Effects Of Hall Current, Dufour Number On Unsteady MHD Chemically Reacting Casson Fluid Flow Over An Inclined Oscillating Plate With Thermal Radiation

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Abstract—The display paper portrays the impact of Hall current on MHD Casson fluid flow with chemical response over a swaying vertical plate which is slanted. The overseeing conditions of stream marvels are illuminated by utilizing Laplace transforms which could be a capable explanatory procedure. The effect of different parameters like Dufour number, Radiation parameter, Schmidt number, etc. are talked about. Advance the essential and auxiliary speed profiles in addition to temperature and concentration profiles underneath the impact of distinctive basic parameters are spoken to graphically.

Index Terms—Casson fluid, Dufour effect, Hall current, MHD, Thermal Radiation

\[ B_0 \] uniform magnetic field  
\[ k_r \] chemical reaction parameter 
\[ C' \] species concentration  
\[ Q_0 \] heat absorption/generation coefficient 
\[ D_M \] mass diffusion coefficient  
\[ T' \] fluid temperature 
\[ D_T \] thermal diffusion coefficient  
\[ t \] dimensionless time 
\[ G_w \] mass Grashof number  
\[ H \] heat generation parameter 
\[ k \] permeability parameter  
\[ \alpha \] Angle of inclination 
\[ k' \] permeability of porous mediu  
Greek symbols
\[ \beta \] Casson parameter 
\[ \rho \] fluid density 
\[ \mu \beta \] plastic dynamic viscosity 
\[ \nu \] kinematic viscosity coefficient 
\[ \rho \] fluid density 
\[ \sigma \] electrical conductivity 
\[ \beta \] Casson parameter 
\[ \theta \] dimensionless fluid temperature 
\[ G_r \] thermal Grashof number 
\[ u \] dimensionless fluid velocity in x direction  
\[ m \] Hall current parameter 
\[ C \] dimensionless species concentration  
Dufour number
1. INTRODUCTION

During recent developments great emphasis has been laid on theoretical studies of Hall effect on Magneto Hydro Dynamic flows due to its outspread applications in power generation and pumps, refrigeration media. Hall accelerators, electric transformers. In flight MHD sun powered material science has been included within the attractive stars structure, the sun powered cycle electronic framework cooling, cover of fibers and granules, the method where the extraction of oil is done, prepare of putting way warm vitality and stream through sitting and permeable materials. Generally by the application of Ohm's law the Hall term representing the Hall current was overlooked in since it has no unmistakable impact for little and sensible values of attractive field. The effects of Hall current are significant if a intense field of magnetism is applied (Cramer, 1973). The reason behind this is, a solid attractive field the electromagnetic force is noticeable. The outcome of recent investigations for the applications of MHD are towards a intense field of magnetism, due to this reason the research on Hall current becomes prominent.

