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Highlights

- Modified Radar Signal
- Supersymmetry Quantum Mechanics
- Vorticity Distribution Function
- Mass of Schrodinger Equations

Discovering Thoughts, Inventing Future

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Target Distance Direct Determination from QPSK Mapped OFDM Modified Radar Signal

By A.A.Hakhoumian

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Abstract- Time shift of the target reflected signal in radar system can be calculated directly from modified QPSK mapped OFDM signal. It makes possible to determine target distance from radar station. When time shift respecting to phase delay depends on OFDM subcarrier number, modified OFDM signal prevents that dependence and lets system to decide the phase delay directly from QPSK-OFDM signal rotation angle of constellation points. Additionally, proposed system requires low computing resources as the entire calculation process could be done during a single OFDM symbol.

Keywords: OFDM, radar, constellation, signal processing, QPSK, time shift, target distance.

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Keywords: OFDM, radar, constellation, signal processing, QPSK, time shift, target distance.

I. Introduction

OFDM signals are in focusfor radar applications due to high time bandwidth product[1, 2]. One of the main applications occurring during utilization of OFDM signals in radar systems is the signal processing which detect target parameters - distance and velocity. One of proposed method based on solving of matrix equations or 2D Fourier transform need high computing resources [3,4].

Previously it was presented new method based on QPSK-OFDM signal constellation processing which make possible to detect Doppler shift and accordingly target velocity [5]. Unfortunately that method couldn't be done directly, without solving target distance detection. It is presented below a new method again based on constellation processing which let to calculate target distance and make previous presented method more reliable and applicable.

II. Calculation Scheme of time delay from Modified OFDM Radar Signal

Target distance estimation in radar system is calculation of time, during which transmitted signal travel to the target and back to the receiver.

$$\tau = \frac{2D}{c} \qquad (1)$$

where D-target distance, c speed of light.

Therefore target distance measurement is the same as timing offset estimation.

Let's consider the effect of timing offset on the OFDM signal constellation which is the representation of a signal modulated by digital modulation scheme, such as 4-QAM or in particularly QPSK.

For a set of N modulated orthogonal subcarriers f_n the transmitted signal can be represented as

$$S_t(t) = \frac{1}{N}\sum_{n=0}^{N-1} \dot{F}_n \exp\{j2\pi f_n t\} \qquad (2)$$

where $\dot{F}_n$ are modulated symbols. For QPSK modulation modulated symbols will be

$$\dot{F}_n = \exp\{j(2k+1)\}, k = 0,1,2,3 \qquad (3)$$

Consequently transmitted OFDM signal symbols points in constellation will have correspondent positions: $\varphi_1 = \frac{\pi}{4}, \varphi_2 = \frac{3\pi}{4}, \varphi_3 = \frac{5\pi}{4}, \varphi_4 = \frac{7\pi}{4}$ (Fig.1).

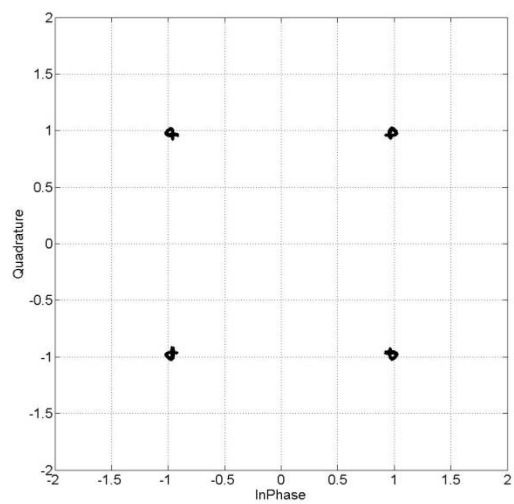

Figure 1 : OFDM transmitted signal constellation.

In communication systems phase difference of each two neighboring symbols could be $0, \frac{\pi}{2}, \pi, \frac{3\pi}{2}$. In such applications when it is necessary to solve time offset, this initial phase difference between each consecutive symbols must be prevented. One of the ways of preventing that initial shift is raising phase to the 4th power [6].

Taking into account only time delay effect from target the received echo signal $S_r(t)$ will be time shifted version of the transmitted signal.

$$S_r(t) = S_t(t-\tau) \qquad (4)$$

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So the received modulation symbols can be represented as

$$\dot{R_n} = \dot{F_n} \exp\{-j2\pi f_n \tau\} \quad (5)$$

As the phase of received symbol depended on subcarrier number, so with a large amount of subcarriers OFDM received symbols in constellation I/Q plane will spread all over plane in an interval $[0,2\pi]$(Fig.2).

To prevent this spreaded constellation, which doesn't give any opportunity to decide phase delay, we can simply take a divison of each consequitive symbols and make a new set of Q_k symbols.

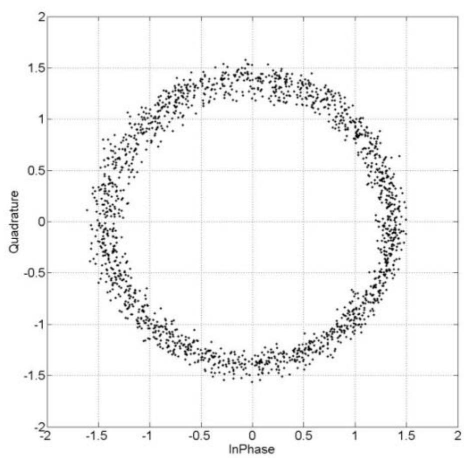

Figure 2 : OFDM received signal constellation consisting time delay.

$$Q_k = \frac{\dot{R_{n+1}}}{\dot{R_n}} = \frac{\dot{F_{n+1}}}{\dot{F_n}} \exp(-j2\pi f_{n+1}\tau + j2\pi f_n \tau) \quad (6)$$

where $k = 1,2, \dots, N-1$. As we stated before, OFDM stransmitted signal symbols can get phase values $\frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}and\frac{7\pi}{4}$, it is obvious that

$$\frac{\dot{F_{n+1}}}{\dot{F_n}} = \exp\left(\mu\frac{\pi}{2}\right) \quad (7)$$

$\mu = 0,1,2,3$.From (6) and (7) new modified OFDM signal can be represented as

$$Q_k = \exp\left(\mu\frac{\pi}{2}\right) \exp\left(-j2\pi\Delta f \tau\right) \quad (8)$$

where $\Delta f = f_{n+1} - f_n$ is subcarrier spacing. Expression (8) shows that time delay is independent from subcarrier number. That's mean that it is the same on all modified OFDM symbols anymore and it can be easily calculated.

$$\Delta\varphi = 360 \cdot \Delta f \tau \quad (9)$$

Fig. 3.a shows modified QPSK transmitted signal constellation while in Fig 3.b it is received modified OFDM signal constellation.

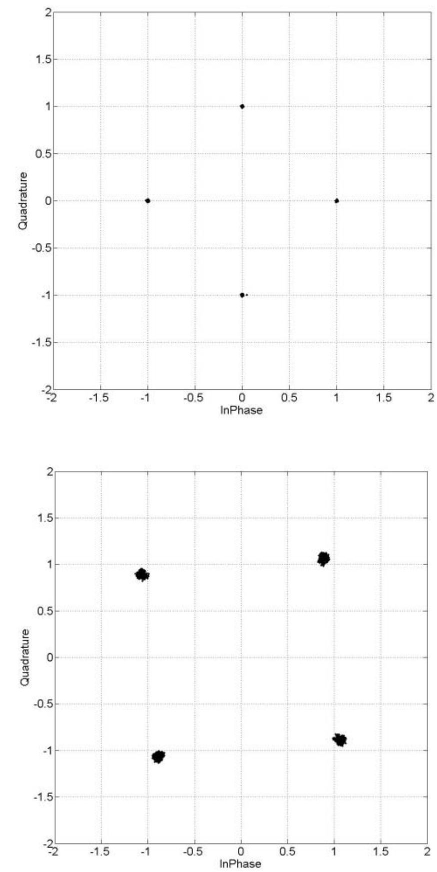

Figure 3 : (a) Modified OFDM transmitted signal constellation, (b) modified OFDM received signal constellation.

III. Distorted QPSK Mapped OFDM Radar Signal Time Delay Expected Value Calculation

In Fig. 3.b we can brightly see that even in all new modified OFDM symbols phase delay had the same impact, however there is still some distortion around the constellation poles. To prevent this distortion and calculate rotated angle more accurately, we simply have to extract an expected value of that rotated symbols (Fig. 4).

Simulations were done in Matlab environment with such parameterization: the carrier frequency $f_c = 24GHz$, OFDM symbol $T = 11\mu s$, guard interval $T_G = 1.375\mu s$. During the simulation our system generated a target with randomly selected actual distance $R_{act} = 248.1m$. Then from modified OFDM received signal we calculate rotated angle Fig 4. We get $\Delta\varphi_{meas} \approx 50.2^{\circ}$and consequently from (9) and (1) we get measured distance of the target from radar station $R_{meas} = 230m$. For absolute error we get

$$E_{\tau,abs} = |R_{act} - R_{means}| = 18.1m \quad (10)$$

And therefore relative percent error will be

$$E_{\tau,rel,\%} = \frac{E_{\tau,abs}}{R_{act}} \cdot 100\% \approx 7\% \tag{11}$$

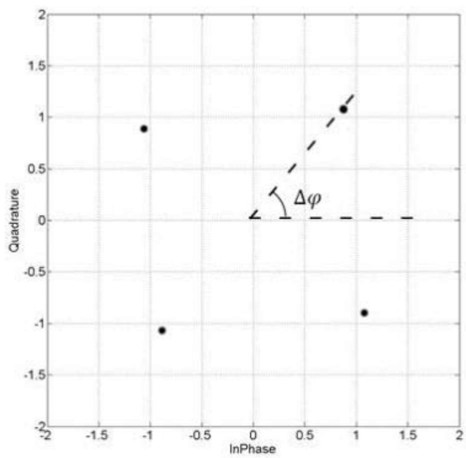

Figure 4 : The constellation of the modified OFDM received Q symbols estimated expected value.

IV. Conclusion

QPSK mapped OFDM modified signal processing let to solve target distance detection problem. Calculation process needs low computing resources because all processing could be done during one OFDM symbol.

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Some Exact Solutions of Non-Newtonian Fluid in Porous Medium with hall Effect Having Prescribed Vorticity Distribution Function

By Manoj Kumar
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Abstract- Two dimensional motion of an incompressible second grade fluid in a porous medium with Hall effects has been considered. Exact solutions are obtained via inverse method when vorticity distribution is proportional to stream function ψ, perturbed by a quadratic term.

Keywords: non-newtonian fluid, porous medium, hall effect, mhd, steady flow.

GJSFR-A Classification : *FOR Code: 040405*

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Keywords: non-newtonian fluid, porous medium, hall effect, mhd, steady flow.

I. Introduction

The study of magneto hydrodynamic (MHD) fluid flows has been a subject of great interest because of their applications in widespread fields like magneto hydrodynamic generators, designing cooling systems with liquid metals, geothermal energy extraction, handling of biological fluids, flow of nuclear fuel slurries, electromagnetic propulsion and flow of blood. A number of researchers (Noreen Sher Akbar, S. Nadeem, R. Ul Haq and Z. H. Khan[1], Manoj Kumar and C.Thakur[2]) worked on some interesting problems in these directions.

But the above studies cannot be implemented in the case of ionized gases because in ionized gases (where the density is low and the magnetic field is strong), there is a conductivity normal to the free spiraling of electrons and ions about the magnetic lines of force before suffering collisions; also, a current is induced in a direction normal to both electric and magnetic fields. This is what we call the Hall Effects. This study has interesting features in problems of MHD generators, Hall accelerators and flight magneto hydrodynamics. N. Ahmad and K. Kr. Das[3], R. K. Deka[4], M.A.M. Abdeen et.al.[5], Haider Zaman et.al.[6] discussed the Hall effects in different situations.

The flows of non-newtonian fluid through porous media have gained a lot of importance in recent years. The flow through porous medium has lot of applications in engineering and science such as groundwater hydrology, petroleum engineering, reservoir engineering, chemical reactors, agricultural irrigation and drainage and recovery of crude oil from the pores of reservoir rocks.

Navier-Stokes equations are inherently non-linear partial differential equations has non general solution and only a small number of exact solutions have been found because the nonlinear inertial terms do not disappear automatically. Exact solutions are very important not only because they are solutions of some fundamental flows but also they serve as accuracy checks for experimental, numerical and asymptotic methods. So in order to perform this task one adopt transformations, inverse or semi-inverse method for the reformulation of equations in solvable form. Some researchers have used hodograph transformation[7,8] in order to linearize the system of governing equations and got some exact solutions. Some authors have used inverse method where some a priory condition is assumed about the flow variables and have found some exact solutions. This method has been extensively used by many researchers for the first grade fluid such as Chandna[9], M. Jamil et.al.[10,11] and others. In case of second grade fluid T. Hayat et.al.[12] applied this method to find some exact solutions. Benharbit and Siddiqui[13] used this method to study steady and unsteady second grade fluid flow by taking vorticity function of the form $\nabla^2\psi=k(\psi-Uy)$. Islam, Mohyuddin and Zhou[14] taking the same form of vorticity function studied the non-newtonian fluid in porous medium with Hall Effect. Further this method was also used by Chandna and Ukpong[15], A.M. Siddiqui et.al.[16], B.Singh and C. Thakur[17], Rana Khalid Naeem[18] , Manoj Kumar et.al.[19] in the study of second grade fluid flow.

In this paper we have studied second grade electrically conducting fluid flow in porous media with Hall Effect. The equations are modeled and solved by assuming the vorticity function proportional to the stream function perturbed by a quadratic stream $B(Cx+Dy+Ey^2)$. We have also found exact solution for finitely conducting steady and unsteady fluid flow.

II. Basic Flow Equation

The basic equations governing the motion of second grade electrically electrically conducting fluid flow in porous media with Hall Effect are given by :

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0 \tag{1}$$

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$$\frac{\partial p^*}{\partial x}+\rho\left[\frac{\partial u}{\partial t}-v\omega\right]=\left(\mu+\alpha_1\frac{\partial}{\partial t}\right)\nabla^2 u-\frac{1}{K}\left(\mu+\alpha_1\frac{\partial}{\partial t}\right)u-\alpha_1 v\nabla^2\omega-\frac{\sigma B_0^{\ 2}}{1+\varphi^2}(u-\varphi v), \tag{2}$$

$$\frac{\partial p^*}{\partial y}+\rho\left[\frac{\partial v}{\partial t}+u\omega\right]=\left(\mu+\alpha_1\frac{\partial}{\partial t}\right)\nabla^2 v-\frac{1}{K}\left(\mu+\alpha_1\frac{\partial}{\partial t}\right)v+\alpha_1 u\nabla^2\omega-\frac{\sigma B_0^{\ 2}}{1+\varphi^2}(v+\varphi u), \tag{3}$$

where $u=u(x, y, t)$, $v=v(x, y, t)$ are the velocity components, $p^*=p^*(x, y, t)$ is the pressure field, μ is the viscosity of the fluid, α_1 is the normal stress moduli, K is the permeability, $\varphi = \sigma B_0/en_e$ is the Hall parameter, σ is the electrical field conductivity, B_0 is the magnetic field, e is the electric charge and n_e is the number density of electrons.

