute scale using $E_{re,n}$ defined in Eq. (7), the values are as follows:

$$E_{re,n}^+ = m_e c^2 - \frac{\alpha^2 m_e c^2}{2n^2}, \qquad n = 1, 2, \cdots. \tag{29}$$

$$E_{re,n}^- = -m_e c^2 + \frac{\alpha^2 m_e c^2}{2n^2}, \qquad n = 1, 2, \cdots. \tag{30}$$

If the above is indicated graphically, the result is as follows (see Fig. 1).

IV. Phenomena which Demonstrate the Existence of Ultra-Low Energy Levels

If it is assumed that the energy of an incident γ-ray is 1.022 MeV ($2m_e c^2$), then due to the effects of the Coulomb potential of atomic nucleus, the γ-ray may suddenly disappear and produce an electron-positron pair (electron-pair creation). The electron and positron pair, which absorbed all of the energy of the γ-ray, are produced, classically speaking, near $r_e/2$ from the center of the atomic nucleus.

If an electron exists at the E_n^- energy levels, then the energy E necessary for the electron to be excited and emitted outside of the shell is as follows due to Eq. (28):

$$E = 2m_e c^2 - \frac{\alpha^2 m_e c^2}{2n^2} \approx 2m_e c^2 = 1.022\,\text{MeV}. \tag{31}$$

Now, how can hydrogen atoms in this energy state be verified? Simply put, it can be predicted that if such an atom is irradiated with a 1.022MeV photon, then a single electron will be emitted to the outside of the shell. However, this sort of phenomenon has not been

Global Journal of Science Frontier Research (A) Volume XV Issue VII Version I Year 2015

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discovered. Actually, the $r=r_e/2$ point is a location where energetically $E_{re}=0$ and an electron-positron pair is created due to the vacuum absorbing the energy of this photon. Since the photon energy is consumed at that time, the photon cannot arrive at an electron in the E_n^- state. Therefore this paper looks at triplet production.

It is generally assumed that in triplet production, in which 2 electrons and 1 positron are created, electron-pair creation occurs not near the atomic nucleus, but near the electron in the outer shell orbital. A total of three particles are created in this case: one outer shell electron forming the atom, and a positron and electron created through pair production. However, in this model, (1.022MeV- E_n^+) should be sufficient as the necessary photon energy. If an energy of 2.044MeV ($4m_ec^2$), is needed for triplet production, then the recoiled electron should be regarded as being at an ultra-low energy level. Thus this theory changes the existing interpretation of triplet production by taking into account the law of conservation of energy.

Now, consider the case where an incident γ-ray has the energy corresponding to the mass of 4 electrons (2.044 MeV). If this is discussed classically, the γ-ray can create an electron and positron near $r=r_e/2$ (see Fig.2).

Even if 1.022 MeV of energy is consumed in this pair creation, the γ-ray still has the energy of corresponding to the mass of 2 electrons (1.022MeV). If the γ-ray gives energy to an electron in the orbital near the proton, the electron will be excited and appear in free space. As a result, 2 electrons and 1 positron will appear in free space.

This paper points out that one of the two electrons which appears is an electron in the E_n^- state. A hydrogen atom in the E_n^- state will henceforth be called a "dark hydrogen atom" in this paper, and indicated as $_D$H (where the D stands for "dark"). Also, the E_n^- in Eq. (28) will be indicated as $_DE_n$, and E_n^+ will be returned to the original symbol E_n. In addition, the $E_{re,n}^-$ in Eq. (30) will be expressed as $_DE_{re,n}$, and $E_{re,n}^+$ will be returned to the original symbol $E_{re,n}$.

Furthermore, the hydrogen molecule produced from $_D$H will be called "dark hydrogen molecule", and indicated as $_DH_2$. In this paper, $_D$H and $_DH_2$ will be grouped together and called either hydrogen at ultra-low energy levels, or "dark hydrogen". In the next section, this paper will examine whether dark hydrogen can be a DM candidate.

V. Discussion

This section examines whether $_D$H and $_DH_2$ have the six characteristics indicated in the introduction.

(1) Hydrogen atoms are the most common atoms in the universe. Therefore, if dark hydrogen exists, it is natural to assume that it is present universally throughout space. Also, it is clear that it is electrically neutral. Therefore characteristics (1) and (2) are satisfied.

(2) The relativistic energy E_{re} of the electron forming H is about $\approx m_ec^2$ (however, $E_{re} < m_ec^2$). In contrast, the relativistic energy E_{re} of the electron forming $_D$H is about $\approx -m_ec^2$ (however, $E_{re} > -m_ec^2$).

Also, as is clear from Eq. (30), $E_{re} < 0$ in the case of the $_D$H electron, and therefore the mass of the electron forming $_D$H has a negative value. $_D$H is about $2m_ec^2$ lighter than H. However, $_D$H has a far smaller radius than H. Now, if the classical radii of $_D$H and H are compared, the results are as follows:

$$\frac{r_1^-}{r_1^+} = \frac{\alpha^2}{4-\alpha^2} \tag{32a}$$

$$=1.331\times10^{-5}. \tag{32b}$$

Therefore, dark hydrogen can achieve a state of far higher density than ordinary hydrogen. It is likely it will be observed as matter with high mass. Therefore, characteristic (3) can be regarded as satisfied.

(3) In atoms and molecules, electrons occupy orbitals starting from states with low energy. However, as shown by Eq. (14), there is a lower limit on the potential energy of an electron in a hydrogen atom. That is,

$$0 > V(r) > -m_ec^2. \tag{33}$$

When an electron in a hydrogen atom makes a transition from E_n^+ to E_n^-, the electron must have the energy of a photon emitted to the outside of the shell. However, the energy necessary for this transition does not remain at the electron if Eq. (33) is taken into consideration. Therefore, a transition from E_n^+ to E_n^- does not occur. In contrast, the transition from E_n^- to E_n^+ is regarded as possible. If a dark electron absorbs $2m_ec^2$ of energy from the outside, the electron in $_D$H is excited, and it transitions to an orbital within the hydrogen atom, or is omitted outside of the shell [This satisfies characteristic (4)].

It is also likely that dark hydrogen satisfies characteristic (5) and (6). For the above reasons, this paper has determined that $_D$H and $_DH_2$ can be DM candidates.

VI. Conclusion

This paper has shown it as possible to demonstrate the existence of $_D$H by changing the interpretation of the phenomenon of triplet production. Also, the characteristics of $_D$H and $_DH_2$ match with the six characteristics indicated in the introduction.

