Details of the work done in the project within the last three financial years

Done in 2009-10:

1. Recruitment of JRF
2. Bought "One HP dc 7000 series desktop computer" and installed
3. Bought "One HP Laserjet LJP3015DN printer" and installed
4. Started literature survey

Done in 2010-11:

1. Bought "One offline 1000VA LI DS UPS system" and installed
2. Study of Relativistic spinning sphere (RSS) and Dynamical spinning sphere (DSS) models of electron
3. Attended in 7th PANE conference and presented paper
4. Participated in DAE-BRNS HEP Symposium
5. Attended and presented paper in NATPAS-2011
6. Communicated two research papers in peer-reviewed journals

Done in 2011-12:

1. The effect of the different radii of the spinning sphere models of the electron on external magnetic field.
2. Relation between the charge and the mass of the electron in spinning sphere model with relativistic velocity of the charge.
3. Developed a modified spinning sphere model of the electron and a modified Compton radius with α–quantized elements in a long series.
4. Attended DAE-BRNS workshop of Hadron Physics during Oct 31-Nov 4, 2011 at BARC, Mumbai.
5. Mr. Sovan Ghosh, the JRF of the project attended the 99th Indian Science Congress at KIIT University during 3-7 January 2012 and there he has been awarded 'Best Poster Award' for his research paper presented in the Physical Sciences section.
6. Six research papers are published during last one year in different peer-reviewed journals. Another three research papers are communicated to the peer-reviewed journals.

Buying and installation of the equipments:

According to our scheme submitted for the project one computer, one printer and one UPS were required for the research work to be carried out. Following the university-procedure we ordered and bought them. After that the computer (One HP dc 7000 series desktop computer), the laser printer (One HP Laserjet LJP3015DN printer) and the UPS (One offline 1000VA LI DS UPS system) are installed properly.

Recruitment of JRF:

Following university procedure we conducted interview and committee recruited one of the short-listed candidates as JRF. The name of the JRF is Mr. Sovan Ghosh. He joined on 22nd February, 2010 and he continued till 31st March, 2012.

Research work:

Study of the relativistic and dynamical spinning sphere models of electron:

Electron is the first particle discovered in the history of particle physics. In 1897 J. J. Thomson discovered electron. There after proton, neutron and other particles came out. From that time to give a proper model of electron endeavors are going on.

In fact the root of this theory is very older than the other branches. Wilhelm Weber first

developed the particle electrodynamics (1946). In 1864 James Clark Maxwell combined the Ampere's law, Biot-Savart's law in a single theory which is a large compilation of empirical laws in electrodynamics. Thomson focused on the electromagnetic mass of a charged particle and corresponding dynamics. His idea was follwed by Lorentz-Abraham-Poincare model of electron. Lorentz replaced Maxwell's macroscopic idea by his microscopic theory. Rose has given the way of thinking about the Relativistic theory of electron.

Relativistic spinning sphere model:

Relativistic Spinning Sphere (RSS) model is given by M. H. Mac Gregor. This is a semi-classical model and it follows classical and quantum mechanical aspects. In standard model of particle physics electron is regarded as a point particle. But the existence of mass, electric charge, spin angular momentum and magnetic moment for a point particle does not seem to be absolutely correct.

As electron is charged particle and depending upon the electric and magnetic properties it interacts with others, the size and shape of electron become essential to be looked after. RSS model is a spectroscopic model that corresponds to known physical laws and helps us to calculate the spectroscopic properties of the particle. To co-relate the mass and the spin of electron the spherical models are introduced.

Here it is taken that the electron is spinning. It is considered to be spinning as fast as it is allowed to – that is with its equator moving at or closer to the velocity of light, c. Again the spin energy of the electron is dictated by the energetic of the electron production mechanism. The significant conclusions from RSS model are: RSS gives the correct gyro-magnetic ratio for electron only when the equator is moving at the full relativistic limit c and secondly the RSS gives the correct Lorentz transformation equations only when the equator is moving at the velocity c. The mass is non-interacting. The mass is "rigid", so that an external force applied to the equatorial charge can be decomposed into a torque plus a force directed through the center of mass.

To deal with this sort of models and properties of the particle we have to know about the size of electron. Because the size or radius can give the hint about the fields related to it. From this point of view we did a detail survey about the radius of electron.

Dynamical spinning sphere model:

Another recent model is dynamical spinning sphere model (DSS model). Here the electron is treated as a classical elementary particle which is a mechanical system whose kinematical space is a homogeneous space of the kinematical group. This particular model is provided by Martin Rivas.