In equations (2) – (3), the vorticity and the modified pressure are given respectively as

$$\omega=\frac{\partial v}{\partial x}-\frac{\partial u}{\partial y}, \tag{4}$$

$$p^*=\frac{\rho}{2}|\mathbf{v}|^2+p-\alpha_1\left[u\nabla^2 u+v\nabla^2 v+\frac{1}{4}|A_1|^2\right], \tag{5}$$

where,

$$|A_1|^2=4\left(\frac{\partial u}{\partial x}\right)^2+4\left(\frac{\partial v}{\partial y}\right)^2+2\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)^2 \tag{6}$$

These systems of equations have three unknowns u, v, and p. Once the velocity field is determined, the pressure field (5) can be found by integrating equations (2) and (3). The continuity equation (1) implies the existence of stream function $\psi(x, y, t)$ such that

$$u=\frac{\partial\psi}{\partial y},\quad v=-\frac{\partial\psi}{\partial x}. \tag{7}$$

Using integrability condition $\partial^2 p^*/\partial x\partial y = \partial^2 p^*/\partial y\partial x$, equation (2) and (3) reduces to

$$\rho\left[\frac{\partial}{\partial t}(\nabla^2\psi)-\{\psi,\nabla^2\psi\}\right]=\left(\mu+\alpha_1\frac{\partial}{\partial t}\right)\nabla^4\psi-\frac{1}{K}\left(\mu+\alpha_1\frac{\partial}{\partial t}\right)\nabla^2\psi-\alpha_1\{\psi,\nabla^4\psi\}-\frac{\sigma B_0^2}{1+\varphi^2}\nabla^2\psi\ . \tag{8}$$

In equation (8) if $K\to\infty$, and neglecting the Hall effects, we obtain the Benharbit and Siddiqui [13] case. If $K\to\infty$, $\alpha_1=0$, and neglecting Hall effects in equation (8), we recover the viscous case equations of Hui[20].

III. Exact Solutions

We shall investigate fluid motion for which vorticity distribution is proportional to the stream function perturbed by the quadratic term in x and y as given by

$$\nabla^2\psi=A\left[\psi-B\left(Cx+Dy+Ey^2\right)\right], \tag{9}$$

where A,B,C,D and E are constants but $A\neq 0$. The special case of $A=0$ corresponds to an irrotational flow.

Introducing this value equation (8) reduces to

$$A\left(\rho-\alpha_1 A-\frac{\alpha_1}{K}\right)\psi_t+\rho BA\{(D+2Ey)\psi_x-\psi_y C\}-\alpha_1 A^2 B\{(D+2Ey)\psi_x-C\psi_y\}=$$

$$\mu A^2\left\{\psi-B\left(Cx+Dy+Ey^2\right)-\frac{2BE}{A}\right\}-\frac{\sigma B_0^2}{1+\varphi^2}A\left[\psi-B\left(Cx+Dy+Ey^2\right)\right]-\frac{\mu A}{K}\left\{\psi-B\left(Cx+Dy+Ey^2\right)\right\}$$

Letting $\Psi=\psi-B\left(Cx+Dy+Dy^2\right)$, the equation reduces to

$$A\left(\rho-\alpha_1 A-\frac{\alpha_1}{K}\right)\Psi_t+\left(\rho BA-\alpha_1 A^2 B\right)\{(D+2Ey)\Psi_x-C\Psi_y\}=\mu A^2\left\{\Psi-\frac{2BE}{A}\right\}-\frac{\mu A}{K}\Psi-\frac{\sigma B_0^2}{1+\varphi^2}A\Psi \tag{10}$$

Also,

$$\nabla^2\Psi=A\Psi-2BE. \tag{11}$$

In equation (10) if $B=0$, $\alpha_1=0$ & $K\to\infty$ and neglecting the Hall effects we obtain the Taylor [20] case. If $\alpha_1=0$, $D=E=0$, $K\to\infty$ and in the case of Hall effects equation (10) reduces to Hui[21] case. Also if $K\to\infty$ and neglecting the Hall effects we obtain the Benharbit and Siddiqui [13] case. Putting $D=E=0$, we reproduce the S. Islam et.al.[14] case.

Dividing equation (10) by A, we have

$$\left(\rho-\alpha_1 A-\frac{\alpha_1}{K}\right)\Psi_t+\left(\rho B-\alpha_1 AB\right)\{(D+2Ey)\Psi_x-C\Psi_y\}=\delta\left(\Psi-\frac{2\mu BE}{\delta}\right), \tag{12}$$

where,

$$\delta = \left\{ \frac{\mu(1+\varphi^2)(KA-1) - \sigma B_0^2 K}{K(1+\varphi^2)} \right\}. \quad (13)$$

a) Creeping Flow

For creeping flow, we have from equation (12),

$$\delta\left(\Psi - \frac{2\mu BE}{\delta}\right) = 0.$$

Since $\delta \neq 0$, we must have $\Psi = \frac{2\mu BE}{\delta}$.

Hence, $\psi = B(Cx + Dy + Ey^2) + \frac{2\mu BE}{\delta}$. (14)

The stream function (14) gives the exact solutions

u = B(D+2Ey),

v = -BC,

$$p = p_0 - \frac{\rho}{2}B^2(C^2+D^2) - 2\alpha_1 B^2 E^2 + B\left[2\rho BCE - \frac{\mu D}{K} - \frac{\sigma B_0^2}{1+\varphi^2}(D+\varphi C)\right]x - 2BE\left[\frac{\mu}{K} + \frac{\sigma B_0^2}{1+\varphi^2}\right]xy + B\left[\frac{\mu C}{K} - \frac{\sigma B_0^2}{1+\varphi^2}(\varphi D - C)\right]y - BE\left[\frac{\sigma B_0^2}{1+\varphi^2}\varphi\right]y^2.$$

b) Steady Flow

For steady flow we have $\Psi_t = 0$, so the system of equations (12) and (11) can be written as

$$(\rho B - \alpha_1 AB)\{(D+2Ey)\Psi_x - C\Psi_y\} = \delta\left(\Psi - \frac{2\mu BE}{\delta}\right), \quad (15)$$

&

$$\nabla^2\Psi = A\Psi - 2BE, \quad (16)$$

We now introduce the following co-ordinate transformations

$$\Psi = \psi - B(Cx + Dy + Ey^2)$$

$$\xi = Cx + Dy + Ey^2$$

$$\eta = y$$

Equation (15) and (16) respectively reduces to

$$(\rho - \alpha_1 A)BC\Psi_\eta = \delta\left(\Psi - \frac{2\mu BE}{\delta}\right), \quad (17)$$

$$\{C^2 + (D+2E\eta)^2\}\Psi_{\xi\xi} + 2(D+2E\eta)\Psi_{\xi\eta} + 2E\Psi_\xi + \Psi_{\eta\eta} = \delta\left(\Psi - \frac{2\mu BE}{\delta}\right). \quad (18)$$

Case I :

One of the solution of equation (17), when, $(\rho - \alpha_1 A) = 0$, is

$$\Psi = \frac{2\mu BE}{\delta}.$$

Hence, $\psi = B(Cx + Dy + Ey^2) + \frac{2\mu BE}{\delta}$.

The stream function gives the exact solutions

u = B(D+2Ey),

v = -BC,

$$p = p_0 - \frac{\rho}{2}B^2(C^2+D^2) - 2\alpha_1 B^2 E^2 + B\left[2\rho BCE - \frac{\mu D}{K} - \frac{\sigma B_0^2}{1+\varphi^2}(D+\varphi C)\right]x - 2BE\left[\frac{\mu}{K} + \frac{\sigma B_0^2}{1+\varphi^2}\right]xy + B\left[\frac{\mu C}{K} - \frac{\sigma B_0^2}{1+\varphi^2}(\varphi D - C)\right]y - BE\left[\frac{\sigma B_0^2}{1+\varphi^2}\varphi\right]y^2.$$

Case II :

When $(\rho - \alpha_1 A) \neq 0$, solving equation (17) (By variable separable method) we get

$$\Psi = \frac{2\mu BE}{\delta} + g(\xi)e^{\lambda\eta}, \quad (19)$$

where, $\lambda = \left\{ \frac{\mu(1+\varphi^2)(KA-1) - \sigma B_0^2 K}{K(1+\varphi^2)(\rho - \alpha_1 A)BC} \right\}$. (20)

To find g(ξ), we substitute equation (19) in to equation (18) and get

$$e^{\lambda\eta}\left[\{C^2 + (D+2E\eta)^2\}g''(\xi) + \{2\lambda(D+2E\eta) + 2E\}g'(\xi) + (\lambda^2 - \delta)g(\xi)\right] = 0. \quad (21)$$

Since ξ, η are independent variables, we must have two cases $E = 0$, $g'(\xi) = 0$.

Case IIa: In this case $E = 0$ and equation (21) becomes

$$(C^2 + D^2)g''(\xi) + 2\lambda D g'(\xi) + (\lambda^2 - \delta)g(\xi) = 0 \quad (22)$$

The solution of (22) combined with equation (19) and also using $\Psi = \psi - B\left(Cx + Dy + Ey^2\right)$, $\xi = Cx + Dy + Ey^2$, $\eta = y$ and taking $E = 0$, we obtain the stream function as :

$$\psi(x,y) = B(Cx + Dy) + A_1 e^{m_1(Cx+Dy)+\lambda y} + A_2 e^{m_2(Cx+Dy)+\lambda y} \text{ for } M > 0, \tag{23.1}$$

$$= B(Cx + Dy) + (B_1 + B_2(Cx + Dy))e^{m_3(Cx+Dy)+\lambda y} \text{ for } M = 0, \tag{23.2}$$

$$= B(Cx + Dy) + C_1 e^{\alpha(Cx+Dy)+\lambda y}\cos(\beta(Cx + Dy) + C_2) \text{ for } M < 0, \tag{23.3}$$

where,

$$M = \lambda^2 D^2 - (C^2 + D^2)(\lambda^2 - \delta^2),$$

$$m_1 = \frac{-\lambda D + \sqrt{M}}{(C^2 + D^2)}, m_2 = \frac{-\lambda D - \sqrt{M}}{(C^2 + D^2)}, m_3 = \frac{-\lambda D}{(C^2 + D^2)},$$

$$\alpha = \frac{-\lambda D}{(C^2 + D^2)}, \beta = \frac{\sqrt{M}}{(C^2 + D^2)}.$$

A_1, A_2, B_1, B_2, C_1 and C_2 are arbitrary constants.

It is noted that the results of S. Islam et.al. (2008) can be recovered as special case by taking C=0 and appropriately choosing the value of constants in the present result.

The exact solution given by equation (23.1) when $M > 0$

$$u = \left[BD + A_1(m_1 D + \lambda)e^{m_1 Cx + (m_1 D+\lambda)y} + A_2(m_2 D + \lambda)e^{m_2 Cx + (m_2 D+\lambda)y}\right], \tag{24.1}$$

$$v = -\left[BC + A_1 m_1 C e^{m_1 Cx + (m_1 D+\lambda)y} + A_2 m_2 C e^{m_2 Cx + (m_2 D+\lambda)y}\right]. \tag{24.2}$$

The exact solution given by equation (23.2) when $M = 0$

$$u = \left[BD + B_2 D e^{m_3 Cx + (m_3 D+\lambda)y} + \{B_1 + B_2(Cx + Dy)\}(m_3 D + \lambda)e^{m_2 Cx + (m_2 D+\lambda)y}\right]. \tag{25.1}$$

$$v = -\left[BC + B_2 C e^{m_3 Cx + (m_3 D+\lambda)y} + \{B_1 + B_2(Cx + Dy)\}m_3 C e^{m_2 Cx + (m_2 D+\lambda)y}\right], \tag{25.2}$$

And equation (23.3) gives the exact solution for $M < 0$

$$u = \left[BD + C_1(\alpha D + \lambda)e^{\alpha Cx + (\alpha D+\lambda)y}\cos(\beta(Cx + Dy) + C_2) + C_1\beta e^{\alpha Cx + (\alpha D+\lambda)y}\sin(\beta(Cx + Dy) + C_2)\right]. \tag{26.1}$$

$$v = -\left[BC + C_1\alpha C e^{\alpha Cx + (\alpha D+\lambda)y}\cos(\beta(Cx + Dy) + C_2) - C_1\beta e^{\alpha Cx + (\alpha D+\lambda)y}\sin(\beta(Cx + Dy) + C_2)\right]. \tag{26.2}$$

In all the above cases p can be calculated by putting the value of u and v in equation (5).

Case IIb: In this case we take $g'(\xi) = 0$, which implies $g(\xi) = a_\circ$, where $a_\circ \neq 0$ is an arbitrary constant and $\delta = \lambda^2$, using this in equation (19), $\Psi = \psi - B\left(Cx + Dy + Ey^2\right)$ and $\eta = y$ we get stream function $\psi = \dfrac{2\mu BE}{\lambda^2} + B\left(Cx + Dy + Ey^2\right) + a_0 e^{\lambda}$, (27)

Hence, we get the exact solution as:

$$u = \left[B(D + 2Ey) + a_0\lambda e^{\lambda y}\right],$$

$$v = -BC, \tag{28}$$

Also p can be calculated by putting the value of u and v in equation (5).

Discussion

Solution (23.1) represents a uniform flow in (x, y) plane, in the region $y > 0$, perturbed by a part which grows and decays exponentially as y increases if $\lambda \rangle 0$ and $\lambda \langle 0$, respectively. The reverse holds true for the region $y < 0$, and the flow is exponential in x and y in both cases. The solution (23.2) can be used to describe, in $y > 0$, a uniform flow plus a different type of perturbation which again grows and decays as y increases in the same as in (23.2). Solution (23.3) represents a uniform flow with a perturbation part which is periodic in x and y and grows and decays exponentially as y increases, respectively, when $\lambda \rangle 0$ and $\lambda \langle 0$ for the region $y > 0$. A similar description can be given for a flow in $y < 0$.

c) *Unsteady Flow*

By rewriting equation (12) in the form

$$\frac{\partial \Psi}{\partial t} + U_1\left\{(D + 2Ey)\frac{\partial \Psi}{\partial x} - C\frac{\partial \Psi}{\partial y}\right\} = \gamma\left(\Psi - \frac{2\mu BE}{\delta}\right), \tag{29}$$

where,

$$\gamma=\left\{\frac{\mu\left(1+\varphi^2\right)(KA-1)-\sigma B_0^2K}{K\left(1+\varphi^2\right)(\rho-\alpha_1A-\alpha_1/K)}\right\},$$

$$U_1=\frac{(\rho B-\alpha_1 AB)}{(\rho-\alpha_1A-\alpha_1/K)} \quad . \tag{30}$$

Solving equation (29) by variable separable method we get

$$\Psi=F(X,Y)e^{\gamma t}+\frac{2\mu BE}{\delta}, \tag{31}$$

where F(X, Y) is an unknown function to be determined and

$$X=x-U_1(D+2Ey)t,\quad Y=y+U_1Ct. \tag{32}$$

Putting the value of Ψ in equation (16)

$$\nabla^2\left[F(X,Y)e^{\gamma t}+\frac{2\mu BE}{\delta}\right]=A\left[F(X,Y)e^{\gamma t}+\frac{2\mu BE}{\delta}\right]-2BE,$$

$$F_{XX}+F_{YY}=AF(X,Y)+2EB\left(\frac{\mu A}{\rho}-1\right)e^{-\gamma t}. \tag{33}$$

Plane wave solution of Helmholtz equation (33) exist in the form

$$F(X,Y)=g(\xi),\ \xi=X\cos\theta+Y\sin\theta,\ -\pi\le\theta\le\pi \tag{34}$$

Using equation (34) in equation (33) we obtain

$$g''(\xi)-Ag(\xi)=2EB\left(\frac{\mu A}{\delta}-1\right)e^{-\gamma t} \quad . \tag{35}$$

Following cases arises:
Case I: When A=0

$$g(\xi)=-2EBe^{-\gamma t}\frac{\xi^2}{2}+C_1\xi+C_2, \tag{36}$$

where C_1 and C_2 are arbitrary constants depending on θ.
A combination of (36) with (34) gives
.
This relation with (32),(31) and $\Psi=\psi-B\left(Cx+Dy+Ey^2\right)$ gives stream function as

$$\psi=-EB\xi^2+(C_1\xi+C_2)e^{\gamma t}+\frac{2\mu BE}{\delta}+B\left(Cx+Dy+Ey^2\right), \tag{37}$$

where,

$$\xi=\{x-U_1(D+2Ey)t\}\cos\theta+\{y+U_1Ct\}\sin\theta\ ,$$

$$\gamma=\frac{-\mu\left(1+\varphi^2\right)-\sigma B_0^2K}{K\left(1+\varphi^2\right)\left(\rho-\alpha_1/K\right)},$$

$$U_1=\frac{\rho B}{\left(\rho-\alpha_1/K\right)}.$$

Hence we get exact solutions as

$$u=-2EB\xi\left(-U_12Et\cos\theta+\sin\theta\right)+C_1\left(-U_12Et\cos\theta+\sin\theta\right)+B(D+2Ey),$$

$$v=-2EB\xi\cos\theta-C_1e^{\gamma t}\cos\theta-BC.$$

P can be calculated by putting the value of u and v in equation (5).
Case II: If $A=\Omega^2\rangle 0$ then solution of equation (35) is

$$g(\xi)=D_1e^{\Omega\xi}+D_2e^{-\Omega\xi}+2EB\left(\Omega^2-1\right)e^{-\gamma t}\left(\frac{\xi^2}{2}-\frac{\Omega^2\xi^4}{24}\right), \tag{38}$$

where D_1 and D_2 are arbitrary constants depending on θ.