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Thus, this paper presents hydrogen with ultra-low energy levels as a strong candidate for DM. If the energy levels of ${}_{\mathrm{D}}\mathrm{H}$ is described at the level of classical quantum theory, the result is as follows.

$$ {}_{\mathrm{D}}E_n = -2m_{\mathrm{e}}c^2 + \frac{\alpha^2 m_{\mathrm{e}}c^2}{2n^2}, \qquad n = 1, 2, \cdots. \tag{34} $$

$$ {}_{\mathrm{D}}E_{\mathrm{re},n} = -m_{\mathrm{e}}c^2 + \frac{\alpha^2 m_{\mathrm{e}}c^2}{2n^2}, \qquad n = 1, 2, \cdots. \tag{35} $$

This paper predicts that, in addition to such dark hydrogen, diverse types of atoms and various types of molecules comprised of diverse types of atoms, can also be candidates for Dark Matter.

VII. Acknowledgments

I would like to express my thanks to the staff at ACN Translation Services for their translation assistance. Also, I wish to express my gratitude to Mr. H. Shimada for drawing figures.

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Figure Captions

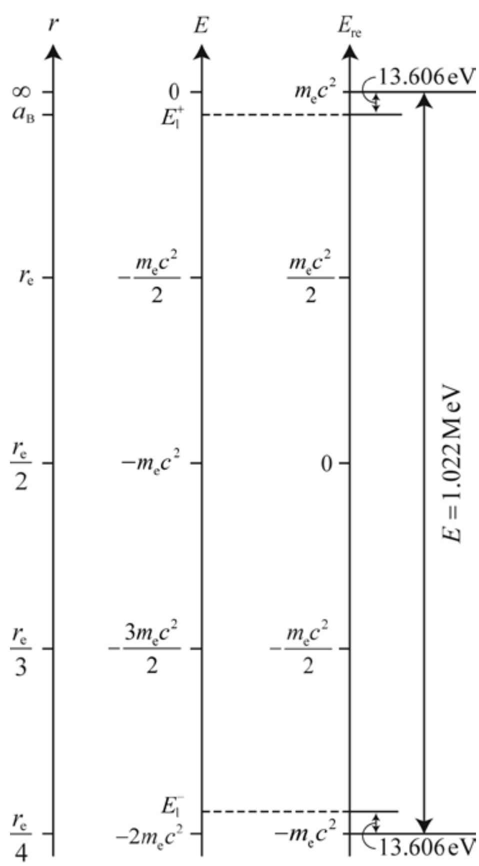

Fig. 1

Fig.1 : The energy levels of the hydrogen atom predicted by classical quantum theory E_n^+ ($E_{\mathrm{re},n}^+$) and the new energy levels whose existence has been indicated by this paper E_n^- ($E_{\mathrm{re},n}^-$). Also, r is physical quantity with meaning within the scope of classical discussions. The region of physical vacuum where pair production is possible in the hydrogen atom is $r_{\mathrm{e}}/2 \ge r > r_{\mathrm{e}}/4$.

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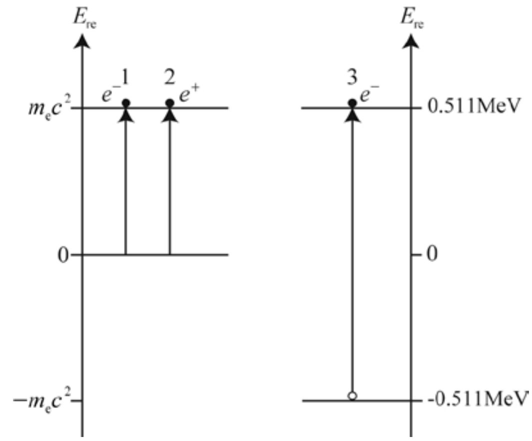

Fig. 2a *Fig. 2b*

Fig. 2 : Interpretation of this paper regarding triplet production. From the perspective of this paper, this γ-ray will give 1.022 MeV of energy to the virtual particles at $r=r_e/2$, and an electron-positron pair will be created (Fig. 2a). When this γ-ray approaches closer to the atomic nuclear, and the electron in the orbital around the proton absorbs this energy, the electron will be excited and appear in free space (Fig. 2b). This paper points out that one of the two electrons which appears is an electron in the E_n^- state.

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Global Journal of Science Frontier Research: A
Physics and Space Science
Volume 15 Issue 7 Version 1.0 Year 2015
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Optimization Control SK Box Manoeuvres for GEO Satellites using Electric Thrusters (OCSKBOX)

By Louardi Beroual & Djamel Benatia

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Keywords: geostationary satellites, SKBOX, box-limit, electric propulsion, specific impulse, quadratic programming.

GJSFR-A Classification : FOR Code: 290207

OPTIMIZATIONCONTROLSKBOXMANOEUVRESFORGEOSATELLITESUSINGELECTRICTHRUSTERSOCSKBOX

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I. Introduction

An astrodynamics orbital station-keeping is the orbital maneuvers made by thruster burns that are needed to keep a spacecraft in a particular assigned orbit.

For many Earth satellites the effects of the non-Keplerian forces, i.e. the deviations of the gravitational force of the Earth from that of a homogeneous sphere, gravitational forces from Sun/Moon, solar radiation pressure and air-drag must be counteracted.

The deviation of Earth's gravity field from that of a homogeneous sphere and gravitational forces from Sun/Moon will in general perturb the orbital plane [1]. For geostationary spacecraft the inclination change caused by the gravitational forces of Sun/Moon must be counteracted to a rather large expense of fuel, as the inclination should be kept sufficiently small for the spacecraft to be tracked by a non-steerable antenna [1,2].

Solar radiation pressure will in general perturb the eccentricity (i.e. the eccentricity vector) [3]. For some missions this must be actively counter-acted with manoeuvers, for geostationary spacecraft the eccentricity must be kept sufficiently small for a spacecraft to be tracked with a non-steerable antenna. Also for Earth observation spacecraft for which a very repetitive orbit with a fixed ground track is desirable, the eccentricity vector should be kept as fixed as possible. A large part of this compensation can be done by using a frozen orbit design, but for the fine control manoeuvres with thrusters are needed [4].