The kinematical space of the mechanical system is the whole Galili group. Considering the lagrangian of system as function of time, degrees of freedom and the time derivative of the degrees of freedom this model is constructed. DSS model describes an elementary particle as a non-relativistic rigid body. This is a mechanical system of six degrees of freedom, which represent the position of a point and the orientation of a body frame attached to that point. There arises the idea of dynamical spinning sphere. The torque of the external forces produces a change in the orientation of the body. Description of the evolution of a different point, follow a helical trajectory around the center of mass.

Zitterbewegung:

The zitterbewegung is a local circulatory motion of the electron presumed to be the basis of the electron spin and magnetic moment. Schrodinger discovered this highly oscillatory, microscopic motion with velocity c, which he called "Zitterbewegung". He attempted a precise description in terms of 'microscopic' dynamical variables (coordinates, momenta and angular momenta) different from 'macroscopic' variables associated with the mean motion.

This has been proposed independently by many physicists. But the zitterbewegung model

proposed by Schrodinger is noteworthy. He examined the behavior in time of the co-ordinate operator x associated with Dirac's equation, and discovered the highly oscillatory, microscopic motion with velocity c, which he called the "Zitterbewegung".

Zitterbewegung was introduced to interpret high-frequency oscillations in free-particle wave packets of the Dirac theory. These oscillations with angular frequency arise from interference between positive and negative energy components of a wave packet. Schroedinger interpreted the oscillations as fluctuations in positions of the electron about an average motion. Thus, his work raised the question:

About the physical significance of the zitterbewegung motion three different answers can be found in the literature:

A. The zbw is a mathematical artifact of the one-particle Dirac theory which does not appear in a correctly formulated quantum field theory.

B. The zbw is an erratic motion of the electron due to random electron-positron pair creation and annihilation.

C. The zbw is a localized helical motion of the electron with an orbital angular momentum which can be identified with the electron spin.

Our contributions:

Thomson gave the idea of classical electron radius, R_0 considering classical electrodynamics and later this was re-constructed by Lorentz, Abraham and Poincare. Hence R_0 is also known as Thomson-scattering length or Lorentz radius.

With the help of Compton scattering experiment the Compton radius of electron, R_C was introduced by equating Einstein energy equation and Planck-Einstein relation and this is approximately 10^2 times larger than the classical electron radius. From the calculation of magnetic self-energy, the magnetic field radius R_H is determined. QED equivalent electron radius R_{QED}, which comes from Lamb shift, is approximately equal to R_C. By considering the quantum mechanical formalism of angular momentum of electron Mac Gregor introduced a corrected version of Compton radius of electron as quantum mechanical Compton radius R_{QMC}. Again considering Schwinger correction of magnetic moment of electron to R_{QMC}, we have QED-corrected quantum mechanical Compton radius R^{α}_{QMC}. Equating the total energy of the electron to the electrostatic contribution of the electron and its magnetic moment, we arrive at the electromagnetic radius of electron R_{em}. This is also known as Bohr radius of hydrogen atom. Charge radius of electron R_E is yet to be calculated precisely. Relativistic Spinning Sphere (RSS) model describes a point charge in an extended Compton-sized electron. Dynamical Spinning Sphere model also supports the same idea . Recent LEP experiments in CERN give the signature of the size of the charge-radius of the electron as $R_E < 10^{-19}$ m (10^{-17} cm).

We also studied about the α-quantized nature of the radii and theoretically predicted a new form of charge-radius which is experimentally predicted by CERN.

α-quantized masses and lifetime of leptons are discussed by Mac Gregor. Our calculations show the α-quantization among several radii of electron, their current contributions and the magnetic fields. It is also shown that all the eight radii of electron are α-quantized. α-quantized relations also enable us to connect the different electromagnetic phenomena that are responsible for the origin of those electron radii. Corresponding current and magnetic fields are also related accordingly. These results strengthen our proposal of the form of charge-radius R_E. Interestingly the value for that radius is consistent with LEP results. The fine-structure constant deals a role of connector between any two radii and this reflects the fact that those different phenomena are also

connected through α only.

Rotation of charge produces current and current introduces magnetic field according to Ampere's law. Magnetic self-energy of an electron is the energy contained in the magnetic field, associated with the magnetic moment. Relativistic spinning sphere model of electron incorporates the idea of a spherical model of electron whose charge is confined in a tiny place at equator of the sphere. As well as the charge is considered to be rotating around the axis of rotation of the sphere.

In the dynamical spinning sphere model of electron the rotation of charge-center around the center of mass is projected. Though Relativistic spinning sphere is approached in a different way, our work with magnetic self-energy and the helical motion of charge combines the two. Secondly this model gives structural behavior with the properties of electron. Thirdly this approves the relation among different radii of electron too.