Combining (38) with equation (34)

$$F(X,Y)=D_1e^{\Omega\xi}+D_2e^{-\Omega\xi}+2EB\left(\Omega^2-1\right)e^{-\gamma t}\left(\frac{\xi^2}{2}-\frac{\Omega^2\xi^4}{24}\right).$$

Putting this value in (31) and using $\Psi=\psi-B\left(Cx+Dy+Ey^2\right)$ we get stream function as

$$\psi=\left(D_1e^{\Omega\xi}+D_2e^{-\Omega\xi}\right)e^{\gamma t}+\frac{1}{12\delta}EB\left(\Omega^2-1\right)\left(12\xi^2-\Omega^2\xi^4\right)+\frac{2\mu BE}{\delta}+B\left(Cx+Dy+Ey^2\right),$$

where,

$$\xi=\left\{x-U_1\left(D+2Ey\right)t\right\}\cos\theta+\left\{y+U_1Ct\right\}\sin\theta,$$

$$\gamma=\frac{\mu\left(1+\varphi^2\right)\left(K\Omega^2-1\right)-\sigma B_0^2K}{K\left(1+\varphi^2\right)\left(\rho-\alpha_1\Omega^2-\alpha_1/K\right)},$$

$$U_1=\frac{\rho B-\alpha_1\Omega^2B}{\left(\rho-\alpha_1\Omega^2-\alpha_1/K\right)}.$$

Hence we get velocity components as

$$u=\left(D_1e^{\Omega\xi}-D_2e^{-\Omega\xi}\right)e^{\gamma t}\Omega\left(-U_12Etcos\theta+\sin\theta\right)+\frac{1}{12}EB\left(\Omega^2-1\right)\left(24\xi-4\Omega^2\xi^3\right)\left(-U_12Etcos\theta+\sin\theta\right)+B\left(D+2Ey\right)$$

$$v=-\left(D_1e^{\Omega\xi}-D_2e^{-\Omega\xi}\right)e^{\gamma t}\Omega\cos\theta-\frac{1}{12}EB\left(\Omega^2-1\right)\left(24\xi-4\Omega^2\xi^3\right)\cos\theta-BC.$$

Also p can be calculated using equation (5).

Case III: If $A=-\Omega^2\langle 0$, then the general function for $g(\xi)$ is

$$g(\xi)=B_1\cos\Omega(\xi+B_2(\theta))+\left(\frac{\xi^2}{2}+\frac{\Omega^2\xi^4}{24}\right)2EB\left(-\Omega^2-1\right)e^{-\gamma t}, \qquad (39)$$

where B_1 and B_2 are arbitrary constants depending on the parameter θ.

Combining equation (39) with equation (34) we get

$$F(X,Y)=B_1\cos\Omega(\xi+B_2(\theta))+\left(\frac{\xi^2}{2}+\frac{\Omega^2\xi^4}{24}\right)2EB\left(-\Omega^2-1\right)e^{-\gamma t}$$

Putting this value in equation (31) and using $\Psi=\psi-B\left(Cx+Dy+Ey^2\right)$ we get stream function as

$$\psi=\left\{B_1\cos\Omega\left(\xi+B_2(\theta)\right)\right\}e^{\gamma t}+\frac{1}{12\delta}EB\left(12\xi^2+\Omega^2\xi^4\right)\left(-\Omega^2-1\right)+\frac{2\mu BE}{}+B\left(Cx+Dy+Ey^2\right),$$

where,

$$\xi=\left\{x-U_1\left(D+2Ey\right)t\right\}\cos\theta+\left\{y+U_1Ct\right\}\sin\theta,$$

$$\gamma=\frac{\mu\left(1+\varphi^2\right)\left(-K\Omega^2-1\right)-\sigma B_0^2K}{K\left(1+\varphi^2\right)\left(\rho+\alpha_1\Omega^2-\alpha_1/K\right)},$$

$$U_1=\frac{\rho B+\alpha_1\Omega^2B}{\left(\rho+\alpha_1\Omega^2-\alpha_1/K\right)}.$$

Hence we get exact solutions as

$$u=-\Omega\sin\theta\left\{B_1\cos\Omega\left(\xi+B_2(\theta)\right)\right\}e^{\gamma t}+\frac{1}{12}EB\left(24\xi+4\Omega^2\xi^3\right)\left(-\Omega^2-1\right)\left(-U_{12}Etcos\theta+\sin\theta\right)+B\left(D+2Ey\right),$$

$$v=-\Omega\cos\theta\{B_1\cos\Omega(\xi+B_2(\theta)\}e^{\gamma t}-\frac{1}{12}EB\left(24\xi+4\Omega^2\xi^3\right)\left(-\Omega^2-1\right)\cos\theta+BC$$

P can be calculated by putting the values of u and v in equation (5).

IV. Conclusion

In this paper we have found the exact solutions of the governing equations of incompressible second grade fluid in a porous medium with the Hall currents under the assumption that vorticity distribution is proportional to the stream function perturbed by a quadratic term. We recovered the solutions of Benharbit and Siddiqui[13], Hui[21] and Islam, Mohyuddin and Zhou[14] in limiting cases if the corresponding conditions are applied. Our solutions are compatible in a limiting case with those of Benharbit and Siddiqui, Hui and Islam et.al. Expressions for streamlines, velocity components and pressure fields are defined in each case. Our solutions are more general and several results of various authors can be recovered in a limiting case.

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Search for Four-Charged Lepton from Decay Doubly-Charged Higgs Pair Production at the Hadron Colliders

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Abstract- The Left-Right symmetry Model (LRSM) is an extension of the Standard Model based on the gauge symmetry group SU(3)C × SU(2)L × SU(2)R × U(1)B-L predicts by existence new particles like doubly-charged Higgs boson, W' new charged boson, Z' new neutral boson and heavy neutrinos. In this work we present an analysis for production four-charged lepton in final state produced via decaying a pair of doubly-charged Higgs boson in the context of LRSM by using Monte Carlo simulation Techniques at both the Large Hadron Collider (proton-proton collisions) and the Fermilab Tevatron Collider (proton-antiproton collisions). In this analysis we assume that the branching ratio of decay channels of left-handed or right-handed doubly-charged Higgs boson BR ($H^{\pm\pm} \rightarrow \ell^{\pm}\ell^{\pm} = 100\%, \ell = e^{\pm}, \mu^{\pm}, \tau^{\pm}$). We carry out a Monte Carlo study of the (Left or Right) doubly charged Higgs pair production and decay to four-charged lepton via the process $pp(\bar{p}) \rightarrow H^{\pm\pm}H^{\pm\pm} \rightarrow \ell^{\pm}\ell^{\pm}\ell^{\pm}\ell^{\pm}$, $\ell = e^{\pm}, \mu^{\pm}, \tau^{\pm}$. From Monte Carlo simulation level the doubly-charged Higgs may be found at the LHC or at the Tevatron in the mass range up to 800 GeV.

Keywords: *LHC, tevatron, left-right model, doubly charged higgs, monte carlo simulation.*

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SEARCHFORFOURCHARGEDLEPTONFROMDECAYDOUBLY-CHARGEDHIGGSPAIRPRODUCTIONATTHEHADRONCOLLIDERS

Strictly as per the compliance and regulations of :

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Abstract- The Left-Right symmetry Model (LRSM) is an extension of the Standard Model based on the gauge symmetry group SU(3)C × SU(2)L × SU(2)R × U(1)B-L predicts by existence new particles like doubly-charged Higgs boson, W' new charged boson, Z' new neutral boson and heavy neutrinos. In this work we present an analysis for production four-charged lepton in final state produced via decaying a pair of doubly-charged Higgs boson in the context of LRSM by using Monte Carlo simulation Techniques at both the Large Hadron Collider (proton-proton collisions) and the Fermilab Tevatron Collider (proton-antiproton collisions). In this analysis we assume that the branching ratio of decay channels of left-handed or right-handed doubly-charged Higgs boson BR ($H^{\pm\pm} \to \ell^{\pm}\ell^{\pm} = 100\%, \ell = e^{\pm}, \mu^{\pm}, \tau^{\pm}$). We carry out a Monte Carlo study of the (Left or Right) doubly charged Higgs pair production and decay to four-charged lepton via the process $pp(\bar{p}) \to H^{\pm\pm}H^{\pm\pm} \to \ell^{\pm}\ell^{\pm}\ell^{\pm}\ell^{\pm},\ \ell = e^{\pm}, \mu^{\pm}, \tau^{\pm}$. From Monte Carlo simulation level the doubly-charged Higgs may be found at the LHC or at the Tevatron in the mass range up to 800 GeV.

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I. Introduction

Doubly-charged Higgs bosons $H^{\pm\pm}$ appear in several extensions beyond the Standard Model, in particular, in Left-Right Symmetric Model (LRSM) [1], in Higgs triplet models [2] and in Little-Higgs models [3]. In addition to the neutral Higgs boson, single charged and doubly-charged Higgs bosons are part of Higgs triplet. Both Higgs bosons may be reconstructed giving two like-charge pairs of leptons with similar invariant mass. Left-Right Symmetric Model predicts the appearance of a left- and a right-handed Higgs triplet both with hypercharge |Y| = 2. In this work we search for doubly-charged Higgs bosons decaying to pairs of electrons and/or muons. Pairs of isolated, high transverse momentum leptons with the same electric charge ($e^{\pm}e^{\pm}, \mu^{\pm}\mu^{\pm}, e^{\pm}\mu^{\pm}$) are selected, and their invariant mass distribution is searched for a narrow resonance. We use Monte Carlo (MC) event generator PYTHIA8 [4] for the simulation of signal and background processes either to generate a given hard interaction at leading order (LO), or for the simulation of showering and hadronization. Also we use MADGRAPH5 [5] to generate diboson and Drell–Yan events. The LRSM predicts dominant decay modes to like-charge lepton pairs $H^{\pm\pm} \to \ell^{\pm}\ell^{\pm}$. Pairs of doubly-charged Higgs bosons can be produced through the Drell-Yan process $(\bar{P}) \to \gamma^*/Z \to H^{--}H^{++}$. The observation of a doubly-charged scalar particle would establish the type II seesaw mechanism as the most promising framework for generating neutrino masses. The minimal type II seesaw model [6] is realized with an additional scalar field that is a triplet under SU(2)L and carries U(1)Y hypercharge Y = 2. The triplet contains a doubly-charged component $H^{\pm\pm}$, a singly-charged component $H^{\pm\pm}$ and a neutral component H^0. The masses of doubly-charged Higgs bosons are constrained depending on the branching ratio into these leptonic final states. A $H^{\pm\pm}$ particle can also occur as a singlet as proposed in the Zee-Babu model [7], where it is postulated for the purpose of generating Majorana neutrino masses. Assuming pair production, coupling to left-handed fermions, and a branching ratio of 100% for each final state.

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II. The Results

The process $pp(\bar{p}) \to H^{++}H^{--} \to \ell^{+}_{\alpha}\ell^{+}_{\beta}\ell^{-}_{\lambda}\ell^{-}_{\delta}$ is simulated using PYTHIA8 [8] event generator for Left-Right Symmetric model new particle $H^{\pm\pm}$. In order to obtain the full signal cross-section, a cut which PYTHIA applies by default on the transverse momentum P_T of the lepton. Left-handed and Right-handed states are distinguished through their decays into left-handed or right-handed leptons. The cross section also depends on the hypercharge Y of the $H^{\pm\pm}$ boson.

a) *Production Cross Section of $H^{\pm\pm}$ at the LHC and the Tevatron*

Figure (1-a) shows the production cross section of doubley-charged Higgs boson pair production and both of H^{++} and H^{--} decay to e^+e^+ and e^-e^- respectively. In this simulation we off all decay channel of $H^{\pm\pm}$, only decays to e^+e^+ and e^-e^- means BR ($H^{\pm\pm} \to e^{\pm}e^{\pm}$) = 1 and we calculate the production and decay of doubly charge Higgs boson (Right-handed and Left handed) at center of mass energies of the

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Large Hadron Collider (proton-proton collision) $\sqrt{s} =$ 7,8,10 and 12 TeV in addition to the production and decay at the Tevatron (proton- antiproton collision) $\sqrt{s} =$ 1.96 TeV, the mass values range here form 200 GeV to 1 TeV . From the Figure we see that the value of production decrease with increase the mass value at both the LHC and the Tevatron for right handed and left-handed doubly charged Higgs boson also the value of cross section at the Tevatron is small than at the LHC which increases with increasing the center of mass energy from 7 TeV to 12 TeV. In order to select events from well-measured collisions, the events are preselected by requiring at least two final-state light leptons, with pT > 30 GeV. If pairs of light leptons with invariant mass less than 12 GeV are reconstructed, neither of the particles is considered in the subsequent steps of the analysis. In Figures (1, b-c) show the production cross section of doubly-charged Higgs boson and decay to $e^{\pm}e^{\pm}, \mu^{\pm}\mu^{\pm}$ *and* $e^{\pm}\mu^{\pm}$ respectively, here the center of mass energy for the LHC is 14 TeV and at the Tevatron is 1.96 TeV we calculated for left-handed and right-handed doubly-charged Higgs boson in Left-Right Symmetric Model .