Electric propulsion engines are more efficient then chemical ones: they require significantly less propellant to produce the same overall effect, for example a specific increase in spacecraft velocity. The propellant is ejected up to 20 times faster than from chemically-based thrusters, and, thus the same propelling force is obtained with a log less propellant, the forces EP produces can be applied continuously for very long periods-months or even years.

To maintain the satellite within box, orbit corrections are achieved by applying velocity impulses to the satellite at a point in the orbit. These impulses are generated by activating the thrusters that are mounted on the satellite as part of the propulsion subsystem.

The tool developed in the frame of this paper is based on numerical optimization techniques and uses a thrusters-based model of the satellite to take directly into account the activity of each thruster used for the control of the satellite on the optimization process. This paper presents the tool design and the main principle of the optimization algorithm. Usually, control strategies consider satellites as a point. The present work includes the mathematical definition and the satellite model that allow considering it as a system. The results of some simulations and their practical applications are presented.

II. Mathematical Modeling

a) Coordinate Frames

The coordinate system used in this work for describing the perturbing forces is the satellite based Radial Tangent Normal (RTN) coordinate system with orthonormal basis $\vec{R}\vec{T}\vec{N}$, The $\vec{R}$ axis is defined as always pointing from the Earth's center along the radius vector toward the satellite, The $\vec{N}$ axis is normal to the orbit plane with direction of the satellite angular momentum vector, The $\vec{T}$ axis is perpendicular to R in the orbit plane

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and with the direction toward the satellite movement. It completes, with the unit vectors R and N, a right-handed orthogonal basis (see Figure 1).

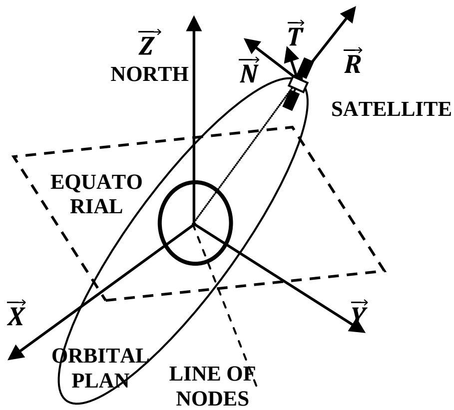

Figure 1 : Coordinate frames

In the flowing, a generic acceleration vector $\vec{u}$ induced from propulsive force acting on the satellite will be expressed as

$$\vec{u} = u_R\vec{R} + u_T\vec{T} + u_N\vec{N} \tag{1}$$

Where $\boldsymbol{u_R}, \boldsymbol{u_T}, \boldsymbol{u_N}$ are the acceleration components along the radial, tangential and normal directions.

b) Orbit elements

A total of six independent parameters are required to describe the motion of a satellite around the earth [3,4].Two of these elements, semi-major axis ***a*** and eccentricity ***e*** describe the form of the orbit, one element the mean anomaly ***M*** defines the position of satellite along the orbit, the three others, the right ascension ***Ω***, inclination ***i*** and argument of perigee $\boldsymbol{\omega}$ define the orientation of the orbit in space. Given these six elements, it is always possible to uniquely calculate the position and velocity vector (see figure. 2).

In many application, satellite orbits are chosen to be near-circular, to provide a constant distance from the surface of the Earth or a constant relative velocity. Typical examples are low-altitude remote sensing satellite or geostationary satellite.

While there is no inherent difficulty in calculating position and velocity from known orbital elements with ***e*** and ***i*** close to zero, the reverse task may cause practical and numerical problems. These problems are due to singularities arising from the definition of some of the classical orbital elements. The argument of perigee $\boldsymbol{\omega}$, for example, is not a meaningful orbital element for small eccentricities, since the perigee itself is not well defined for an almost circular orbit. Similar consideration apply to small inclination ***i*** where the line of node is no longer well defined and where the equations for Ω become singular. Several attempts have therefore been made to substitute other parameter for the classical keplerian elements. These elements are usually referred to as non-singular, regular or equinoctial elements [4].

The satellite orbit plane is defined thanks to the component of the inclination vectors (with modulus *tan(i/2)*) direct alone the line of nodes and pointing towards the ascending node.

$$\vec{i} = [p \quad q]^T = 2\tan\left(\frac{i}{2}\right)[\cos\Omega \quad \sin\Omega]^T \cong [\cos\Omega \quad \sin\Omega]^T, i \to 0 \tag{2}$$

The satellite trajectory on its orbit is defined to the semi major axis ***a***, and supposing the parameters Ω and $\boldsymbol{\omega}$ in the same plane, to the component of the eccentricity vector directed alone the line of apsis and pointing towards the perigee.

$$\vec{e} == [h \quad k]^T = e[\cos(\Omega+\omega) \quad \sin(\Omega+\omega)]^T = e[\cos\tilde{\omega} \quad \sin\tilde{\omega}]^T \tag{3}$$

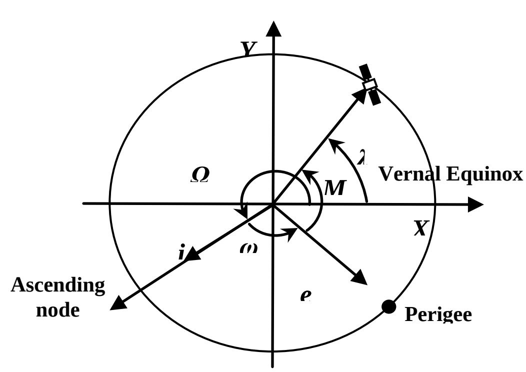

Figure 2 : Orbit elements

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Finally, the position of the satellite along its orbit is represented by the mean longitude

$$l = \tilde{\omega} + M - \Theta(t) \tag{4}$$

Where Θ is the Greenwich sidereal angle.

c) Dynamics for a GEO satellite

The motion of GEO satellite can be described by the rat of change of the equinoctial orbital parameters under the influence of the forces acting on the satellite. The geostationary dynamics results in the flowing nonlinear time varying system

$$\dot{x}(t) = \mathcal{K}(x(t)) + \mathfrak{L}(t, x(t)) + \mathcal{G}(t, x(t))u(t) \tag{5}$$

Where

$$x = [a \;\; \mathcal{p} \;\; \mathcal{q} \;\; \mathcal{h} \;\; \mathcal{k} \;\; l\;]^T \tag{6}$$

$$u = [u_R \;\; u_T \;\; u_N\;]^T \tag{7}$$

And the functions, $\mathcal{K}$,$\mathfrak{L}$ and $\mathcal{G}$ are the variation contribution to the equinoctial elements coming respectively from the Kipler's, Lagrange's and Gausse planetary equations [6] and [7].