Investigation of Warm exchange in expansion to mass exchange of an incompressible thick liquid over an extending surface is considered by Magyari and Keller [1]. They gotten similarity solutions pertaining to a subjective stretching surface. Proceeding from this study, a few analysts examined almost the impacts warm exchange of a gooey incompressible liquid over a stretching surface beneath distinctive conditions. Emad M. Aboeldahab et al. [2] explored the concept of warm exchange, effect of Mass exchange and the impact of Hall currents along a vertical plate beneath the combined results of buoyancy force, species and thermal diffusion in transverse magnetic subject. The resultant conditions are fathomed by fourth-order R-K strategy with the application of little Reynolds number. Joule warming and dissemination impacts of thickness on shaky MHD stream from a vertical plate inserted in permeable media beneath the impact of warm source. Ion-slip and Hall current is analyzed by Emad M. Abo-Eldhahab et al. [3]. The overseeing conditions are fathomed by utilizing explicit finite difference method. Salem and Abd El-Azz [4] have displayed the impact of chemical response and Hall currents on MHD stream over extending surface with warm era or assimilation. A detailed study of the unsteady Magneto Hydrodynamic flow of an Casson fluid between parallel insulating porous plates in state of viscous dissipation, heat transfer and the Hall Effect were studied by Hazem Ali Atla et al. [5]. Sudhakar et al. [6] analyzed lobby impact on the MHD stream along a permeable level plate with, soret impact, duffer impact and chemical response by utilizing Galerkin finite element strategy. Afkuzzaman et al [7] investigated the impacts of Lobby streams on the insecure Coutte stream of Casson liquid by keeping up steady temperatures on the plates beneath transverse attractive field. The Magneto Hydro Dynamic move of a Casson liquid beyond a vertical plate with swaying and constant temperature. The liquid which is passing through a permeable media and has conduction was examined by Asam Khalid et al. [8]. Vasundhara, Sarojamma [9] investigated the concept of Corridor impact on MHD Casson Liquid streams surrounding an amplifying Sheet with Convective Boundary Condition and Suction. Vedavathi, et al.[10] examined the impacts of thermalradiation, warm dissemination and chemical response on Magneto Hydro Dynamic Casson liquid stream past a vertical plate within the nearness of a warm source. The affects of radiation and chemical reaction at the Magneto hydroactive oscillatory movement over a vertical permeable plate is talked about by way of Ramana Reddy etal [11]. Dhanaalakshmi, and Jayarami Reddy, etal [12]explored the soret and Chemical response affects on Magneto hydro active loose convection move over a permeable vertical plate with warm generation. Ramana Reddy, et al. [13] revealed a nitty gritty consider of chemical response and Radiation impacts on Magnetohydrodynamic stream along a moving vertical plate in permeable media. Jasmine Benzair et al [14] studied the effects of chemical reaction over a vertical cone and flat plate saturated with the porous medium, double dispersion and non-uniform heat source on unsteady, MHD free convective Casson fluid flow was analyzed on the same. Unsteady Casson fluid flow past a flat plate with chemical reaction and saturated with the porous medium of non-darcy category discussed by Mythili, et al. Rajput et al [16] explored the impact of Hall associated chemical effects on time dependent Magneto Hydro Dynamic flow over a periodical plate with inclination, variable wall temperature and mass diffusion. Srinivasacharya et al. [17] hurled light on the concept of unbaltering mixed convective warm trade stream of a nanofluid over a vertical channel with lobby current and ion-slip parameter impacts. To unravel the nonlinear standard differential conditions the homotopy procedure was connected. The vacilated stream speed and concentration of Nano molecule lessens as ion-slip parameter increases and it prompts a rise within the speed and temperature. The impact of joule heating and Non-uniform warm supply on MHD stream of micropolar liquid past an extending sheet in porous medium, here the stream is with chemicals radiative is analyzed by charan kumar etal [18]. Arundhati et al [19] showed up a striking picture on think almost of warm and mass trade stream through a penetrable vertical channel with warm disussion, dissemination thermo and chemical reaction impacts, vijaya, et al [20] looked in to the impacts of Soret and radiation on an unstable stream of a casson fluid through penetrable vertical channel with development and contraction. Advance Hymavathi etal[21] contemplated the ponder of casson liquid stream and warm exchange over an exponentially permeable extending surface with warm radiation.Vedavathi et al [22]examined the impacts of Chemical response, Radiation and Dufour on MHD Casson liquid stream over a vertical plate with warm source or sink. Dhanalakshmi.et al [23]studied the impacts of Chemical response and soret on MHD free convection stream past a vertical permeable plate with warm era. Ramana Reddy etal[24] expanded the issue on MHD stream along a moving vertical permeable plate. Encourage Dhanalakshmi,[25]etal inspected the impacts of soret and Chemical response on MHD free convective and radiative liquid stream past a vertical permeable plate with warm era . A constant study of Chemical ly responding MHD casson liquid stream over a semi-permeable extending sheet is performed by Krishna etal[26],Chandra Sekhar Reddy et al [27]examined the impacts of radiation and warm dissemination on shaky MHD free-convection stream past a fluctuating plate with inclined divider temperature and concentration. Sreedevi etal[28] uncovered the impacts of Diffusion thermo and warm dissemination impacts on MHD stream past a porous extending sheet with warm radiation.Baby rani, et al.[29] Talked concerning the impacts of chemical reaction , Lobby current and thermal radiation on the Magneto Hydrodynamic free convective stream over a slanted permeable plate. Ramana reddy et al [30] investigated the Arrangements of Shaky MHD Stream and Warm Exchange over a Extending Surface by utilizing numerical procedure. Jaya rami reddy et al. [31] Performed a nitty gritty ponder of MHD stagnation point stream of carreau nanofluid with the impacts of chemical reaction,thermal radiation, and warm sourcwewt suction or infusion by utilizing numerical stratagy Hymavathi.T and w-Sridhar [32]focused on dissemination of chemically responsive species over MHD casson liquid stream over an exponentially extending surface by utilizing kellerbox numerical strategy .