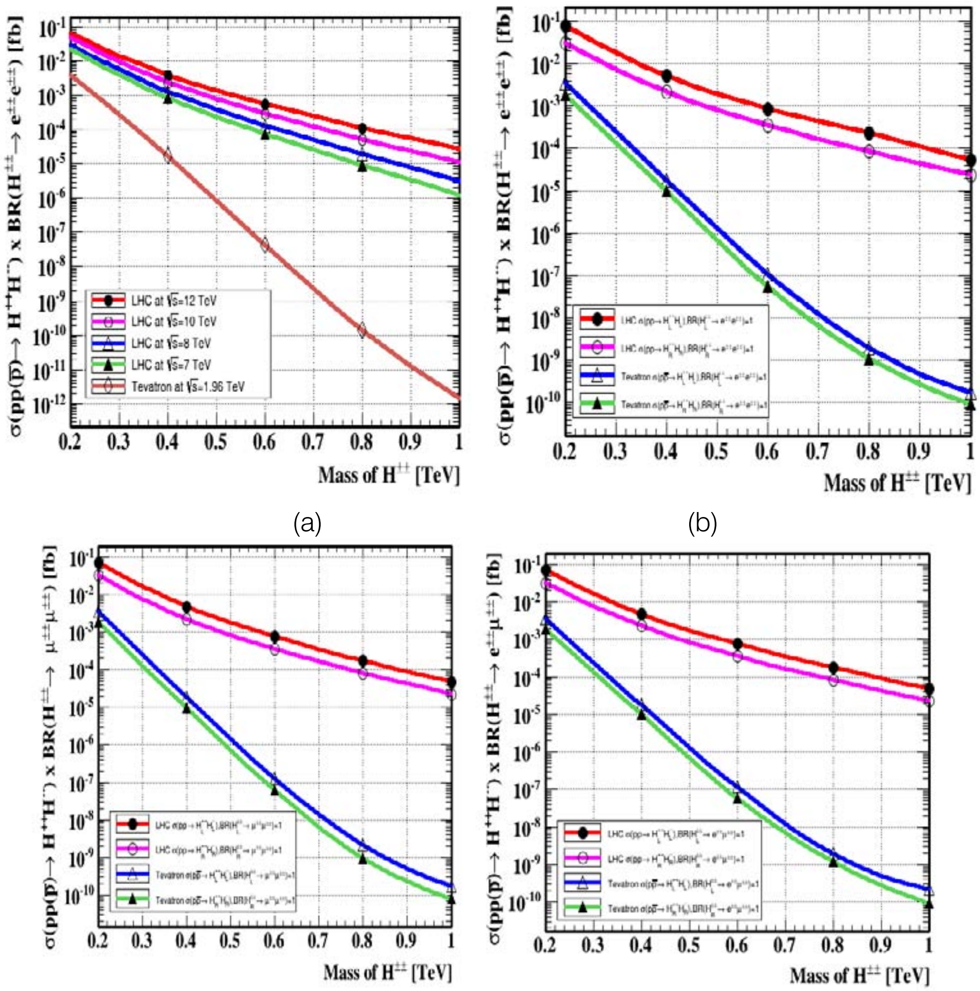


Figure 1 : The production cross section times branching ratio for pair production of $H_L^{\pm\pm}$ or $H_R^{\pm\pm}$ bosons at the LHC and the Tevatron decays to (a) $e^{\pm}e^{\pm}$ at the LHC energies 7,8,10 and 12 TeV and (b) $e^{\pm}e^{\pm}$ (c) $\mu^{\pm}\mu^{\pm}$ (d) $e^{\pm}\mu^{\pm}$ at 14 TeV (in the Left-Right Symmetric Model using Pythia8 and MadGraph5).

The main production mechanisms of $H^{\pm\pm}$ bosons at hadron colliders are pair roduction via an s-channel Z boson or photon exchange and associated production with a $H^{\pm\pm}$ boson via a W-boson exchange but in our work we study the production of $H^{\pm\pm}$ in concept of Left-Right Symmetric Model (LRSM) .

At D0 detector at the Fermilab Tevatron Collider. In the absence of an excess above the standard model background, lower mass limits M($H_L^{\pm\pm}$) >150 GeV/c2 and M($H_R^{\pm\pm}$) >127 GeV/c2. For left-handed and right-handed doubly-charged Higgs bosons assuming a 100% branching ratio into leptons BR($H^{\pm\pm} \rightarrow \ell^{\pm}\ell^{\pm} = 100\%, \ell = e^{\pm}, \mu^{\pm}, \tau^{\pm}$).

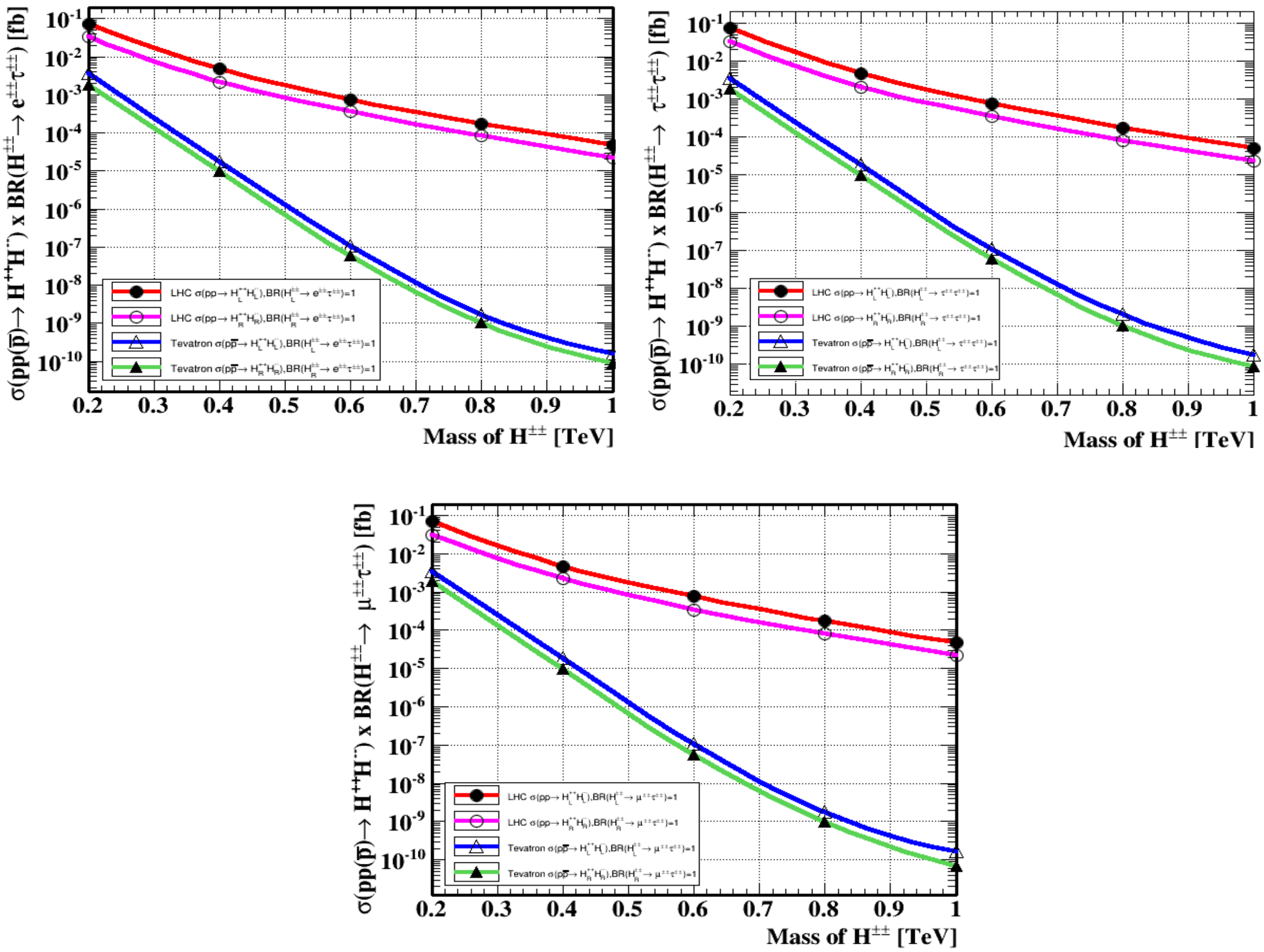


Figure 2 : The production cross section times branching ratio for pair production of $H_L^{\pm\pm}$ or $H_R^{\pm\pm}$ bosons at the LHC and the Tevatron decays to (a) $e^{\pm}\tau^{\pm}$ (b) $\mu^{\pm}e^{\pm}$ (c) $\tau^{\pm}\tau^{\pm}$ at $\sqrt{s} = 14$ TeV (in the Left-Right Symmetric Model using Pythia8 and MadGraph5).

b) Decay Width of $H^{\pm\pm}$

Doubly-charged Higgs bosons can couple to either left-handed or right-handed fermions. In Left-Right Symmetric Model, the two cases are distinguished and denoted $H_L^{\pm\pm}$ and $H_R^{\pm\pm}$. The $H^{\pm\pm}$ boson may decay to a pair of like-sign leptons whose invariant mass is consistent with the mass of $M(H^{\pm\pm})$. The partial decay width to leptons is given by:

$$\Gamma(H^{\pm\pm} \to \ell^{\pm}\ell^{\pm}) = k\frac{h_{\ell\ell'}^2}{16\pi}m(H^{\pm\pm})$$

Where k = 2 if both leptons have the same flavour ($\ell = \ell'$) and k = 1 if they have a different flavor. The factor $h_{\ell\ell'}$ is the coupling parameter.

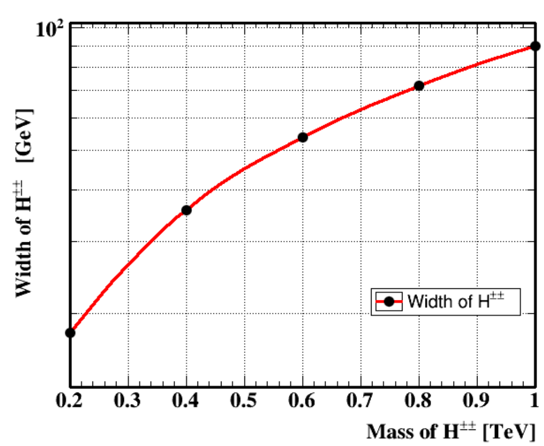


Figure 3 : Decay Width of $H^{\pm\pm}$ bosons as a function of $H^{\pm\pm}$ mass values (in the Left-Right Symmetric Model using Pythia8 and MadGraph5).

The electron identification uses a cut-based approach in order to reject jets misidentified as electrons, or electrons originating from photon conversions. In addition, electrons are required to have pT > 20 GeV and $|\eta| < 2.5$. For Muon candidates are required to have pT > 5 GeV and $|\eta| < 2.4$. Isolation of the final state leptons plays a key role in suppressing the SM backgrounds.

c) Branching Ratios of $H^{\pm\pm}$

The mass limits obtained for the $H^{\pm\pm}$ bosons depend on the ranching ratio (BR) assumed. The most stringent limits were set by the CMS Collaboration [9], masses below 382 GeV, 391 GeV, and 395 GeV for, $e^{\pm}e^{\pm}, \mu^{\pm}\mu^{\pm}$ *and* $e^{\pm}\mu^{\pm}$ final states, respectively, assuming left-handed couplings and a 100% branching ratio to each final state. In current work a search for a $H^{\pm\pm}$ boson decaying to pairs of electrons or muons or taus with the same electric charge $H^{\pm\pm} \to e^{\pm}e^{\pm}$, $H^{\pm\pm} \to \mu^{\pm}\mu^{\pm}$ and $H^{\pm\pm} \to \tau^{\pm}\tau^{\pm}$ is 12% but for electrons and muons and taus is 22% . Also the branching fraction of doubly-charged Higgs boson decay to W boson is small as shown in Figure (4)

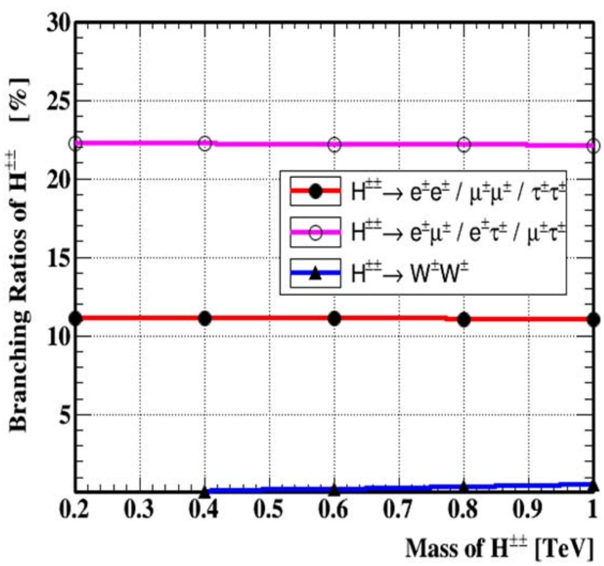


Figure 4 : Branching Ratios of $H^{\pm\pm}$ bosons as a function of $H^{\pm\pm}$ mass values (in the Left-Right Symmetric Model using Pythia8 and MadGraph5).

d) Dilepton Invariant Mass Distributions

Figure (5) shows the invariant mass distributions for the two leptons in final state produced from $H^{\pm\pm}$ bosons decay for different values of $H^{\pm\pm}$ masses at the LHC $\sqrt{s}$=14 TeV for $e^{\pm}e^{\pm}, \mu^{\pm}\mu^{\pm}$ *and* $e^{\pm}\mu^{\pm}$. The invariant mass of the lepton pair must be larger than 15 GeV, and for $e^{\pm}e^{\pm}$ the region close to the Z-boson mass (70 GeV < m($e^{\pm}e^{\pm}$) < 110 GeV) is excluded due to a large background from $Z \to e^{\pm}e^{\pm}$ events with an electron charge misidentification, as described below. The first limits on the $H_L^{\pm\pm}$ mass were derived based on the measurements done at PEP and PETRA experiments [11]. Next, the $H^{\pm\pm}$ was searched for at the MARK II detector at SLAC [12], the H1 detector at HERA [13] and the LEP experiments [14].

As we mentioned before the pair production cross section for left-handed doubly charged Higgs bosons for 200 GeV < M($H^{\pm\pm}$) < 800 GeV is larger than that for the right-handed states due to different couplings to the intermediate Z boson [10]. Leptons must have a transverse momentum above 30 GeV, in pairs where the higher transverse momentum lepton is an electron, it is required to have pT > 25 GeV. All pairs of electrons or muons with the same electric charge are considered, so more than one lepton pair may be reconstructed per event.

In our search we look for an excess of events in one or more flavor combinations of same-sign lepton pairs coming from the decays $H^{\pm\pm} \to \ell^{\pm}\ell'^{\pm}$ so the final states containing four charged leptons are considered. From the dilepton events to test the presence of a $H_L^{\pm\pm}$ boson at LHC and Tevatron through resonance search technique $M(\ell^{\pm}\ell^{\pm})$ analysis. By using PYTHIA8 we note 4 peaks correspond to four different values of $H_L^{\pm\pm}$ mass 200,400,600 and 800 GeV. The most important experimental signature of the $H^{\pm\pm}$ is the presence of two like-charge leptons in the final state, with a resonant structure in their invariant mass spectrum. In this final state the background from SM processes is expected to be very small. For the four-lepton final state from $H^{++}H^{--}$ pair production, both Higgs bosons may be reconstructed, giving two like-charge pairs of leptons with similar invariant mass.