$\mathcal{K}$: Describes the satellite motion under the effect of the gravitational attraction of the earth considered with takes into account the effect of the natural perturbing forces.

$\mathfrak{L}$: Take into account the effect of the natural perturbing forces.

$\mathcal{G}$: Given by the acceleration by thrusts.

The translation of nonlinear model (equation 5) into the linear model we use the Taylor series up to first order around the nominal operating points

$$x_0 = [a_0 \;\; 0 \;\; 0 \;\; 0 \;\; 0 \;\; l_0\;]^T \tag{8}$$

$$u_0 = [0 \;\; 0 \;\; 0\;]^T \tag{9}$$

We obtain

$$\dot{\mathfrak{x}}(t) = \mathcal{A}(t)\mathfrak{x}(t) + \mathcal{B}(t)\mathcal{u}(t) + \mathcal{D}(t) \tag{10}$$

Where

$$\mathfrak{x} = x - x_0 \text{ and } \mathcal{u} = u - u_0 \tag{11}$$

The $\mathcal{A}(t)$ and $\mathcal{D}(t)$ matrices turn out to be time varying because of the presence of periodic terms with periods equal to multiples of the periodicities of the earth, sun and Moon motion relative to the satellite.

The matrix $\mathcal{B}(t)$ is a periodic function with period equal to 24 hours.

$$\mathcal{B}(t) = \frac{1}{v_0}\begin{bmatrix} 0 & 2a_0 & 0 \\ 0 & 0 & \frac{1}{2}\sin\psi_0 \\ 0 & 0 & \frac{1}{2}\cos\psi_0 \\ -\cos\psi_0 & 2\sin\psi_0 & 0 \\ \sin\psi_0 & 2\cos\psi_0 & 0 \\ -2 & 0 & 0 \end{bmatrix} \tag{12}$$

Where

v_0 station keeping velocity equal to $\sqrt{\frac{\mu}{a_0}}$, μ is the earth gravitational coefficient.

And

$$\psi_0 = l_0 + \Theta(t) \tag{13}$$

The *GEO* orbits are characterized by very small values of eccentricity e and inclination i. the longitude and latitude can be defined

$$\lambda = l + 2\,\mathcal{h}\,sin(l + \Theta) - 2\mathcal{k}\,cos(l{+}\Theta \tag{14}$$

$$\varphi = 2\mathcal{p}\,sin(\lambda + \Theta) - 2\mathcal{q}\,cos(\lambda{+}\Theta \tag{15}$$

We denote *y* the spacecraft position vector, which can be considered as the output variable of the nonlinear model

$$y = f(x, t) \tag{16}$$

The output equation into its Taylor series up to the first order around x_0 [8], we get the output equation of the linear time varying system (eq.10)

$$y = C(t)\mathfrak{x} \tag{17}$$

Where

$$y = [\lambda - l_0 \quad \varphi\,]^T \tag{18}$$

And

$$C(t) = \begin{bmatrix} 0 & -a_0\cos\psi_0 & -a_0\sin\psi_0 & 0 & 0 & 0 \\ 1 & -2\cos\psi_0 & 2\sin\psi & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & -2\cos\psi_0 & 2\sin\psi_0 \end{bmatrix} \tag{19}$$

III. Station Keeping Box Problem Formulation

The station keeping box represents the maximum permitted values of the excursion of satellite in longitude λ and latitude φ. The *SK* box can be considered as pyramidal solid angle, whose vertex is at centre of the earth.

Is defined by the two half angles of vertex, one within plan of equator *E-W* width $2\lambda_{max}$ and other in the plan satellite meridian *N-S* width $2\varphi_{max}$ (see Figure. 3).

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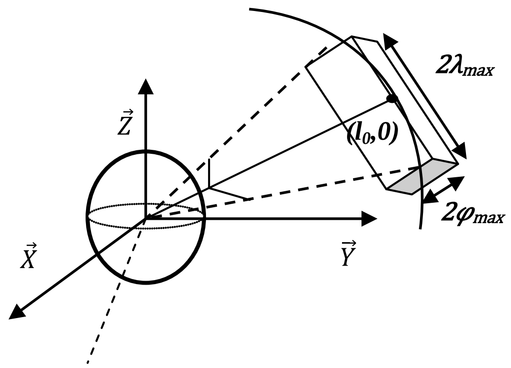

Figure 3 : Station keeping box

The station keeping problem can be formulated as constrained linear quadratic continuous time optimal control problem [9]. Given the linear model equation (10) and equation (17) with initial condition $\overline{\boldsymbol{X}}(t_i) = \overline{\boldsymbol{X}}_i$, the problem is to find the control optimal $\overline{\boldsymbol{u}}_{opt}(t)$ over a finite time horizon t_f-t_i the minimize the criterion

$$J = \frac{1}{2}\int_{ti}^{tf} (y^T(t)\, Q(t)\, y(t) + u^T(t)\, R(t)\, u(t)\,)\, dt \qquad (20)$$

Subject to the conditions

$$-y_{max} \le y \le y_{max} \qquad (21)$$

Where

$$y_{max} = [\lambda_{max} \quad \varphi_{max}\,] \qquad (22)$$

The thruster accelerations are defined as control laws in the optimization problems. These control variables can thus take at any time any value comprised between zero and the maximum thruster acceleration, in general with j thruster, we can write the control vectors in RTN fram as

$$u_j = \frac{1}{m}\Gamma F_j \qquad (23)$$

Where m is the spacecraft and $\boldsymbol{\Gamma}$ is the thruster system configuration matrix can be defined for a satellite equipped with four electric thrusters as

$$\Gamma = \begin{bmatrix} -sin\gamma\, cos\sigma & -sin\gamma\, cos\sigma & -sin\gamma\, cos\sigma & -sin\gamma\, cos\sigma \\ sin\gamma\, sin\sigma & sin\gamma\, sin\sigma & sin\gamma\, sin\sigma & sin\gamma\, sin\sigma \\ -cos\gamma & -cos\gamma & cos\gamma & cos\gamma \end{bmatrix} \qquad (24)$$

And F is the thrust vector of the thruster system

$$0 \le F \le F_{max} \qquad (25)$$

We defined the constraints on the control variable by

$$\frac{-F_{max}}{m} \le \Gamma(\Gamma\Gamma^T)^{-1}u \le \frac{F_{max}}{m} \qquad (26)$$

IV. Numerical Solution of the Problem

A number of different techniques are available for the numerical solution of the station keeping box problem. In this work we will consider the direct method for solution of continuous optimal control problem, the idea behind direct method is to discrete the control time history and/or stat variable history [10,11].