In this paper the Lobby impact on time dependent Magneto hydrodynamic chemically responding Casson liquid stream over a vertical swaying and slanted plate is depicted The related conditions relating to liquid stream are illuminated by utilizing Laplace changes which may be a capable explanatory strategy. The affect of different parameters like Dufour number, Radiation and Schmidt number etc. are examined.More the temperature and concentration profiles in enlargement to essential and auxiliary speed profiles to a lower place the impact of numerous basic Parameters square measure spoken to graphically.

2 METHODOLOGY

A cautious think around the consider has been laid on Magneto hydro dynamic fluid stream past an electrically non conducting plate which is slanted to a point \( \alpha \) to the Y-axis.The Geometrical demonstrate is portrayed as takes after. As z-axis stand opposite to the plane, the plate is within the headin.A uniform attractive fieldof quality Bois connected ordinary tothe heading of liquid stream.. At first the liquid as well as the
plane got to be a stand still at consistent temperature. The plate begin rising and falling in its possess plane with recurrence w at time T and species concentration within the liquid taken as Co. This causes a rise Tw in temperature of the plate. The concentration C increments straightly with time.

**Fig-1: Physical model of the problem**

The rheological condition of state for an isotropic and incompressible stream of a Casson fluid is given by

\[ \tau_{ij} = 2\mu_B \left( \frac{p_y}{\pi} \right) \sigma_{ij} - \pi_c \]

Where \( \mu_B \) is plastic dynamic viscosity of the non-Newtonian fluid, \( p_y \) is the yield stress of fluid, \( \pi \) is the product of the component of deformation rate with itself. \( \pi_c \) denotes critical value of this product based on the non-Newtonian fluid.

The over seeing partial differential equations are

\[ \frac{\partial u}{\partial x} - \frac{\partial u}{\partial y} = 0 \]  
\[ \frac{\partial u}{\partial t} = a \left( 1 + \frac{1}{\beta} \right) \frac{\partial^2 u}{\partial y^2} - \frac{\sigma}{\rho(1 + m^2)} \frac{\beta^2 (u + m v)}{1} \]  
\[ \frac{\partial v}{\partial t} = k \frac{\partial^2 v}{\partial y^2} + \frac{\partial q_v}{\partial x} + \frac{D_u K_v \beta_c}{1} \frac{\partial^2 C}{\partial y^2} \]  
\[ \frac{\partial C}{\partial t} = D \frac{\partial^2 C}{\partial y^2} - K_r (C - C_w) \]  

Initial and boundary conditions are

\[ t' \leq 0, u = 0, v = 0, T' = T_{\infty}, C' = C_{\infty} \]

**At y = 0**

\[ t' > 0, u \rightarrow u_0, T' \rightarrow T_{\infty}, C' \rightarrow C_{\infty} \] as \( y' \rightarrow \infty \)

\[ C = C_{\infty}, C' = C_{\infty} \]

\[ G_t = \frac{\nu \beta^2 (T'_{\infty} - T_{\infty})}{U'} \]

\[ M = \frac{\sigma B^2 \nu}{\rho U_0^2} \]

\[ H = \frac{\sigma_B \nu^2}{k U_0^2} \]

\[ S_r = \frac{D_r (T'_{\infty} - T_{\infty})}{\nu (C'_{\infty} - C_{\infty})} \]