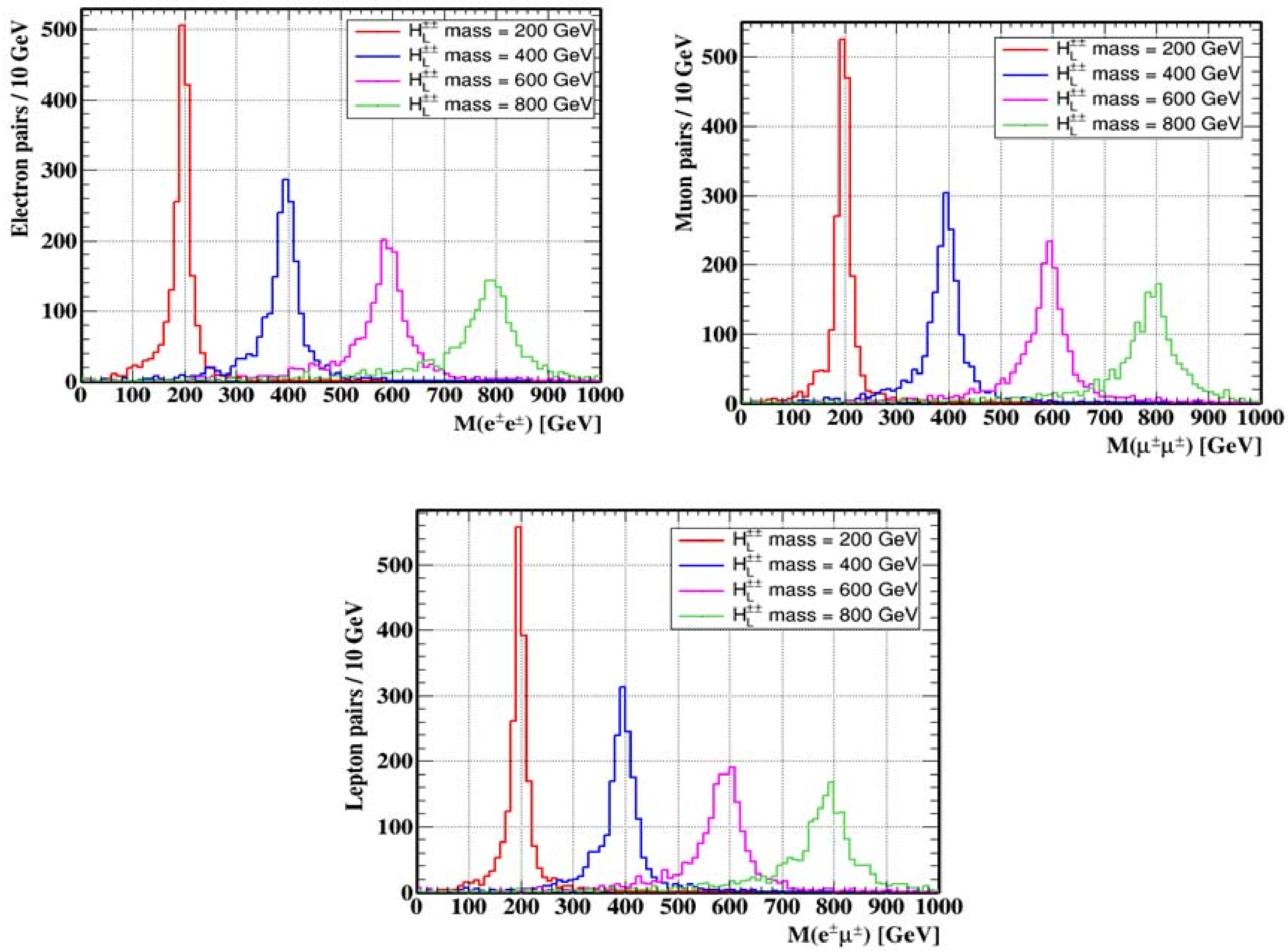


Figure 5 : Invariant mass distributions for two leptons in final state produced from $H_L^{\pm\pm}$ bosons decay for different values of $H_L^{\pm\pm}$ mass at the LHC $\sqrt{S}$=14 TeV (a) $e^{\pm}e^{\pm}$ (b) $\mu^{\pm}\mu$, (c) $e^{\pm}\mu^{\pm}$ (in the Left-Right Symmetric Model using Pythia8 and MadGraph5).

Experiments at the CERN LEP collider have searched for pair production of doubly charged Higgs bosons in $e^{\pm}e^{\pm}$ interactions. Mass limits for decays into muons of $M(H_L^{\pm\pm})$ >100.5 GeV/c2 and $M(H_R^{\pm\pm})$ >100.1 GeV/c2 were obtained by the OPAL collaboration [24], and a limit of M($H_{L(R)}^{\pm\pm}$) > 99.4 GeV/c2 by the L3 collaboration [25]. Similar limits were set for decays into electrons and τ-leptons [26]. Previous searches for $H^{\pm\pm}$ have been performed by the LEP collaborations in $e^{\pm}e^{\pm}$ collisions and by the D0 [27] and CDF [28] collaborations at the Tevatron $p\bar{p}$ collider.

e) Leptons Angular Distributions

Figure (6) shows the angular distribution of four leptons in final state of produced from the decay of pair doubly-charged Higgs boson events which act as forward and backward events for interaction. The angular distribution can also be used to test the presence of $H_L^{\pm\pm}$ boson at the LHC and the Tevatron, we see from the figure that there is a symmetry around value for different values of masses for $H_L^{\pm\pm}$.

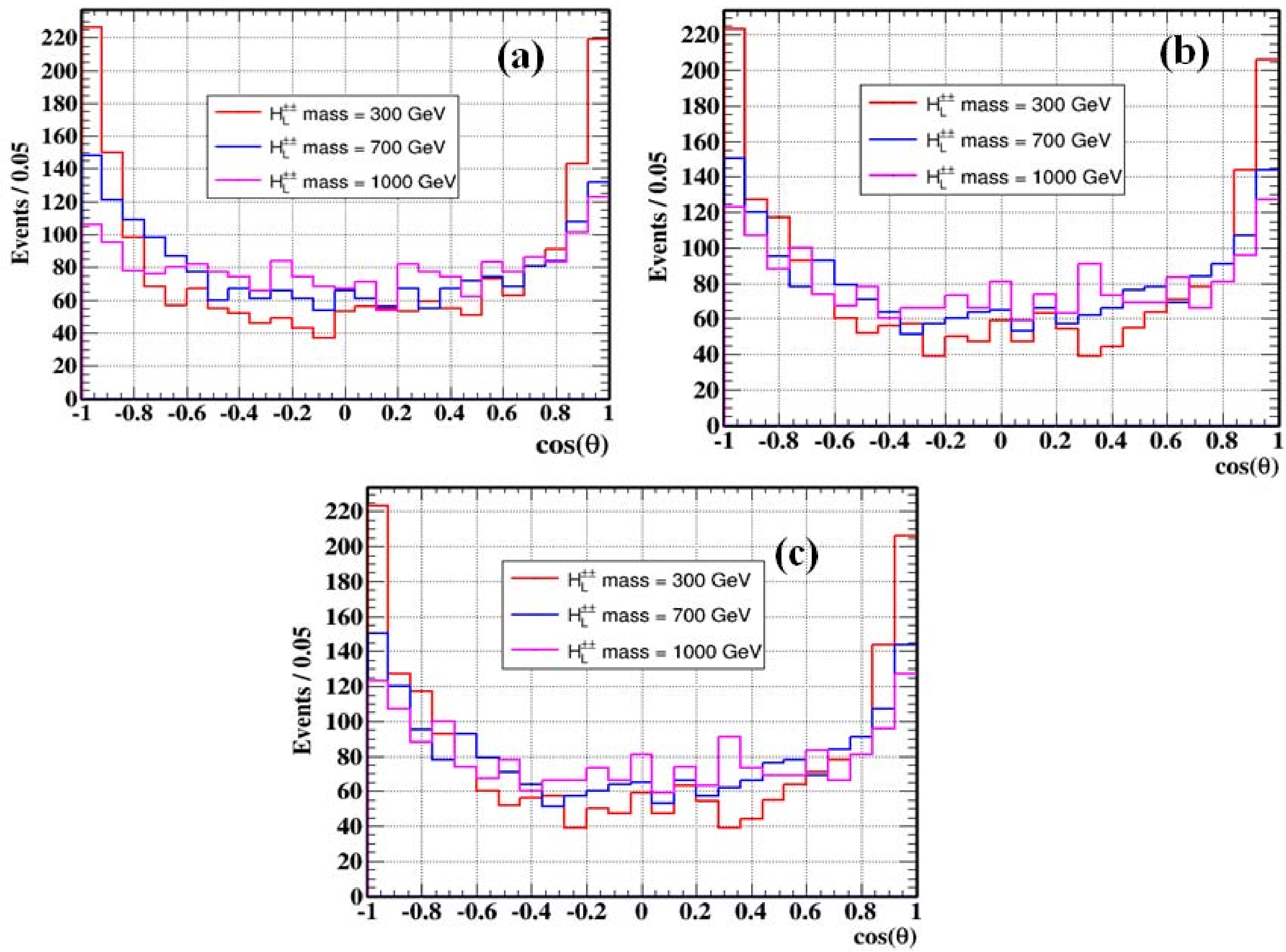
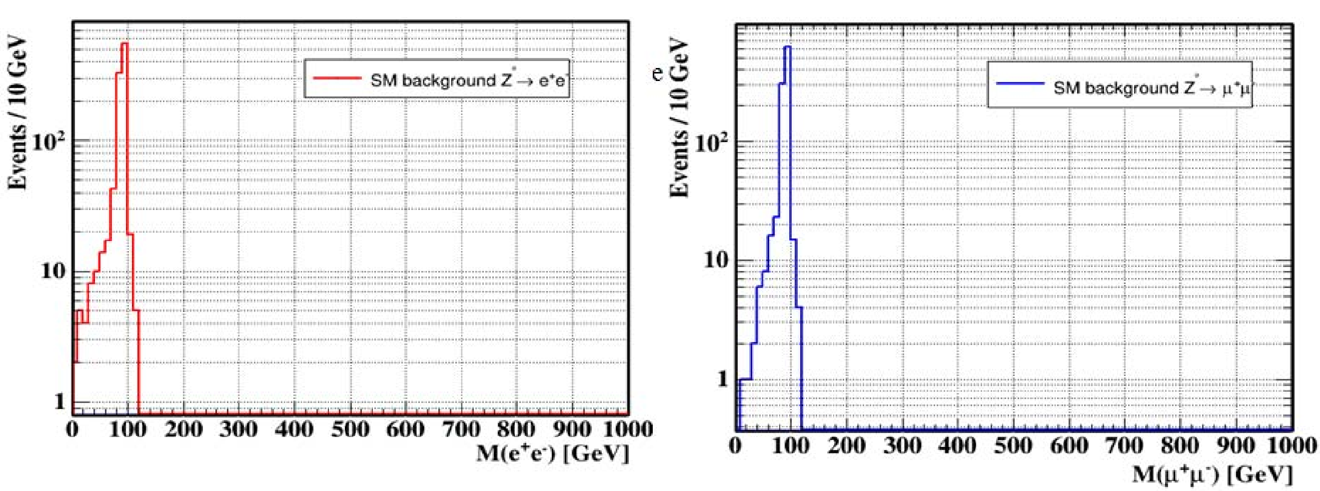


Figure 6 : Angular distribution (forward and backward) of leptons in the final state produced from doubly charged Higgs decay for M($H_L^{\pm\pm}$) =300,700 and 1000 GeV at the LHC $\sqrt{s}$=14 TeV (a) $e^{\pm}e^{\pm}$ (b) $\mu^{\pm}\mu^{\pm}$ (c) $e^{\pm}\mu^{\pm}$ (in the Left-Right Symmetric Model using Pythia8 and MadGraph5).

f) Standard Model Background

The dominant SM background comes from Zo decay. Figure (7) shows the generated $e^{\pm}e^{\pm}$, $\mu^{\pm}\mu^{\pm}$ *and* $e^{\pm}\mu^{\pm}$ events for a reconstructed mass of 300 GeV for SM Zo. We note that there is a peak centered around 100 GeV. According to the SM this peak corresponds to the production of a Zo with a mass of 91.188 GeV. This process



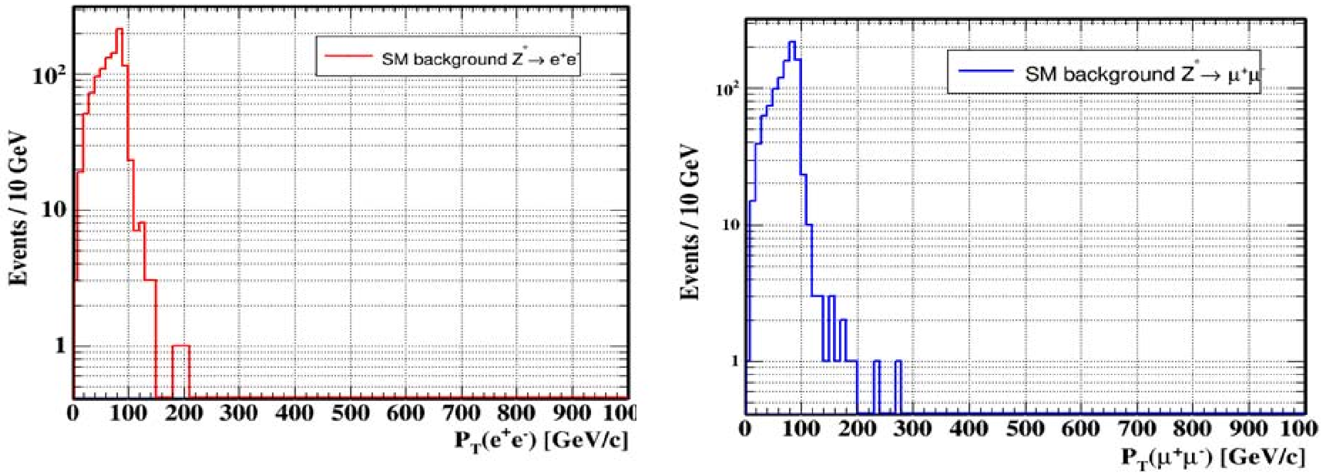


Figure 7 : The Drell-Yan process background – the invariant mass of electrons and muons (Top) produced from Z° boson and the transverse momentum for electrons and muons (Bottom) (in the Left-Right Symmetric Model using Pythia8 and MadGraph5).

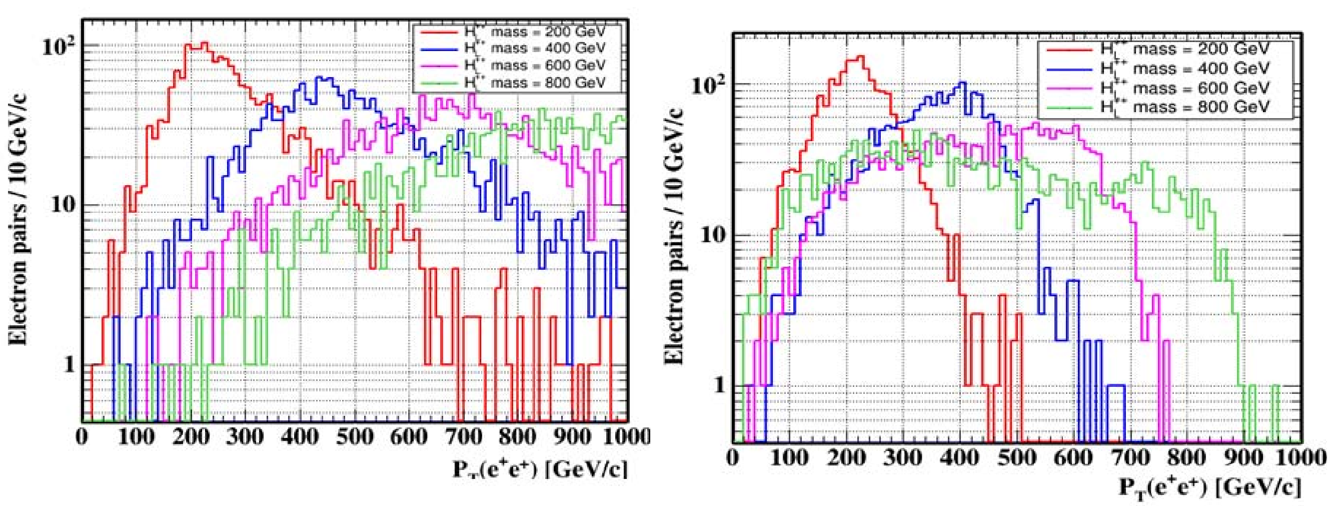
SM backgrounds in this search come from like-sign lepton pairs is WZ production, and smaller sources include ZZ, like-sign WW, $t\bar{t}W$, and $t\bar{t}Z$production. The $H^{\pm\pm}$ process is simulated using PYTHIA8 [16] to estimate the acceptance and efficiency for reconstructing $H^{\pm\pm}$ bosons with masses between 200 GeV and 800 GeV. The latest results are from the Tevatron and ATLAS [17–19] experiments, which set lower limits on the $H^{\pm\pm}$ mass between 112 and 355 GeV, depending on assumptions regarding $H^{\pm\pm}$ branching fractions. In all previous searches, only the pair-production mechanism, and only a small fraction of the possible final state combinations, were considered. The addition of associated production and all possible final states significantly improves the sensitivity and reach of this analysis.