In this technique, the control inputs have to be written explicitly as function of the stat and its rate of change so that bounds on the control variables have translated in bunds on the attainable rates of change of the state variable [12].

The linear model (equation 10) can be written in different form, characterized by matrix B. to this purpose, we can use the Lyapunov transformation [9,13], in the stat space defined as

$$\tilde{\mathfrak{x}} = \mathcal{L}(t)\mathfrak{x} \qquad (27)$$

Where

$$\mathcal{L}(t) = v_0\begin{bmatrix} 0 & 0 & 0 & 2\cos\psi_0 & -2\sin\psi_0 & -1 \\ 0 & 0 & 0 & 2\cos\psi_0 & -2\sin\psi_0 & -3/2 \\ -3/2a_0 & 0 & 0 & 2\sin\psi_0 & 2\cos\psi_0 & 0 \\ 0 & 2\cos\psi_0 & -2\sin\psi_0 & 0 & 0 & 0 \\ 0 & 2\sin\psi_0 & 2\cos\psi_0 & 0 & 0 & -2\sin\psi_0 \\ -2/a_0 & 0 & 0 & 2\sin\psi_0 & 2\cos\psi & 0 \end{bmatrix} \qquad (28)$$

The linear system (equation 10) can be written in the new state variables $\tilde{\mathfrak{x}}$ as

$$\dot{\tilde{\mathfrak{x}}}(t) = \tilde{A}(t)\tilde{\mathfrak{x}}(t) + \tilde{B}(t)u(t) + \tilde{D}(t) \qquad (29)$$

And we can write the control variable of the linear dynamics as a function of the state variable, so

$$u(t) = \tilde{B}^{-1}\dot{\tilde{\mathfrak{x}}}(t) - \tilde{B}^{-1}\tilde{A}(t)\tilde{\mathfrak{x}}(t) - \tilde{B}^{-1}\tilde{D}(t) \qquad (30)$$

Where

$$\tilde{B}^{-1} = [\mathcal{L}(t)B(t)]^{-1} \qquad (31)$$

We obtained

$$u(t) = M\dot{\tilde{\mathfrak{x}}}(t) - M\tilde{A}(t)\tilde{\mathfrak{x}}(t) - M\tilde{D}(t) \qquad (32)$$

Where

$$M = \tilde{B}^{-1} = \begin{bmatrix} 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix} \qquad (33)$$

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And can be write the state variable as

$$\dot{\tilde{\mathfrak{x}}}(t) = \tilde{A}(t)\tilde{\mathfrak{x}}(t) + \tilde{D}(t) \quad (34)$$

And the output equation given by

$$y(t) = \tilde{C}(t)\tilde{\mathfrak{x}}(t) \quad (35)$$

Where

$$\tilde{C}(t) = C(t)\mathcal{L}^{-1}(t) \quad (36)$$

The station keeping problem formulated in the previous section as a constrained continuous time optimal control problem can be translated in a quadratic programming problem with constraint only on the state variables.

Above a finite time horizon t_f-t_i discretized in N intervals of length equal h each. The control optimal $u^{opt}(t)$ is taken constant equal to

$$u_k^{opt} \qquad \text{With } k=0,1,\dots,N\text{-}1 \quad (37)$$

The problem is consist in finding the optimal sequence $\tilde{\mathfrak{x}}_k^{opt}$ that minimized the criterion

$$J = \frac{1}{2}\sum_{k=1}^{N} y_k^T\, Q_k\, y_k + \frac{1}{2}\sum_{k=0}^{N-1} u_k^T\, R_k\, u_k \quad (38)$$

With

$$y_k = \tilde{C}_k\tilde{\mathfrak{x}}_k \quad (39)$$

$$u_k = M\frac{\tilde{\mathfrak{x}}_{k+1}-\tilde{\mathfrak{x}}_k}{h} - M\tilde{A}_k\frac{\tilde{\mathfrak{x}}_{k+1}-\tilde{\mathfrak{x}}_k}{2} - M\tilde{D}_k \quad (40)$$

Subject

- The output variable *y(t)*

$$-y_{max} \leq y_k \leq y_{max} \quad (41)$$

- The control variable u *(t)*

$$\frac{-F_{max}}{m} \leq \Gamma(\Gamma\Gamma^T)^{-1}u_k \leq \frac{F_{max}}{m} \quad (42)$$

- The auxiliary state variable $\tilde{\mathfrak{x}}(t)$

$$\frac{\tilde{\mathfrak{x}}_{k+1}-\tilde{\mathfrak{x}}_k}{h} = \tilde{A}_k\frac{\tilde{\mathfrak{x}}_{k+1}+\tilde{\mathfrak{x}}_k}{2} + \tilde{D}_k \quad (43)$$

A step-by-step walkthrough of the algorithm is as follows:

Step1: Formulation of SKBOX problem

- Fixed the finite time horizon t_f-t_i=1 day.
- The weighting matrices are equal to: $R=I_{2\times2}$ and $Q=I_{2\times2}$.
- Fixed the initial orbital elements vector $x(t_i)$.

Step2: Finding the optimal solution with minimized the criterion J with a discretization step of length h=0.01 day.

Step3: Obtained the optimal control with equation (40).

Step4: Finding the output variable with equation (39).

Step5: Repeat the previous steps for 1yaer.

V. Numerical Simulation

The initial orbital elements for this simulation can be found in Table 1.

Table I : Initial Orbital Elements

Orbital parameter	Value
Semi major axis(*km)*	42166.279
Right ascension of A.N (°)	82
Eccentricity	0.0000778
Inclination (°)	0.002044
Argument of perigee (°)	315.67725
Mean anomaly (°)	324.34109

The satellite is considered in this simulation is equipped with four thrusters mounted on its anti nadir face (see Figure 4).the configuration of the force vector is

$$F = [F_1 \quad F_2 \quad F_3 \quad F_4] \quad (42)$$

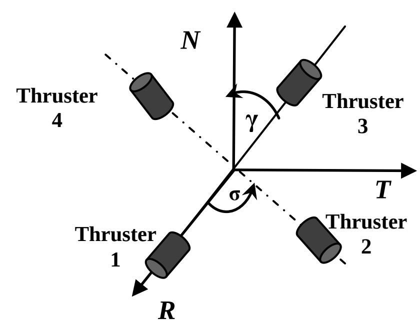

Figure 4 : Configuration force vector

The characteristics for this satellite can be found in Table 2.