The essential conditions of velocity, temperature and concentration can be communicated within the non-dimensional shape

\[ u = \frac{1 + 1}{\beta^2} \frac{\partial^2 u}{\partial y^2} + G_t \cos \alpha + G_c \cos \alpha - \frac{M (u + v)}{(1 + m^2)} \]

\[ v = \frac{1 + 1}{\beta^2} \frac{\partial^2 v}{\partial y^2} + \frac{M (m u - v)}{(1 + m^2)} \]

\[ \frac{\partial \gamma}{\partial t} = \left( \frac{1}{\beta^2} \right) \frac{\partial^2 \gamma}{\partial y^2} - \frac{R}{\gamma^2} (\theta) + \frac{D_u}{\gamma^2} \frac{\partial^2 C}{\partial y^2} \]

\[ \frac{\partial C}{\partial t} = \left( \frac{1}{Sc} \right) \frac{\partial^2 C}{\partial y^2} - (K_r) C \]

**At y = 0**

\[ t' > 0, u = u_0 \cos \omega t, v = 0, \theta = t, C' = t \]

\[ t' \leq 0, u = 0, v = 0, T' = T_{\infty}, C' = C_{\infty} \]

Writing the equations (8) and (9) in compact form

By taking \( F = u + i v \)

\[ \frac{\partial F}{\partial t} = \left( \frac{1 + 1}{\beta^2} \right) \frac{\partial^2 F}{\partial y^2} + G_t \cos \alpha + G_c \cos \alpha - \frac{M (1 + m^2)}{(1 + m^2 ^2)} F \]

Finally, the boundary conditions become

For all \( y \)

\[ t' \leq 0, \text{If } F = 0, \theta = 0, \text{and } C = 0 \]
3 SOLUTION OF THE PROBLEM

By the appliance of Laplace transform strategy with initial and boundary conditions, Correct arrangements were gotten from the equations (8), (9), (10) and (11)

\[
F(y,t) = \frac{1}{4} \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right] + \frac{e^{\sqrt{y} B (\sqrt{y} - A) + (\sqrt{y} - A)t}}{2 A_1^2} \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right] + \frac{G(y,t)}{2 A_1}
\]

\[
F(y,t) = \frac{1}{4} \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right] + \frac{e^{\sqrt{y} B (\sqrt{y} - A) + (\sqrt{y} - A)t}}{2 A_1^2} \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right]
\]

\[
A_{10} = \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right] + \frac{e^{\sqrt{y} B (\sqrt{y} - A) + (\sqrt{y} - A)t}}{2 A_1^2} \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right]
\]

\[
A_{11} = \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right] + \frac{e^{\sqrt{y} B (\sqrt{y} - A) + (\sqrt{y} - A)t}}{2 A_1^2} \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right]
\]

\[
A_{12} = \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right] + \frac{e^{\sqrt{y} B (\sqrt{y} - A) + (\sqrt{y} - A)t}}{2 A_1^2} \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right]
\]

\[
A_{13} = \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right] + \frac{e^{\sqrt{y} B (\sqrt{y} - A) + (\sqrt{y} - A)t}}{2 A_1^2} \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right]
\]

\[
A_{14} = \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right] + \frac{e^{\sqrt{y} B (\sqrt{y} - A) + (\sqrt{y} - A)t}}{2 A_1^2} \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right]
\]

\[
F(y,t) = \frac{1}{4} \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right] + \frac{e^{\sqrt{y} B (\sqrt{y} - A) + (\sqrt{y} - A)t}}{2 A_1^2} \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right]
\]