The kinematic properties of $H_L^{\pm\pm}$ and $H_R^{\pm\pm}$ bosons are identical only their cross sections differ. In this article the results of a search for a doubly-charged Higgs boson at the LHC and the Tevatron using Monte Carlo simulation Techniques experiments are presented the pair-production process $pp(\bar{p}) \to H^{++}H^{--} \to \ell_\alpha^+\ell_\beta^+\ell_\lambda^-\ell_\delta^-$ [20, 21] and the associated production process $pp(\bar{p}) \to H^{++}H^{--} \to \ell_\alpha^+\ell_\beta^+\ell_\lambda^-\nu_\delta$ [22, 23] are studied.

g) Transverse Momentum Distributions

The transverse-momentum PT distributions and rapidity of the $H_L^{\pm\pm}$ boson provide new information about the dynamics of proton collisions at high energies and the PT spectrum provides a better understanding of the underlying collision process at low transverse momentum.

Figure (8) shows the transverse momentum PT distributions of different combination of electron and muon in final state in invariant mass region $200 < M_{e^+e^-} < 800$ GeV produced from $H_L^{\pm\pm}$ decay. The results are obtained using PYTHIA8 of proton-proton collisions at a center-of-mass energy of 14 TeV at LHC. The distributions are measured over the ranges $|\eta| < 2.5$.



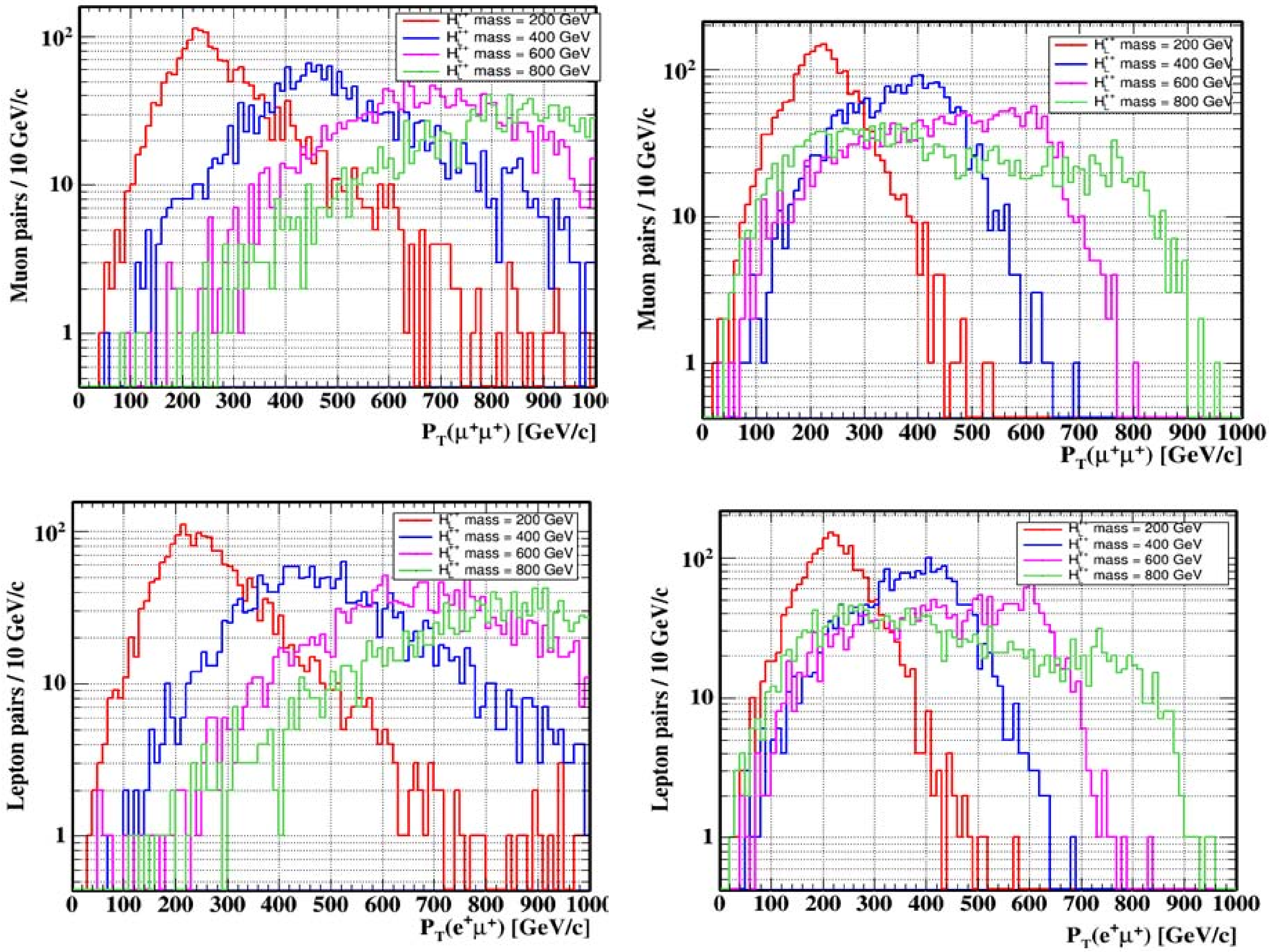


Figure 8 : Transverse momentum distributions of $e^{\pm}e^{\pm}$, $\mu^{\pm}\mu^{\pm}$ and $e^{\pm}\mu^{\pm}$ for different values of $H_L^{\pm\pm}$ mass at the LHC $\sqrt{s}$=14 TeV (Left column) and at the Tevatron $\sqrt{s}$=1.96 TeV (Right column)

For the $e^{\pm}e^{\pm}$, $\mu^{\pm}\mu^{\pm}$ and $e^{\pm}\mu^{\pm}$ channels in Figure (5) assuming a branching ratio to the given lepton flavour of 100% assuming that the sum of the branching fractions of the $H^{\pm\pm}$ to all lepton flavour combinations is 100%. The dominant background in this analysis arises from electroweak processes where real high pT muons are created from W or Z boson decays as well as non-isolated muons originating from jets. The SM backgrounds and signal processes are generated with Pythia8 [29].

The signal final state consists of four charged leptons. Two like-sign leptons originate from the $H^{\pm\pm}$ decay and are expected to be visible in the detector in most cases. A search for a doubly-charged Higgs boson in proton-proton and proton-antiproton collisions are presented. The search is performed using events with three or more isolated charged leptons of any flavor. The $H^{\pm\pm}$ particle carries double electric charge, and decays to same-sign lepton pairs $\ell^{\pm}\ell'^{\pm}$. The relevant Production cross sections, calculated following are presented in Figures 1 and 2. $H^{\pm\pm}$ is assumed to decay in 100% of the cases in turn in each of the possible lepton combinations $ee, \mu\mu, \tau\tau, e\mu, e\tau, \mu\tau$

h) Transverse Energy Distributions

Figure (9) show the transverse energy of different combination of leptons produced from the decay of for different values of $H_L^{\pm\pm}$ masses at the LHC $\sqrt{s}$ =14 TeV (Left column) and at the Tevatron $\sqrt{s}$ =1.96 TeV (Right column). We see that there are four peaks for every mass value of $H_L^{\pm\pm}$. Transverse energy is defined as $E_T = E\sin(\theta)$

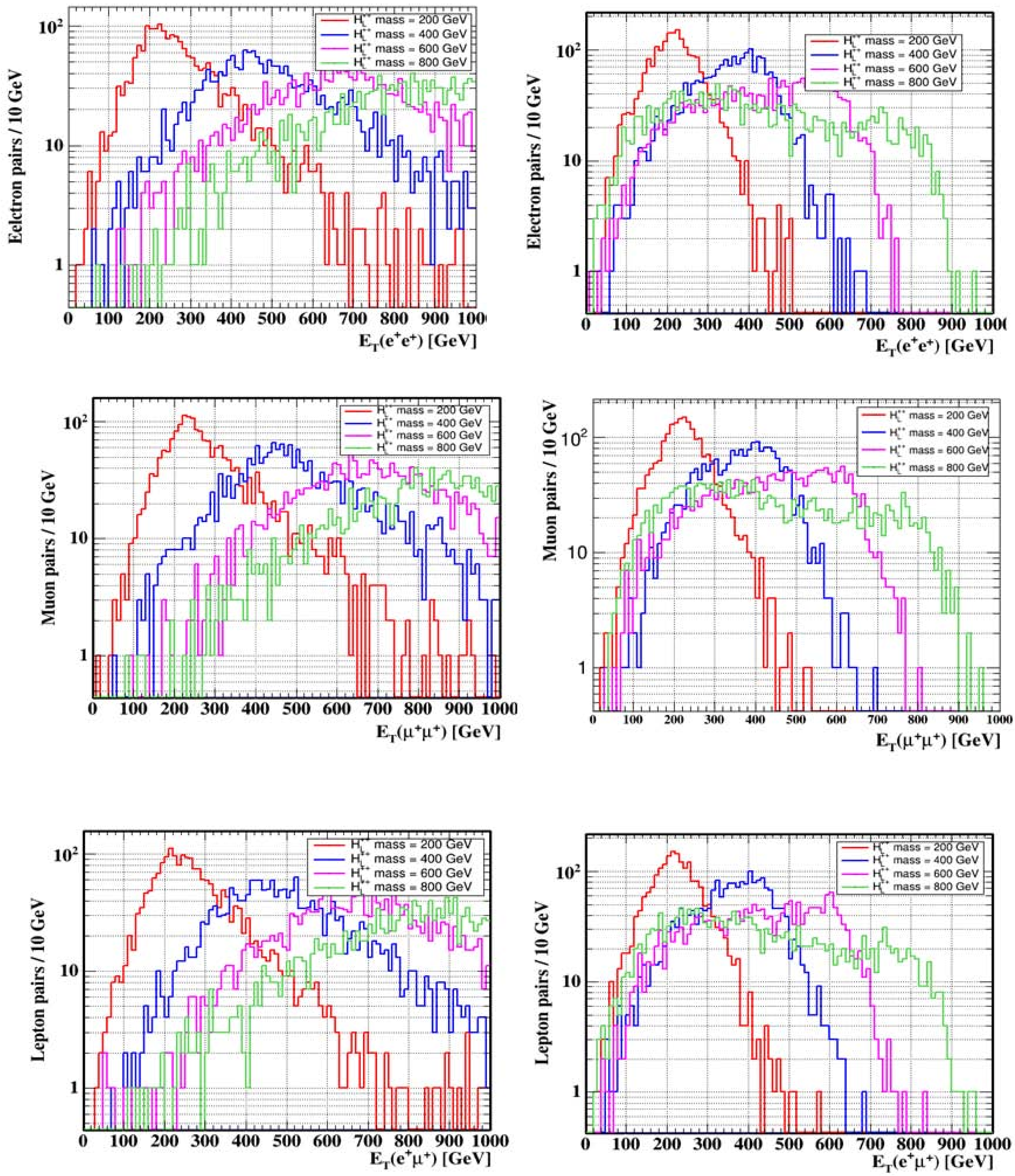


Figure 9 : Transverse Energy distributions of $e^{\pm}e^{\pm}$, $\mu^{\pm}\mu^{\pm}$ *and* $e^{\pm}\mu^{\pm}$ for different values of $H_L^{\pm\pm}$ mass at the LHC $\sqrt{s}$ =14 TeV (Left column) and at the Tevatron $\sqrt{s}$ =1.96 TeV (Right column).

i) Pseudorapidity Distributions

The selected electrons must be in the central or in the forward regions of |η| < 2.5 then we choose the two highest-energy electron or muons where η is the pseudo rapidity of emitted electrons which describes the angle of a particle relative to beam axis.

$$\eta = -\ln\left[\frac{\theta}{2}\right]$$

θ is the angle between the particle momentum vector P and the beam axis see figure.

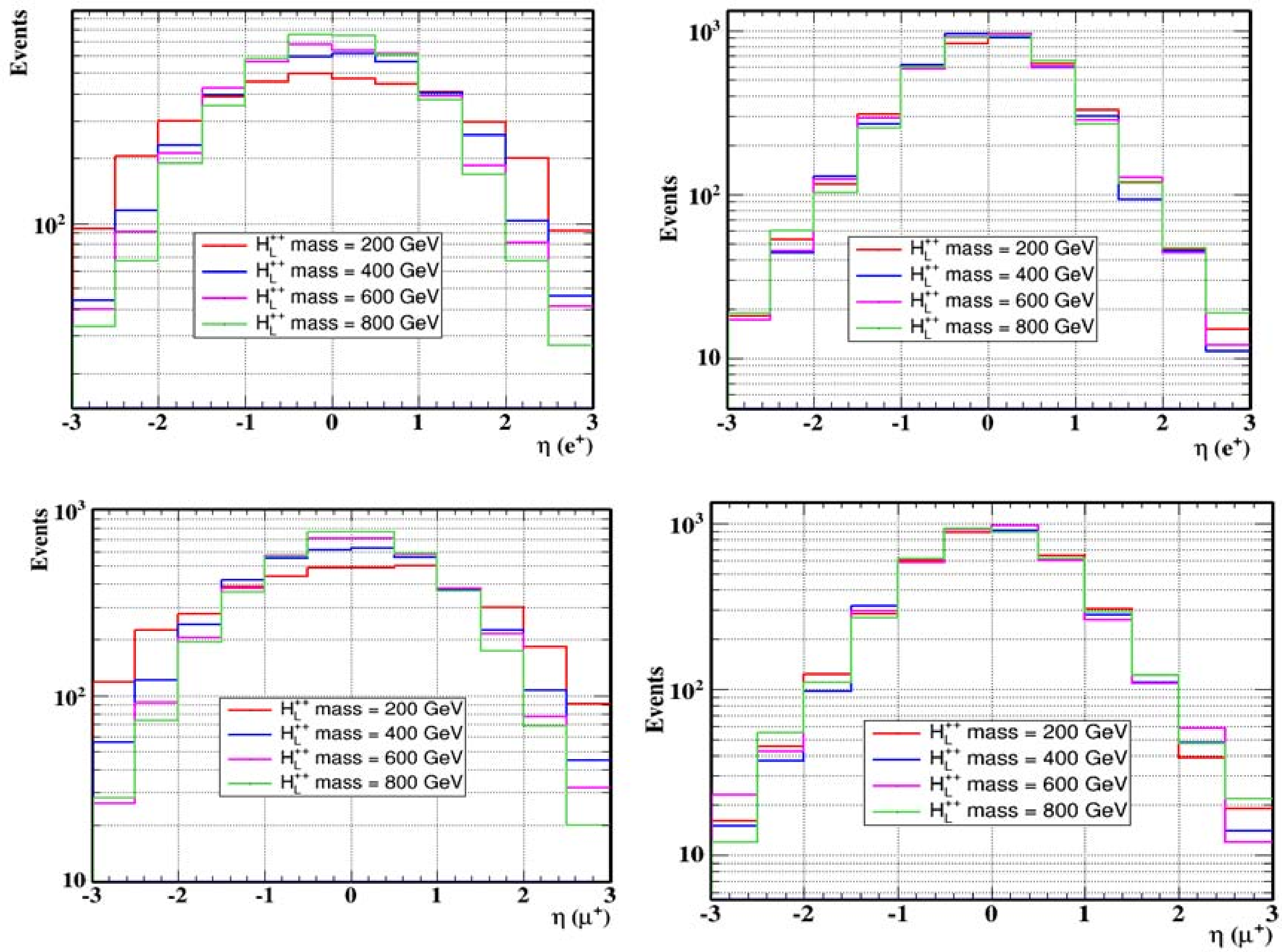


Figure 10 : Pseudorapidity distributions of Electrons and Muons for different values of $H_L^{\pm\pm}$ mass at the LHC $\sqrt{s}=$ $=14$ TeV (Left column) and at the Tevatron $\sqrt{s}=1.96$ TeV (Right column)

j) Rapidity Distribution

The Rapidity y is a measure of where a lepton is located in space and is defined as:

$$y = \frac{1}{2}\ln\frac{(E+P_T)}{(E-P_T)}$$

where E is the energy of the H^{++} candidate and PT is its longitudinal momentum along the anticlockwise beam axis (the z axis of the detector). The y and PT of H^{++} are determined from the leptons momenta.. The distributions are corrected for signal acceptance and efficiency and for the effects of detector resolution and electromagnetic final-state radiation (FSR) using an unfolding technique based on the inversion of a response matrix. The final result takes into account the bin width and is normalized by the measured total cross section.