Table II : Characteristics of Satellite

Characteristics of satellite	Value
Spacecraft masse (*kg)*	4500
Can angles of thruster (°)	50
Slaw angles of thruster (°)	15
Maximum force modulus (N)	0.17
Specific impulse (s).	3800s

The objective is to determine the set of manoeuvers to be executed in order to keep the satellite in a latitude and longitude box centered at the station longitude l_0=10deg with λ_{max}=0.01deg and φ_{max}=0.01deg.

Figure 5, Figure 6 and Figure 7 illustrates the historical time of the optimal acceleration control components in *RTN* frame for one year.

Negative and positive values of optimal acceleration radial allow maintain the satellite in a latitude window equal to]-0.01°, 0.01°[, positive values of optimal tangential acceleration fix the satellite into a longitude interval]-0.01°, 0.01°[, and the variation of

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optimal acceleration normal centered the satellite in the box.

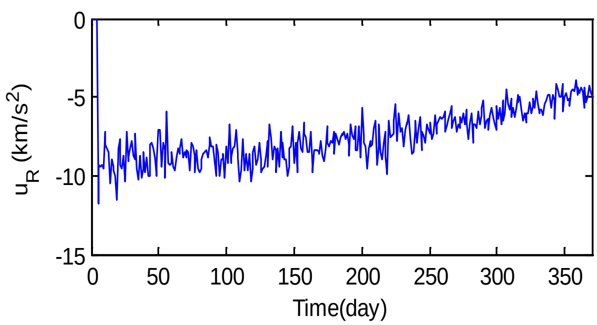


Figure 5 : Optimal acceleration radial control for one year

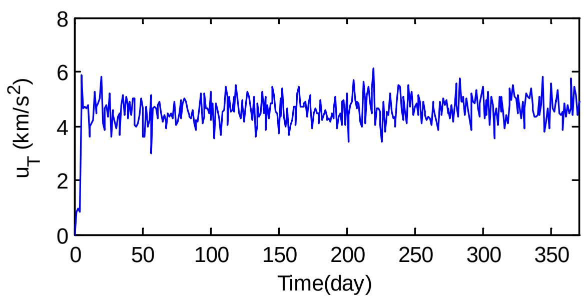


Figure 6 : Optimal acceleration tangential control for one year

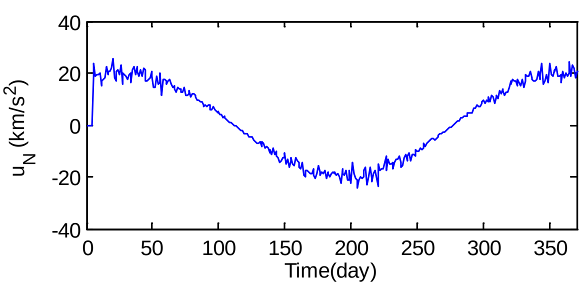
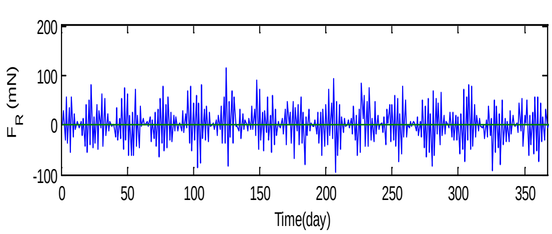


Figure 7 : Optimal acceleration normal control for one year

Figure 8 illustrates the evolution of the three components of propulsive force in *RTN* frame for one year with the maximum force modulus $F_{max}=0.17N$.

The variation in propulsive Force allows producing the optimal acceleration to control the satellite in latitude and longitude box. The thruster forces values are lower them maximum propulsive forces.



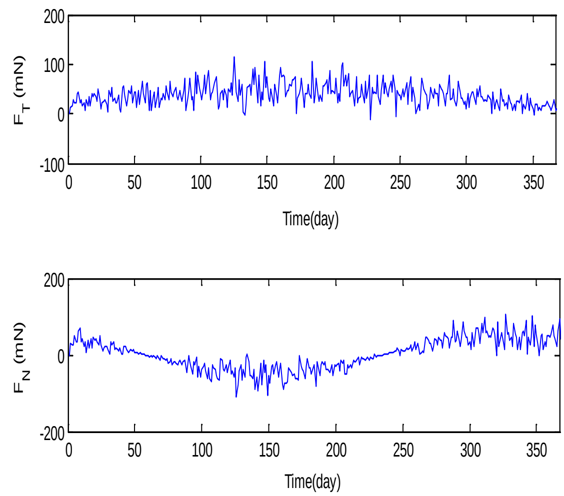


Figure 8 : Propulsive force for one year in RTN frame

Figure 9 Shows the controlled and uncontrolled manoeuvers time histories of the latitude for the station keeping box in condition ±0.01deg. In *SKB*ox no-controlled, the variation in latitude value is not fixing in the box. For this problem the *SKB*ox controlled is used for fixing the variation in latitude into the box.

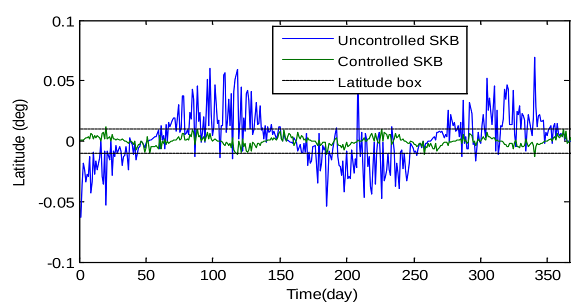


Figure 9 : Time histories of the latitude for one year

Figure 10 illustrates the controlled and uncontrolled manoeuvers time histories of the true longitude for the station keeping box in condition ±0.01deg. In *SKB*ox no-controlled, the variation in longitude value is not fixing in the box. For this problem the *SKB*ox controlled is used for fixing the variation in longitude into the box.