\[
A_{15} = \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right] + \frac{e^{\sqrt{y} B (\sqrt{y} - A) + (\sqrt{y} - A)t}}{2 A_1^2} \left[ e^{-\sqrt{y} B (\sqrt{y} + A) + (\sqrt{y} + A)t} \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}}) - \text{erfc}(\frac{\sqrt{y} B}{2 \sqrt{t}} + \sqrt{y} B) \right]
\]
\[ + \frac{A_{12}}{2A_{13}} \left\{ e^{-\sqrt{B} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{B}}{2 \sqrt{t}} \right) + e^{\sqrt{B} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{B}}{2 \sqrt{t}} + \sqrt{(A_{23}t)} \right) \right\} \]

\[ - \frac{A_{10} (1 - A_{9})}{2A_{11}} \left\{ \left( t - \frac{y^2 \sqrt{P}}{2A_{11}} \right) e^{-\sqrt{P} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{P}}{2 \sqrt{t}} - \sqrt{(A_{23}t)} \right) + \left( t + \frac{y^2 \sqrt{P}}{2A_{11}} \right) e^{\sqrt{P} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{P}}{2 \sqrt{t}} + \sqrt{(A_{23}t)} \right) \right\} \]

\[ + \frac{A_{10} (1 - A_{9})}{2A_{11}} \left\{ \left( t - \frac{y^2 \sqrt{P}}{2A_{11}} \right) e^{-\sqrt{P} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{P}}{2 \sqrt{t}} - \sqrt{(A_{23}t)} \right) + \left( t + \frac{y^2 \sqrt{P}}{2A_{11}} \right) e^{\sqrt{P} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{P}}{2 \sqrt{t}} + \sqrt{(A_{23}t)} \right) \right\} \]

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\[ + \frac{A_{10} (1 - A_{9})}{2A_{11}} \left\{ \left( t - \frac{y^2 \sqrt{P}}{2A_{11}} \right) e^{-\sqrt{P} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{P}}{2 \sqrt{t}} - \sqrt{(A_{23}t)} \right) + \left( t + \frac{y^2 \sqrt{P}}{2A_{11}} \right) e^{\sqrt{P} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{P}}{2 \sqrt{t}} + \sqrt{(A_{23}t)} \right) \right\} \]

\[ + \frac{A_{10} (1 - A_{9})}{2A_{11}} \left\{ \left( t - \frac{y^2 \sqrt{P}}{2A_{11}} \right) e^{-\sqrt{P} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{P}}{2 \sqrt{t}} - \sqrt{(A_{23}t)} \right) + \left( t + \frac{y^2 \sqrt{P}}{2A_{11}} \right) e^{\sqrt{P} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{P}}{2 \sqrt{t}} + \sqrt{(A_{23}t)} \right) \right\} \]

\[ + \frac{A_{10} (1 - A_{9})}{2A_{11}} \left\{ \left( t - \frac{y^2 \sqrt{P}}{2A_{11}} \right) e^{-\sqrt{P} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{P}}{2 \sqrt{t}} - \sqrt{(A_{23}t)} \right) + \left( t + \frac{y^2 \sqrt{P}}{2A_{11}} \right) e^{\sqrt{P} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{P}}{2 \sqrt{t}} + \sqrt{(A_{23}t)} \right) \right\} \]

\[ + \frac{A_{10} (1 - A_{9})}{2A_{11}} \left\{ \left( t - \frac{y^2 \sqrt{P}}{2A_{11}} \right) e^{-\sqrt{P} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{P}}{2 \sqrt{t}} - \sqrt{(A_{23}t)} \right) + \left( t + \frac{y^2 \sqrt{P}}{2A_{11}} \right) e^{\sqrt{P} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{P}}{2 \sqrt{t}} + \sqrt{(A_{23}t)} \right) \right\} \]

\[ + \frac{A_{10} (1 - A_{9})}{2A_{11}} \left\{ \left( t - \frac{y^2 \sqrt{P}}{2A_{11}} \right) e^{-\sqrt{P} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{P}}{2 \sqrt{t}} - \sqrt{(A_{23}t)} \right) + \left( t + \frac{y^2 \sqrt{P}}{2A_{11}} \right) e^{\sqrt{P} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{P}}{2 \sqrt{t}} + \sqrt{(A_{23}t)} \right) \right\} \]