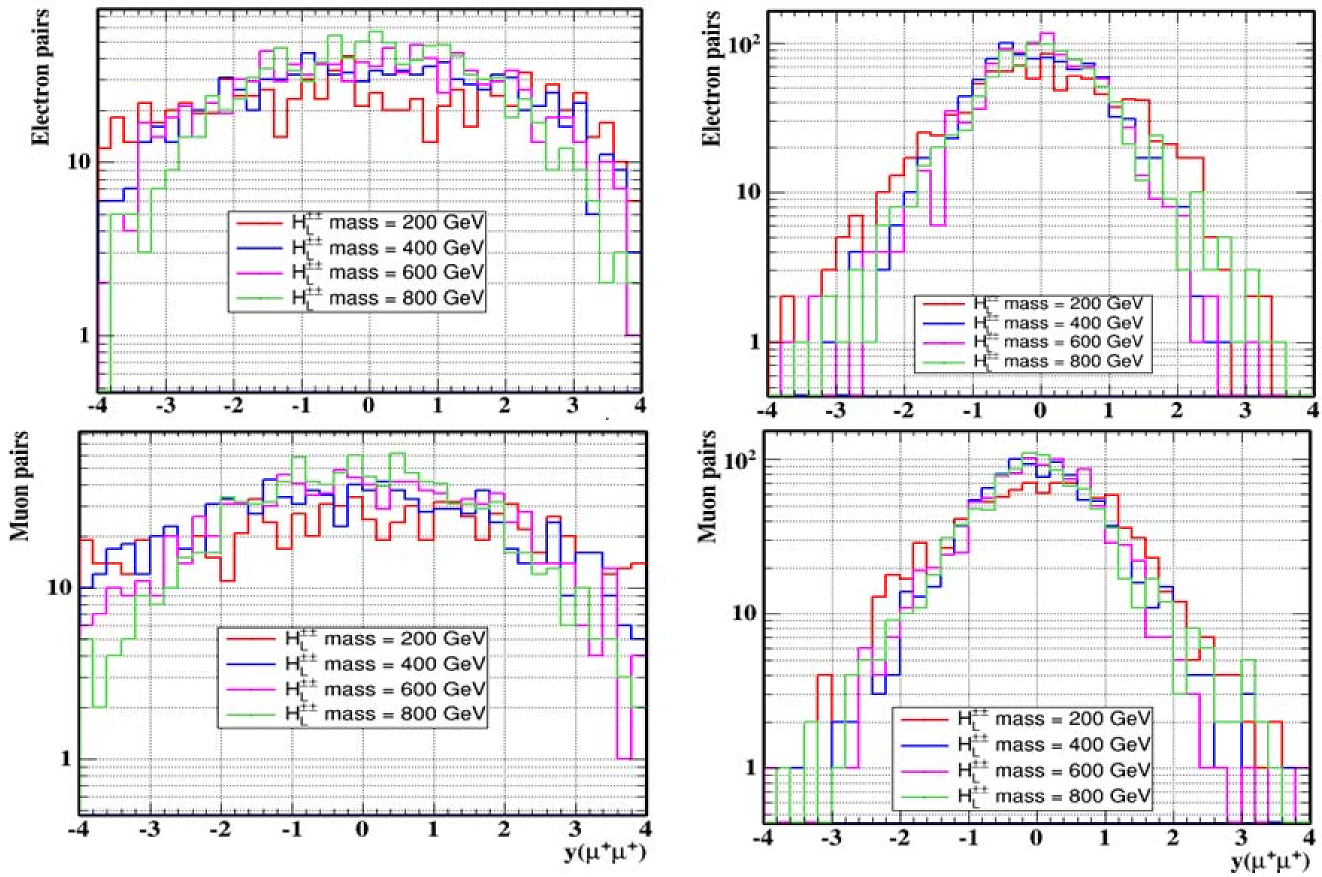


Figure 11 : Rapidity distributions of Electrons and Muons for different values of $H_L^{\pm\pm}$ mass at the LHC $\sqrt{s}$ =14 TeV (Left column) and at the Tevatron $\sqrt{s}$ =1.96 TeV (Right column)

III. Conclusion

In this work we have analyzed doubly-charged Higgs pair production at the Tevatron and the LHC using Monte Carlo event generators Pythia8 and also by MadGraph5. The doubly-charged Higgs boson can be decayed to $e^{\pm}e^{\pm}, \mu^{\pm}\mu^{\pm}$ *or* $e^{\pm}\mu^{\pm}$ so we can search for four charged leptons in final state produced from doubly-charged Higgs boson pair via the process$pp(\bar{p}) \to H^{\pm\pm}H^{\pm\pm} \to \ell^{\pm}\ell^{\pm}\ell^{\pm}\ell^{\pm},\ \ell = e^{\pm}, \mu^{\pm}$. We serarched for a narrow resonance peak in the dilepton mass distribution produced from $H^{\pm\pm}$ decay. Also we calculated the production Cross section of doubly charged Higgs boson pair at the LHC and at the Tevatron for left-hand $H_L^{\pm\pm}$ and right-hand $H_R^{\pm\pm}$. We found that the production cross section depends on the mass of the $H^{\pm\pm}$ boson in the final state. We calculated different dynamics distributions for the different combination of leptons in the final states assuming pair production couplings to left handed leptons, and a branching ratio of 100% BR($H^{\pm\pm} \to \ell^{\pm}\ell^{\pm} = 1, \ell = e^{\pm}, \mu^{\pm}$). for each final state. Finally, the doubly charged Higgs may be found at the LHC or at the Tevatron in the mass range up to 800 GeV.

IV. Acknowledgment

It is a pleasure to thank Prof. Torbjörn Sjostrand - Lund Univ. Sweden for useful discussions of PYTHIA, Prof. Johan Alwall - Stanford Univ. USA for useful discussions of MadGraph5/MadEvent. The work by Maxim Yu. Khlopov was supported by the Ministry of Education and Science of Russian Federation, project 3.472.2014/K and in the part related with various forms of dark matterby the grant RFBR 14-22-03048.

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Supersymmetry Quantum Mechanics and Exact Solutions of the Effective Mass of Schrodinger Equations with Rosen-Morse Potential

By R.Amiri & M.Tavakkoli
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Abstract- In quantum mechanics a localized attractive potential typically supports a (possibly infinite) set of bound states, characterized by a discrete spectrum of allowed energies, together with a continuum of scattering states, characterized (in one dimension) by energy-dependent phase shift. The Morse potential named after physicist Philip M.Morse, is a convenient model for the potential energy of a diatomic molecule. It is a better approximation for the vibrational structure of the molecule than the quantum harmonic oscillator because it explicitly includes the effects of bond breaking such as the existence of unbound states. It also accounts for the anharmonicity of real bonds and the non-zero transition probability for overtone and combination bands. The Morse potential can also be used to model other interactions such as the interaction between an atom and a surface. We here make the case that the trigonometric Rosen-Morse potential is exactly soluble in terms of a family of real orthogonal polynomials and present the solutions. and analytical solutions of the Klein-Gordon equation for the Rosen-Morse potential with equal scalar and vector potentials are studied in this paper.

Keywords: *supersymmetry, morse-rosen potential, eckart potential, schrodinger eqation.*

GJSFR-A Classification : *FOR Code: 020699*

SUPERSYMMETRY QUANTUM MECHANICS AND EXACT SOLUTIONS OF THE EFFECTIVE MASS OF SCHRODINGER EQUATIONS WITH ROSEN-MORSE POTENTIAL

Strictly as per the compliance and regulations of :

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Keywords: supersymmetry, morse-rosen potential, eckart potential, schrodinger eqation.
PACs: 11.30.Pb

I. Introduction

The supersymmetric quantum mechanics manages a family of exactly soluble potentials, one of them being the trigonometric Rosen-Morse potential. As long as this potential is obtained from the Eckart potential by complexification of the argument and one of the constants,also its solutions have been concluded rfom those of the Eckart potential by same procedure.

Supersymmetric quantum mechanics was originally proposed by Witten as a simple learning ground for the basic concepts of supersymmetric quantum field theories but soon after it evolved to a research field on its own rights. Supersymmetric quantum mechanics starts with the factorization of one-dimensional Hamiltonians,

$$H(y) = -\frac{\hbar^2}{2m}\frac{d^2}{dy^2} + V(y) \tag{1}$$

According to $H(y) = A^{+}(y)A^{-}(y) + \mathcal{E}$ with $A^{\pm}(y) = (\pm\frac{\hbar}{\sqrt{2m}}\frac{d}{dy} + U(y))$ Where *U(y)* is the superpotential [1-3]. supersymmetry is arguably the most attractive mechanism to stabilize the hierarchy between the fundamental scale (e.g. the Planck scale $M_* \sim 10^{18}$ *GeV)* and the electroweak scale ($M_w \sim$ 100*GeV*). However, superpartners of the standard model particles have not been observed up to energies of order *Mw*, so supersymmetry must be broken at or above the weak scale.The phenomenology of supersymmetry depends crucially on the mechanism of supersymmetry breaking and the way that supersymmetry breaking is communicated to the observable sector. The supersymmetric quantum mechanics manages a family of exactly soluble potentials, one of them being the trigonometric Rosen-Morse potential .we make the point that the trigonometric Rosen-Morse potential is of possible interest to quark physics in so far as it captures the essentials of the QCD quark-gluon dynamics [4-6].

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II. The Morse Potential Energy Function

Exact solutions of the effective mass of schrodonger equations for the mentioned potentials are interesting in the fields of material science and condense matter physics. There are various methods for exact solutions to energy eigenvalues and corresponding wave function [7,8].

We can quite write the schrodinger equation in three dimensions for a diatomic molecule with the mass of nuclei m_1 and m_2 as the following form:

$$\left(-\frac{\hbar^2}{2\mu}\nabla^2 + V(r)\right)\psi_{nlm}(r,\theta,\varphi) = E\psi_{nlm}(r,\theta,\varphi) \tag{2}$$

Where $\hbar$, μ , $V(r)$ and E are Planck's constant, reduced mass, spherical potential and eigenvalue energy of a quantum system. The radial part of the wave function $R_{nl}(r)$ is defined by relation of $\psi_{nlm}(r,\theta,\varphi) = \frac{R_{nl}(r)}{r} Y_{lm}(\theta,\varphi)$ In that case, the radial schrodinger equation is written by,

$$\frac{d^2R_{nl}(r)}{dr^2} + 2\left(E - V_{eff}\right)R_{nl}(r) = 0 \tag{3}$$

Where we simply suppose that $\hbar = \mu = 1$ and V_{eff} equal the Rosen-Morse potential plus centrifugal term [8,9].

Exactly solvable 1-dimensional Schrodinger equations play an important role in quantum physics. The best known are the harmonic oscillator and the radial equation for the hydrogen atom, which are covered in every course of quantum mechanics.

The Morse potential energy function is o the form

$$V_{eff}(r) = D_e\left(1 - e^{-a(r-r_e)}\right)^2 \tag{4}$$

Here r is the distance between the atoms, r_e is the equilibrium bond distance, D_e is the well depth (defined relative to the dissociated atoms), and a controls the width of the potential) the smaller a is, the larger the well). The dissociation energy of the bond can be calculated by subtracting the zero point energy $E(0)$ from the depth of the well. The force constant of the bond can be found by Taylor expansion of $V(r)$ around $r = r_e$ to the second derivative of the potential energy function, from which it can be shown that the parameter, a, is

$$a = \sqrt{\frac{K_e}{2D_e}} \tag{5}$$

Where K_e is the force constant at the minimum of the well. Since the zero of potential energy is arbitrary, the equation for the Morse potential can be rewritten any number of ways by adding or subtracting a constant value. When it is used to mode the atom- surface interaction, the Morse potential is usually written in the form:

$$V_{eff}(r) - D_e = D_e\left(e^{-2a(r-r_e)} - 2e^{-a(r-r_e)}\right) \tag{6}$$

Where r is now the coordinate perpendicular to the surface. This form approaches zero at infinite r and $-D_e$ at its minimum. It clearly shows that the Morse potential is the combination of a short-range repulsion and a longer-range attractive tail.