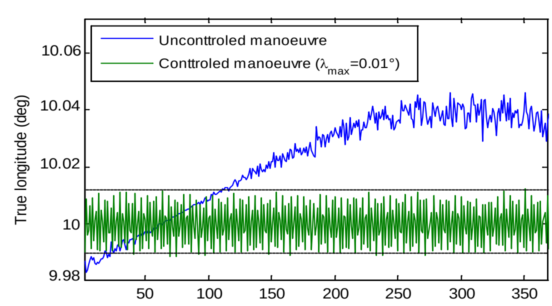


Figure 10 : Time histories of true longitude for one year

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VI. Conclusion

In this paper a new method for station keeping box of geostationary satellite equipped with electric propulsion has been developed, we considered a novel approach based on direct method for solution of continues optimal control. Using this method, satellite position can be directly controlled based on the optimal acceleration for thruster, simulation results have demonstrated that the satellite can be tightly controlled in the station keeping box.

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Global Journal of Science Frontier Research: A
Physics and Space Science
Volume 15 Issue 7 Version 1.0 Year 2015
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Oscillating Theory of the Universe

By Koijam Manihar Singh, Kangujam Priyokumar Singh & Mukunda Dewri
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Abstract- We propose here a new theory of the cosmic evolution of the universe, giving its name as the "oscillating theory of the universe". In this theory we have an endless universe having different epochs in its continuing endless process, an epoch being equal to one complete oscillation starting from a big bang like event and undergoing through different phases until it arrives at a pseudo crunch to be followed by another big bang like event, of course, after a bounce. This moment of time is the end of an epoch and the beginning of another new epoch, which happens after a complete oscillation. In this oscillating theory the length of an epoch need not be equal to the length of another epoch. And interestingly, it is found that there exists the significance of negative time at some point during the cosmic evolution of the universe.

Keywords: *dark energy, oscillating universe, scalar field, radiation/matter-dominated.*

GJSFR-A Classification : *MSC 2010: 83F05*

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Oscillating Theory of the Universe

Koijam Manihar Singh [α], Kangujam Priyokumar Singh [σ] & Mukunda Dewri [ρ]

Abstract- We propose here a new theory of the cosmic evolution of the universe, giving its name as the "oscillating theory of the universe". In this theory we have an endless universe having different epochs in its continuing endless process, an epoch being equal to one complete oscillation starting from a big bang like event and undergoing through different phases until it arrives at a pseudo crunch to be followed by another big bang like event, of course, after a bounce. This moment of time is the end of an epoch and the beginning of another new epoch, which happens after a complete oscillation. In this oscillating theory the length of an epoch need not be equal to the length of another epoch. And interestingly, it is found that there exists the significance of negative time at some point during the cosmic evolution of the universe.

Keywords: dark energy, oscillating universe, scalar field, radiation/matter-dominated.

I. Introduction

There have been some theories and models of the universe, namely, standard big bang theory and inflationary models [Guth(1981), Albrecht and Steinhardt(1982), Linde (1982)], steady state theory [Hoyle and Narlikar (1964)], Brans-Dicke theory [Brans and Dicke (1961)], Dirac cosmology [Dirac (1973)], pre-big bang model [Gasperini and Veneziano (1993), Gasperini et al.(1997), Gasperini and Veneziano (2003)], ekpyrotic model [Khoury et al. (2001), Khoury et al. (2002a), Khoury et al. (2002b)], Horava-Witten heterotic M-theory [Horava and Witten (1996), Lukas et al. (1999a), Lukas et al. (1999b)], cyclic theory of the universe [Steinhardt and Turok (2002a), Steinhardt and Turok (2002b)], and the new ekpyrotic model [Buchbinder et al.(2007a), Buchbinder et al. (2007b), Buchbinder et al.(2008), Creminelli and Senatore (2007)]. In this paper, we attempt to introduce another new theory of the universe in which the universe undergoes an endless series of oscillations forming different epochs, and we name it as the "oscillating theory of the universe". Our model differs from oscillatory model introduced earlier based on a closed universe; rather our universe is flat and infinite. Our universe no longer passes through a singularity in which the energy and the temperature diverge, rather the density and the temperature remain finite at the transition. Tolman (1934) pointed out that entropy produced during one cycle would be added to the entropy produced in the next, causing each cycle to be longer than the one before it. But his assumption is not necessarily true in our case. One oscillation may be longer or shorter than the next one as in our case the accelerated expansion, caused by the dark energy, is already diluting almost all the entropy, black holes and other debris accompanied with our universe which was produced in the previous epoch.

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II. A Brief Sketch of the Oscillating Theory

In the proposed oscillating theory of the universe we consider the evolution of a scalar field ϕ coupled to our universe with gravity. In this theory one epoch begins with a big bang, after which the inflationary phase comes with a high rate of expansion. After a short period a stage is reached when the scalar field ϕ becomes nearly fixed during which the universe undergoes radiation-dominated and matter-dominated phases. Next during this process the universe reaches a stage when the potential energy of the scalar field begins to dominate giving a period of accelerated expansion which is the present age of the universe. During this period of accelerated expansion, the black holes, matter, radiation, all debris, neutron stars, neutrinos will be diluted away making the universe empty, smooth and flat. During this period the slope of the potential $V(\phi)$ causes the scalar field ϕ to roll down in the negative direction and the accelerated expansion will continue during which the potential energy almost drops to zero. At this point the universe will be dominated by the kinetic energy of the scalar field ϕ. But again, this kinetic energy will be damped away by the expansion of the universe. Then the moment comes when the total energy consisting of the kinetic energy and negative potential energy almost becomes zero at which moment the universe seems to be static momentarily. Then the scalar field starts to roll back towards $-\infty$ and the universe begins to contract. Now the kinetic energy of ϕ grows which means that the gravitational energy is being converted to the kinetic energy of ϕ. Thus the kinetic energy becomes increasingly dominant and the scalar field diverges as the radius of the universe tends to zero. Then a bounce follows and radiation is produced and the universe is beginning to expand. Though, for some time, the kinetic

Global Journal of Science Frontier Research (A) Volume XV Issue VII Version I Year 2015

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energy density of the scalar field continues to dominate over the radiation, soon after the universe becomes radiation-dominated, and it undergoes a radiation-dominated phase, and then followed by a matter-dominated phase. During this phase the motion of the scalar field is rapidly damping, and it remains with almost reaching its maximum value. Then after a period of some billion years the potential energy of the scalar field begins to dominate, still ϕ rolling towards $-\infty$. As the scalar field rolls towards $-\infty$ the expansion of the universe begins diluting all the debris, the black holes, neutron stars etc. and flattening and making smooth the universe again. Then when all the energy of the scalar field is used up the universe seems to have a momentary pause, after which it (the universe) starts contracting leading to a pseudo crunch. Then after a bounce it goes for a big bang starting anew the process of evolution in the positive direction again. Thus the universe goes on in an endless continuing process, where there is the significance of negative time in the evolution process of the universe, at least during the period when $\phi \to -\infty$. Here the periods of oscillation may not be necessarily equal.