Here we started with the current-loop formulation for the rotation of the charge of the electron. The most striking result came out when we used the different radii for the current-loop.

We have the expression of current in terms of charge, mass and spin of the electron as

$$I_G = \frac{c^2}{4\pi}\left(\frac{\text{charge.mass}}{\text{spin}}\right).$$

Indeed we got the current-loop expressions for all eight radii of the electron in the above-mentioned form and they all show similar pattern only with α-quantized nature. In similar pattern we get the magnetic fields also.

The relations between the current expressions for different radii of the electron is expressed as

$$I_C = \alpha I_0 = \alpha^{-1} I_{em} = \sqrt{3} I_{QMC} = \sqrt{3}\left(1+\frac{\alpha}{2\pi}\right) I^{\alpha}_{QMC}.$$

The expression for the relation amongst the self-magnetic fields for different radii is

$$B_C = \alpha^2 B_0 = \alpha^{-2} B_{em} = 3B_{QMC} = 3\left(1+\frac{\alpha}{2\pi}\right) B^{\alpha}_{QMC}.$$

When we consider the charge's rotation under the influence of external magnetic field also, the magnetic field and current are expressed in terms of the three intrinsic parameters as

$$B_C(z) = \alpha^{-1}\left(\frac{em}{\frac{\hbar}{2}}\right)\left[\frac{mc^2}{2\hbar} - \omega\right] = \frac{\hbar}{\mu}\left[\frac{mc^2}{2\hbar} - \omega\right]$$

and

$$I_C = \alpha^{-1}\frac{c^2}{4}\left(\frac{em}{\frac{\hbar}{2}}\right)\left[1 - \frac{2\omega R_C}{c}\right].$$

The subscript '*C*' refers to the Compton radius. In similar manner we get the expressions for other radii also. The α-quantized pattern for different radii is also maintained there. Indeed we have reproduced the fine-structure constant also in terms of ratio of the product of the charge and mass of the electron to the spin of the electron.

We have investigated also about the electromagnetic mass of the electron in the spinning sphere structure of the electron and we have expressed the electromagnetic mass in terms of charge as

$$m.\frac{\alpha}{2\pi} = \frac{\mu_0 e^2}{24\pi^3 R}.$$

The electromagnetic mass of the electron is a fraction of the total charge of the electron and that

helps to match the theoretical and experimental values of the magnetic moment of the electron. This is other words give the charge-mass relation too.

We have worked on the relations of the radii of the electron. This gave the a-quantization of the electron radii. Following the properties of the other radii and the relations amongst the different radii, we have arrived to the mathematical form of the charge radius of the electron, the order of which is in agreement with the result of LEP experiment at CERN and it is given by our calculation as

$$R_E = \frac{e^6}{m\hbar^2 c^4}.$$

Using relations amongst different radii of the electron, we have introduced a new radius (say Composite radius) of the electron and this is a composition of the Compton radius and the Classical radius as

$$R_{C0} = R_C + \frac{R_0}{2\pi}.$$

This particular radius gives the signature of the helical motion of the electron charge. Helical motion of the electric charge around the center of mass is known as Zitterbewegung motion. The n-th turn velocity, magnetic field and the generalized angular momentum of the charge of the electron in the helical motion are respectively

$$v_n = v_{n-1}\left[\frac{L_{n-1}}{eR_C^2 B_{n-1}} - \frac{1}{2c}\right],$$

$$B_n = B_1\left(\frac{R_E + 2\pi R_{C0}}{R_E + 2n\pi R_{C0}}\right)\left[\frac{L_1}{eR_C^2 B_1} - \frac{1}{2c}\right]\left[\frac{L_2}{eR_C^2 B_2} - \frac{1}{2c}\right]\cdots\left[\frac{L_{n-1}}{eR_C^2 B_{n-1}} - \frac{1}{2c}\right]$$

and

$$L_n = \left[\frac{L_1}{eR_C^2 B_1} - \frac{1}{2c}\right]\left[\frac{L_2}{eR_C^2 B_2} - \frac{1}{2c}\right]\cdots\left[\frac{L_{n-1}}{eR_C^2 B_{n-1}} - \frac{1}{2c}\right]\left[mv_1 R_C + \frac{eR_{C0}^2 B_1}{2c}\left(\frac{R_E + 2\pi R_{C0}}{R_E + 2n\pi R_{C0}}\right)\right].$$

Thus we have connected the relativistic spinning sphere, dynamical spinning sphere and the zitterbewegung. In other words, the composite radius can be expressed as

$$R_{C0} = R_C\left(1 + \frac{\alpha}{2\pi}\right),$$

which is an extended version of the Compton radius. This helps us to express the anomalous magnetic moment of the electron as

$$a = \frac{\alpha}{2\pi} + K_2\left(\frac{\alpha}{2\pi}\right)^2 + K_3\left(\frac{\alpha}{2\pi}\right)^3 + K_4\left(\frac{\alpha}{2\pi}\right)^4 + \ldots\ldots,$$

where K_2, K_3, K_4 are the multiplicative numerical factors for respective orders of the fine structure constant. The order of α is in this result is in agreement with the recent calculations of the higher order of the magnetic moment of the electron.