The schrodinger equation

$$\left(-\partial_r^2 + V_{eff}(r) - \delta\right)\varphi(r) = 0 \tag{7}$$

Where

$$V_{eff}(r) = \frac{cosr}{sinr} + \left(\frac{\mu^2}{4} - \frac{1}{4}\right)\frac{1}{sin^2 r} \tag{8}$$

This potential is known as the Rosen-Morse potential, also the trigonometric Rosen-Morse potential. to write the stationary states on the Rosen-Morse potential, i.e. solution $\psi(v)$ and E(v) of the following schrodinger equation:

$$\left(-\frac{\hbar^2}{2m}\frac{\partial^2}{\partial r^2} + V_{eff}(r)\right)\psi(v) = E(v)\psi(v) \tag{9}$$

It is convenient to introduce the new variables:

$$x = ar, \quad x_e = ar_e, \quad \lambda = \frac{\sqrt{2mD_e}}{a\hbar}, \quad \mathcal{E}_v = \frac{2m}{a^2\hbar^2}E(v) \tag{10}$$

Then, the schrodinger equation takes the simple form:

$$\left(-\frac{\partial^2}{\partial x^2} + V_{eff}(x)\right)\psi_n(x) = \varepsilon_n\psi_n(x) \tag{11}$$

$$V_{eff}(x) = \lambda^2\left(e^{-2(x-x_e)} - 2e^{-(x-x_e)}\right) \tag{12}$$

Its eigenvalues and eigenstates can be written as:

$$\varepsilon_n = -(\lambda - n - \tfrac{1}{2})^2 \tag{13}$$

$$\psi_n(z) = N_n z^{\lambda-n-\frac{1}{2}} e^{-\frac{1}{2}z} L_n^{2\lambda-2n-1}(z) \tag{14}$$

Where $z = 2\lambda e^{-(x-x_e)}$. whereas the energy spacing between vibrational levels in the quantum harmonic oscillator is constant at $h\nu_O$, the energy between adjacent levels decreases with increasing v in the Rosen-Morse oscillator.

$$\frac{E_v}{hc} = \omega_e\left(v + \frac{1}{2}\right) - \omega_e\chi_e(v + \tfrac{1}{2})^2 \tag{15}$$

In which the constants ω_e and $\omega_e\, x_e$ can be directly related to the parameters for the Rosen-Morse potential. As is clear from dimensional analysis, for historical reasons the last equation uses spectroscopic notation in which we represents a wave number obeying $E = hc\omega$, and not an angular frequency given by $E = \hbar\omega$ [10-12].

figure 1: the Morse potential (dark) and harmonic oscillator potential (light) unlike the energy levels of the harmonic oscillator potential, which are evenly sapced by $\hbar\omega$, the Morse potential level spacing decreases as the energy approaches the dissociation energy. The dissociation energy D_e is larger than the true energy required for dissociation D_0 due to the zero point energy of the lowest (v=0) vibrational level.[12]

One of the main problems which are involved in many physical processes is the difference of energy state between ground state and first excited state for potential wells. Ground state wave energy E^1 and first excited state energy E^2, as a result:

$$E^1 = \frac{\int_{-\infty}^{+\infty}\varphi(x)(\delta H)\varphi(x)dx}{\int_{-\infty}^{+\infty}\varphi^2(x)dx} = \frac{\int_{-\infty}^{+\infty}\varphi(x)\left[\frac{\left[\psi_0^1(x_0)\right]^2}{I_1}\right]\delta(x-x_0)\varphi(x)dx}{\int_{-\infty}^{+\infty}\varphi^2(x)dx} + \frac{\int_{-\infty}^{+\infty}\varphi(x)\left[\frac{\left[\psi_0^1(-x_0)\right]^2}{I_1}\right]\delta(x+x_0)\varphi(x)dx}{\int_{-\infty}^{+\infty}\varphi^2(x)dx} =$$
$$\frac{1}{4}\left[\frac{1}{I_1} + \frac{1}{I_2}\right]\frac{1}{\int_{-\infty}^{+\infty}\varphi^2(x)dx} \tag{16}$$

$$E^2 = -\{\int_{-\infty}^{-x_0} dx \left[\frac{E^1 \int_{-\infty}^{x} \varphi^2(x)dx}{\varphi(x)}\right]^2 + \int_{-x_0}^{+x_0} dx \left[\frac{E^1 \int_{-x_0}^{x} \varphi^2(x)dx}{\varphi(x)}\right]^2 + \int_{x_0}^{x} dx \left[\frac{E^1 \int_{x}^{\infty} \varphi^2(x)dx}{\varphi(x)}\right]^2\} \tag{17}$$

$$\Delta E = E^1 + E^2 \tag{18}$$

$$I_+ = \int_{nx_0}^{\infty} \left(\psi_0^1(y)\right)^2 dy, \qquad I_- = \int_{-\infty}^{-nx_0} \left(\psi_0^1(y)\right)^2 dy \tag{19}$$

III. The Shpe of the Trigonometric Rosen-Morse Potential

The study of exactly solvable potentials in quantum mechanics for years has received a lot of attention. For solvable models, the simplest generation technique is supersymmetric quantum mechanics, which is equivalent to the factorizatior method, the intertwining technique and the Darboux transformation method.it is well known that the spectrum of the generated Hamiltonian differs little from the initial one. This suggests a way to realize, in practice, the spectral design: (i) one starts from a potential having a spectrum close to the desired one. (ii) then, by appropriately moving creating or deleting a certain set of levels, and iterating the method as many times as needed to achieve the required spectrum, one will arrive at a Hamiltonian (or a set of Hamiltonians),which could model the situation under study [13].

We adopt the following form of the trigonometric Rosen-Morse potential

$$v(z) = -2bcotz + a(a+1)csc^2 z \tag{20}$$

With $a > -\frac{1}{2}$ and displayed in Fig.1. Here, $z = \frac{y}{d}$, $v(z) = V(zd)/(\frac{\hbar^2}{2md^2})$ and $\mathcal{E}_n = E_n/(\frac{\hbar^2}{2md^2})$, with y being the one-dimensional variable, d a properly chosen length scale, *V(y)* the potential in ordinary coordinate space, and E_n the energy level.

Our point here is that *v(z)* interpolates between the Coulomb - and the infinite wall potential going through an intermediary region of linear-*z*-and harmonic-oscillator-z^2 dependences. To see this it is quite instructive to expand the potential in a Taylor series which for appropriately small z takes the form of a coulomb like potential with a centrifugal barrier like term, provided by the $csc^2 z$ part,

$$v(z) \approx -\frac{2b}{z} + \frac{a(a+1)}{z^2}, \quad z << 1 \tag{21}$$

For $z < \frac{\pi}{2}$ we can the take Eq. (20) plus a linear like perturbation

$$\Delta v(z) = \frac{a(a+1)}{3} + \frac{2bz}{3} \tag{22}$$

[14-16]

The $\frac{1}{x^2}$ potential has no ground state, and the allowed energies are not quantized. Perhaps some potential are just plain illegal in quantum mechanics. It seems odd, though, that we never encounter such difficulties in classical mechanics.

Well, in the first place there are classical precursors. Moreover there do exist systems represented by a $\frac{1}{x^2}$ potential [17].

IV. The Rosen-Morse Potentia as Complexified Eckart Potential

Exactly solvable 1-dimensional schrodinger equation play an important role in quantum physics. The best known are the harmonic oscillator and the radial for the hydrogen atom, which are covered in every course of quantum mechanics. A number of other examples were discovered in the 30's of the last century [18].

Before proceeding further we first introduce a properly chosen length scale d and change variables in the one-dimensional equation

$$H(y) = -\frac{\hbar^2}{2m}\frac{d^2}{dy^2} + V(y) \tag{23}$$

To dimensionless ones according to

$$z = \frac{y}{d}, \; v(z) = \frac{V(dz)}{(\hbar^2/2md^2)}, \quad \epsilon_n = \frac{E_n}{(\hbar^2/2md^2)} \tag{24}$$

Next we employ the Eckart potential,

$$v(z) = -2bcothz + a(a-1)csch^2 z \tag{25}$$

Where $b > a^2$. The exact solutions to the Eckart potential read:

$$\psi_n(x) = c_n(x-1)^{(\beta_n - n - a)/2}(x+1)^{-(\beta_n+n+a)/2} P_n^{\beta_n - n - a, -(\beta_n+n+a)}(x)$$

$$x = \coth z\,, \qquad \beta_n = \frac{b}{n+a} \tag{26}$$

Here, $P_n^{(\beta_n - n - a, -(\beta_n+n+a))}(x)$ are the well known Jacobi polynomials with $n \le (b^{1/2} - a)$ and c_n is a constant. Equation {26} equivalently rewrites to

$$\psi_n(x) = c_n(x^2-1)^{-(n+a)/2} e^{-\beta_n \operatorname{arccoth} x} P_n^{(\beta_n - n - a, -(\beta_n+n+a))}(x) \tag{27}$$

The corresponding energy value spectrum is determined by

$$\epsilon_n = -(n+a)^2 - \frac{b^2}{(n+a)^2} \qquad (28)$$

Complexify the argument of the Eckart potential and one of its constants according to

$$z \to -iz\,, or\,, equivalently,\ x \to ix\,,\ \ b \to ib \quad (29)$$

Substitution of Eq.{29} into {25} results in

$$v(z) = -2bcot\ z + a(a-1)csc^2 z \qquad (30)$$

Morse potential is concluded from Eq.{27} through complexification of b and x leading to

$$\psi_n(ix) = c_n((ix)^2-1)^{-(n+a)/2} e^{-\beta_n \ \text{arccoth}\ ix}\ P_n^{((i\beta_n-n-a),(i\beta_n+n+a))}(ix) \qquad (31)$$

[19]

V. Spectrum and Wave Functions of the Trigonometric Rosen-Morse Potential

Solving schrodinger' equation for the trigonometric Rosen-Morse potential as obtained in Ref [20,21] All in all, the trigonometric Rosen-Morse potential and its real orthogonal polynomial solutions open new venues in the calculation of interesting observables in both supersymmetric quantum mechanics and particle spectroscopy [20,21].

The one- dimensional schrodinger equation with the trigonometric Rosen-Morse potential reads:

$$\frac{d^2}{dz^2}R_m(z) + (2bcotz - a(a+1)csc^2 z + \varepsilon_n)R_m(z) = 0 \qquad (32)$$

Our pursued strategy in solving it will be to first reshape it to the particular case of a Sturm-Liouville equation {32} of the form

$$s(x)\frac{d^2}{dx^2}F_m(x) + \frac{1}{w(x)}\left(\frac{d}{dx}s(x)w(x)\right)\frac{d}{dx}F_m(x) + \lambda_m F_m(x) = 0 \qquad (33)$$

And they try to solve it by means of the so called Rodrigues representation

$$F_m(x) = \frac{1}{K_m w(x)}\frac{d^m}{dx^m}(w(x)s(x)) \qquad (34)$$

Where Km is the normalization constant. And

$$\lambda_m = -m(K_1\frac{d}{dx}F_1(x) + \frac{1}{2}(m-1)\frac{d^2}{dx^2}s(x) \quad (35)$$

[21].

VI. Conclusion

In this paper we have discussed on the solution of the schrodinger equation with Rosen-Morse potential. In that case we have written radial part of schrodinger equatin with centrifugal term. Helping the factorization method and comparing it with associated Jacobi differential equation, we have obtained energy eigenvalue and wave function. We also have considered two different cases such as s-wave and Eckart potential for the Rosen-Morse.

All in all the Rosen-Morse potential and its real orthogonal polynomial solutions open new venues in the calculation of interesting observables in both supersymmetric quantum mechanics and particle spectroscopy.

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Table 1 : Some Potentials and Relations [22-28].

potential	relation
Rosen-Morse	$V(r) = -V_1 sech^2 \alpha r + V_2 tanh \alpha r^*$
Woods-Saxon	$V(r) = -\frac{V_0}{1+exp\left(\frac{r-R}{a}\right)}$ **
Eckart	$V(r) = -k\frac{coshr}{sinhr} + \left(\frac{\mu^2}{4}-\frac{1}{4}\right)\frac{1}{sinh^2 r}$ ***
Poschl-Teller	$V(r) = \left(\alpha^2-\frac{1}{4}\right)\frac{1}{4sin^2\frac{r}{2}} + \left(\beta^2-\frac{1}{4}\right)\frac{1}{4cos^2\frac{r}{2}}$ ****
Morse	$V(r) = D_e\left(1-e^{-a(r-r_e)}\right)^2$ *****
Manning-Rosen	$V(r) = -k\frac{sinhr}{coshr} - \left(\frac{\mu^2}{4}-\frac{1}{4}\right)\frac{1}{cosh^2 r}$ ******
Hulthen	$V(r) = -\frac{z}{\alpha}\frac{exp\frac{-r}{\alpha}}{1-exp\frac{-r}{\alpha}}$ *******

1. Rosen-Morse, In this relation V_1 and V_2 denotes the depth of the potential and a is the range of the potential.
2. The Wood-Saxon potential, is a mean field potential for the nucleons (protons and neutrons) inside the atomic nucleus, which is used to approximately describe the forces applied on each nucleon, in the shell model for the structure of the nucleus.in this potential V_0 (having dimension of energy) represents the potential well depth, a is a length representing the surface thichness of the nucleus, and $R = r_0 A^{\frac{1}{3}}$ is the nuclear radius where $r_0 = 1.25$ fm and A is the mass number.

3. Eckart, This potential was proposed and solved by C.Eckart. A natural real domain for this potential is $]0,\infty[$
4. Poschl-Teller, This potential was proposed and solved by Poschl and Teller.A natural real domain for this potential is $]0,\pi[$.
5. Morse, In this potential r is the distance between the atoms, re is the equilibrium bond distance.
6. Manning-Rosen, This potential was proposed and solved by M.F.Manning and N.Rosen. A natural real domain for this potential is $]-\infty,\infty[$.
7. Hulthen, The Hulthen potential is a short - range potential which behaves like a Coulomb potential for small values for r and decreases exponentially for large values of r. in this potential a is the screening parameter and z is a constant which is identified with the atomic number when the potential is used for atomic phenomena.

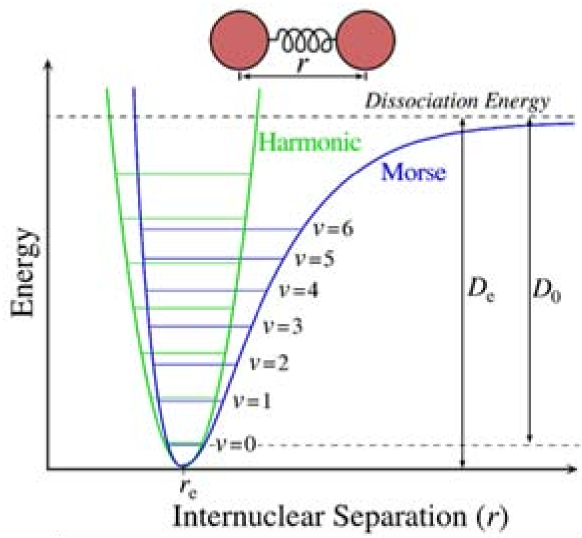

Figure 1: the Morse potential and harmonic oscillator potential

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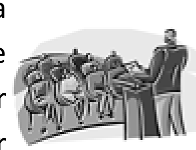

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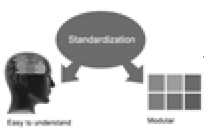

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The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.
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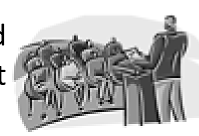

The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of “Open Association of Research Society, U.S.A (OARS)” so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

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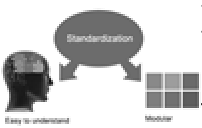
We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.



After nomination of your institution as "Institutional Fellow" and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

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Note :

"

- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

Process of submission of Research Paper

The Area or field of specialization may or may not be of any category as mentioned in 'Scope of Journal' menu of the GlobalJournals.org website. There are 37 Research Journal categorized with Six parental Journals GJCST, GJMR, GJRE, GJMBR, GJSFR, GJHSS. For Authors should prefer the mentioned categories. There are three widely used systems UDC, DDC and LCC. The details are available as 'Knowledge Abstract' at Home page. The major advantage of this coding is that, the research work will be exposed to and shared with all over the world as we are being abstracted and indexed worldwide.

The paper should be in proper format. The format can be downloaded from first page of 'Author Guideline' Menu. The Author is expected to follow the general rules as mentioned in this menu. The paper should be written in MS-Word Format (*.DOC,*.DOCX).

The Author can submit the paper either online or offline. The authors should prefer online submission.Online Submission: There are three ways to submit your paper:

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1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript’s Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

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The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

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(f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;

(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

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(i) References in the proper form.

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It is vital, that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

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27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

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.

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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.

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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.

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 definite statistics - 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.

The Administration Rules

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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