III. An Oscillating Model of the Universe

Here, as an illustration, we take up an oscillating universe. The line element considered is that of the flat and homogeneous Robertson-Walker metric

$$ds^2 = -dt^2 + a^2(t)[dr^2 + r^2(d\theta^2 + sin^2\theta d\varphi^2)] \quad (1)$$

where a is the scale factor. And the study of our model is taken up using the action S which describes the gravity, the scalar field ϕ, and the matter and radiation fluids in the form

$$S = \int d^4x\sqrt{-g}\,[\tfrac{1}{16\pi G}R - \tfrac{1}{2}(\partial\phi)^2 - V(\phi) + \psi^4(\phi)(\varrho_r + \varrho_m)], \quad (2)$$

where R is the Ricci scalar and $V(\phi)$ is the scalar potential. And it is such that the coupling $\psi^4(\phi)$ between the scalar field ϕ and the radiation (ϱ_r) and the matter (ϱ_m) densities causes the densities to remain finite at the moment of transition from the big crunch to the big bang event.

From (1) and (2) we get the field equations

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\left(\frac{1}{2}\dot{\phi}^2 + V + \psi^4\varrho_r + \psi^4\varrho_m\right) \quad (3)$$

$$\frac{\ddot{a}}{a} = -\frac{8\pi G}{3}\left(\dot{\phi}^2 - V + \psi^4\varrho_r + \frac{1}{2}\psi^4\varrho_m\right) \quad (4)$$

Here the scalar field ϕ satisfies the equation

$$\ddot{\phi} + 3H\dot{\phi} = -\frac{dV}{d\phi} - \frac{d\psi}{d\phi}\psi^3\varrho_m \quad (5)$$

where

$$H = \frac{\dot{a}}{a} \quad (6)$$

is the Hubble constant.

For radiation or matter the equation of fluid motion is given by

$$a_\psi \frac{d\varrho_\alpha}{da_\psi} = a\frac{d\varrho_\alpha}{da} + \frac{\psi}{\frac{d\psi}{d\phi}}\frac{\partial\varrho_\alpha}{\partial\phi_\alpha} = -3(\varrho_\alpha + p_\alpha) \quad (7)$$

where $\alpha = r, m$.

Also, $a_\psi = a\psi(\phi)$, and p_α is the pressure for the portion of the fluid whose energy density is ϱ_α. Here assumption is implicitly made that radiation and matter couple to $\psi^2(\phi)g_{ij}$ (having scale factor a_ψ) rather than the Einstein metric g_{ij} alone (with scale factor a).

In our case we take the potential of the scalar field in the form

$$V(\phi) = V_0(1 - e^{-b\phi})f(\phi), \quad (8)$$

where $f(\phi)$ is a function such that $V(\phi) \to 0$ as $\phi \to -\infty$. With such a choice we can attain a realistic astrophysical situation by taking $b \geq 10$ and making today's dark energy density which is roughly 6×10^{-30} gm/cm^3 equal to V_0.

Regarding the coupling $\psi(\phi)$, we take

$$\psi(\phi) \sim \varrho^{-\phi/\sqrt{6}} \quad as\ \phi \to -\infty \quad (9)$$

Here we choose $\psi(\phi)$ such that a_ψ and the matter and radiation densities are finite at $a = 0$ during the process of evolution. For large b, the potential is such that $\frac{V''}{V} >> 1$ for $\phi_{min} < \phi < 0$. And in this region the constant term is seen to be irrelevant and we may take $-V_0 e^{-b\phi}$ for V. Considering the motion of ϕ back and forth across the potential regime we find a solution to study the moments (periods) before and after the bounce. Over this region $-V_0 e^{-b\phi}$ can represent potential V, and a corresponding simple scaling solution is

$$a(t) = t^p, \quad (10)$$

$$V = -V_0 e^{-b\phi} = \frac{-p(1-3p)}{t^2}, \quad (11)$$

$$p = \frac{2}{c^2}, \quad (12)$$

which corresponds to an expanding or contracting universe according to t is positive or negative. And here $t = 0$ is chosen to correspond to a bounce. Thus at this particular juncture first t is negative which corresponds to a contracting universe leading to a pseudo big

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crunch; then at $t = 0$ there is a bounce and just after that t is positive which corresponds to an expanding universe with a big bang. Thus at $t = 0$ one epoch of oscillation is completed, and from next moment onwards another epoch begins with a big bang.

IV. Conclusion

With the different arguments and reasons given above and observance of the continuity of the universe with such a theory and the results obtained here we have good reason to think of the oscillating theory as a very much viable new theory of the universe. Considering a model universe with a particular scalar field we have successfully shown that our universe can have different epochs of oscillation, one epochs consisting as usual of the radiation-dominated, matter-dominated and dark energy dominated phases. The different phases have been shown explicitly in our model. Finally we arrive at a juncture where an epoch of oscillation ends and after a bounce another epoch begins with a big bang. During each epoch there is a period of time when $\phi \to -\infty$ during which there is an implication for the existence of negative time; and such a similar situation arises also at the transit period from one epoch to another epoch. In this way the evolution of our universe is an endless process containing different epochs, each epoch comprising of a complete oscillation as we proposed.

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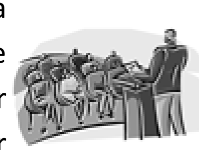

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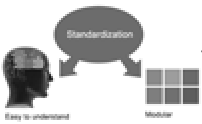

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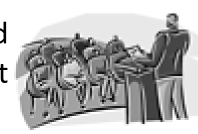

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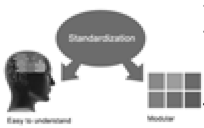

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Note :

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3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

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28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

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Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including <u>definite statistics</u> - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- 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.

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.
- Do not give permission to anyone else to "PROOFREAD" your manuscript.
- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

Criterion for Grading a Research Paper (Compilation) by Global Journals Inc. (US)

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Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
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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ISSN 9755896

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