Again, this prompts us to rewrite the composite radius and also the entire helical path calculation with higher order calculation.

Main features coming out from our work:

1 Established the relations amongst all eight radii of the electron.
2 Revealed the α-quantized nature of the radii of the electron
3 Shown the α-quantization of the current and the magnetic field
4 Related Rydberg constant with electro radii

5 α–quantization in the relations of the Rydberg constant
6 Prediction of the radius of muon for an electromagnetic structure
7 Prediction of the radius of tau for an electromagnetic structure
8 Classical radius is a contracted form from Compton radius
9 Total energy of electron is a sum of the energies produced by charge and mass
10 Introduced a new radius; Composite radius of the electron
11 Composite radius obeys QED correction
12 Composite radius gives signature of a helical motion of charge
13 Towards the pole of the sphere, speed of the charge increases
14 Supports the point-particle model at pole
15 Supports the extended model at equator
16 Maximum energy is at equatorial zone
17 Energy reduces away from the equator
18 Charge stays mostly at equator

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List of Publications:

1. Ghosh, S., Devi, M. R., Choudhury, A. and Sarma, J. K. Self Magnetic Field and Current-loop of Electron with Five Different Radii and Intrinsic Properties, *Int. J. App. Phys.* 1(2) 91--100, 2011.
2. Ghosh, S., Choudhury, A. and Sarma, J. K. Relations of the electron radii and electron model, *Int. J. Phys.* 4(2) 125--140, 2011.
3. Ghosh, S., Choudhury, A. and Sarma, J. K. Electromagnetic mass and charge in the framework of spinning sphere model of electron, *Int. J. App. Phys.* 1(2) 119--123, 2011.
4. Ghosh, S., Choudhury, A. and Sarma, J. K. External magnetic field with different radii of electron and intrinsic properties of electron invoking the spinning sphere model of electron, *Pac-Asi. J. Maths.* 5(2) 109--115, 2011.
5. Ghosh, S., Choudhury, A. and Sarma, J. K. Radii of electrons and their α-quantized relations, *Indian. J. Phys.* DOI 10.1007/s12648-012-0083-5.
6. Ghosh, S., Choudhury, A. and Sarma, J. K. Radius of electron, magnetic moment and helical motion of the charge of electron, *Apeiron* , 19(3) 247-263, 2012.
7. Ghosh, S., Choudhury, A. and Sarma, J. K. Electromagnetic mass and charge of the electron at the relativistic speed (communicated).
8. Ghosh, S., Choudhury, A. and Sarma, J. K. Magnetic self-energy and helical motion of charge invoking spinning sphere model of electron (communicated).
9. Ghosh, S., Choudhury, A. and Sarma, J. K. Magnetic moment of the electron in higher order from the modified Compton radius (communicated).

Research papers Presented:

1. Electromagnetic Energy, Spin and Velocity of the Electron in the Framework of the Uniformly Charged Spinning Sphere at 57th Annual Technical Session of Assam Science Society in Gauhati University on 16th March, 2012 (oral)
2. Magnetic Self-Energy and Helical Motion of Charge Invoking Spinning Sphere Model of Elecron at 99th Indian Science Congress during 3rd to 7th January, 2012 at KIIT University (Poster). This poster was awarded as the best poster in Physical Sciences at 99th Indian Science Congress.
3. Behaviour of External Magnetic Field with Different Radii of Electron and Intrinsic Properties of Electron 99th Indian Science Congress during 3rd to 7th January, 2012 at KIIT University, Bhubaneswar (Poster).
4. Helical Motion of Charge and Electron Structure at National Workshop on "Nuclear And Atomic Techniques Based Pure And Applied Sciences" at Department of Tezpur University in collaboration with UGC-DAE during 01-03 February, 2011. (Poster)
5. The radii of the electron and their α-quantized relations at 7th PANE National Conference during

5th to 6th Oct, 2010 at Department of Physics, Manipur University at Imphal, Manipur (Oral).
6. Self Magnetic Field (internal) of Electron and the intrinsic properties at 97th Indian Science Congress at Kerala University from 3rd to 7th January, 2010 (Oral).

Date: 15.11.2012
Time: 10 am

Principal Investigator

Co-investigator