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\[ + \frac{A_{10} (1 - A_{9})}{2A_{11}} \left\{ \left( t - \frac{y^2 \sqrt{P}}{2A_{11}} \right) e^{-\sqrt{P} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{P}}{2 \sqrt{t}} - \sqrt{(A_{23}t)} \right) + \left( t + \frac{y^2 \sqrt{P}}{2A_{11}} \right) e^{\sqrt{P} \sqrt{A_{22} + (A_{43})}} \text{erfc} \left( \frac{y \sqrt{P}}{2 \sqrt{t}} + \sqrt{(A_{23}t)} \right) \right\} \]
+ \frac{A_{12}}{2 A_{11}} (e^{-y \sqrt{S_c} \sqrt{(A_{24})} + (A_{24})} + e^{y \sqrt{S_c} \sqrt{(A_{24})} + (A_{24})}) e^{-y \sqrt{S_c} \sqrt{(A_{24})} + (A_{24})}) - \frac{A_{12}}{2 A_{11}} (e^{-y \sqrt{S_c} \sqrt{(A_{24})} + (A_{24})} + e^{y \sqrt{S_c} \sqrt{(A_{24})} + (A_{24})}) e^{-y \sqrt{S_c} \sqrt{(A_{24})} + (A_{24})})

\theta(y, t) = \frac{1}{2} \left\{ \left( t - \frac{y \sqrt{P_r}}{2 A_{4}} \right) e^{-y \sqrt{S_c} \sqrt{(A_{24})} + (A_{24})} + \left( t + \frac{y \sqrt{P_r}}{2 A_{4}} \right) e^{y \sqrt{S_c} \sqrt{(A_{24})} + (A_{24})} \right\} + \left\{ \left( t - \frac{y \sqrt{P_r}}{2 A_{4}} \right) e^{-y \sqrt{S_c} \sqrt{(A_{24})} + (A_{24})} + \left( t + \frac{y \sqrt{P_r}}{2 A_{4}} \right) e^{y \sqrt{S_c} \sqrt{(A_{24})} + (A_{24})} \right\}

\frac{A_{12}}{2 A_{11}} \left\{ \left( \frac{y \sqrt{P_r}}{2 A_{4}} \right) e^{-y \sqrt{S_c} \sqrt{(A_{24})} + (A_{24})} + \left( \frac{y \sqrt{P_r}}{2 A_{4}} \right) e^{y \sqrt{S_c} \sqrt{(A_{24})} + (A_{24})} \right\} + \frac{A_{12}}{2 A_{11}} \left\{ \left( \frac{y \sqrt{P_r}}{2 A_{4}} \right) e^{-y \sqrt{S_c} \sqrt{(A_{24})} + (A_{24})} + \left( \frac{y \sqrt{P_r}}{2 A_{4}} \right) e^{y \sqrt{S_c} \sqrt{(A_{24})} + (A_{24})} \right\}

4. RESULTS AND DISCUSSIONS

For the clear analysis of the problem the analytical solutions pertaining to Temperature, speed, and concentration within the consideration of lobby impact on MHD Casson liquid stream with chemical response, warm, radiation and Dufour impact displayed graphically. For the present study the parameters used and their values are given as below:

<table>
<thead>
<tr>
<th>Pr</th>
<th>Du</th>
<th>l</th>
<th>w</th>
<th>kr</th>
<th>β</th>
<th>Gr</th>
<th>Gm</th>
<th>R</th>
<th>M</th>
</tr>
</thead>
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<tr>
<td>7</td>
<td>5</td>
<td>1</td>
<td>1</td>
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<td>0.05</td>
<td>0.05</td>
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So all graphs and tables thus correspond to these values unless specifically indicated with in the specific graph or table. Figures 2 to 19 portray the impact of different parameters on essential and auxiliary speeds. From figures 2 and 3 it is revealed that essential and auxiliary speeds diminish with expanding values of α. Figures 4 and 5 outline the impact of Hall current on fundamental speed u and auxiliary speed v separately. Owing to the reality that Hall current quickens essential and auxiliary speeds. Figures 6 and 7 revealed that essential and auxiliary speeds diminish with expanding values of Du. This is often since of increment in dissemination rate. From figures 6 and 7 it is taken note that due to the increment in dynamic viscosity essential and auxiliary speeds diminishes with consecutive values of β. The impounding nature of Magnetic parameter causes drop in essential speed, where as auxiliary speed increments. It was portrayed in figures 10 and 11. Figures 12 and 13 demonstrate the impact of Grashof number. As can be seen an increase in Gm leads to increase in essential speed and decrease in auxiliary speed. Figures 14 and 15 depict the effects of frequency of oscillation w on auxiliary and essential velocities. It is evident from the figures that essential speed decreases and auxiliary speed rises on increase in w. Figures 16 and 17 display the impact of radiation parameter R on u and v. It is visible that primary velocity decreases with increase in R where as secondary velocity increases with increasing R up to certain extent and then reverse trend was observed. Figure 18 and 19 illustrate the influence of chemical reaction parameter Kr on auxiliary and essential speeds respectively. From figure 18 and 19 it is apparent that the increase in Kr results, decrease in both auxiliary and essential speeds. The liquid temperature versus boundary layer vary arises in figure 20-22 are shown graphically for different values of R, Pr and Du. It is obvious from figure 20 that liquid temperature diminishes on increment in esteem of R since of Rosseland approximation. From figure 21, it is taken note that liquid temperature reduces with increase in Pr. This due to diminish in thermal conductivity. Figure 22 appears that increment in Du upgrades the temperature of the liquid. Figures 23 and 24 appears that, impact of chemical reaction parameter kr and schmidt number sc on concentration profiles. It is taken into thought that when the chemical response increments as the concentration dispensions diminish. Physically, numerous unsettling influences takes place for a dangerous case, within the neareness of chemical response. Due to this tall molecular motion is caused. This brings down the concentration disseminations within the liquid stream and increments the transport marvels. This might result in a drop in concentration profiles by dint of rise within the chemical response parameter. With increment within the Schmidt number the concentration decreases.
Figure 3: Commitment of angle of inclination on auxiliary speed

Figure 4: Commitment of Hall current parameter on essential speed

Figure 5: Commitment of Hall current parameter on auxiliary speed

Figure 6: Contribution of Dufour number on essential speed

Figure 7: Contribution of Dufour number on auxiliary speed

Figure 8: Impact of Casson parameter on essential speed

Figure 9: Impact of Casson parameter on auxiliary speed

Figure 10: Influence of Magnetic parameter on essential speed

Figure 11: Influence of Magnetic parameter on auxiliary speed

Figure 12: Impact of MassGrashof number on essential speed
Figure-13: Impact of Mass Grashof number on Auxiliary speed

Figure-14: Contribution of Frequency of oscillation on Essential speed

Figure-15: Contribution of Frequency of oscillation on auxiliary speed

Figure-16: Impact of Thermal Radiation on Essential speed

Figure-17: Impact of Thermal Radiation on Auxiliary speed

Figure-18: Contribution of Chemical reaction parameter on Essential speed

Figure-19: Contribution of Chemical reaction parameter on secondary velocity

Figure-20: Effect of Thermal Radiation on Temperature

Figure-21: Contribution of prandtl number on Temperature

Figure-22: Influence of Dufour number on Temperature
In fluid dynamics the skin friction is the contact between moving liquid and its encasing surface. The skin friction coefficient $S_f$ which maybe a dimensionless frictional push, it is valuable in assessing not as it were add up to frictional drag applied on an object. But moreover convectonal warm exchange rate on its surface.

$$S_f = \left(1 + \frac{1}{\beta} \right) \frac{\partial \phi}{\partial y} = \tau_x + i \tau_y$$

The Nusselt number (Nu) is the extent of convective to conductive heat-transfer at a boundary in a fluid. This tells us early how much the heat transfer is overhauled due to fluid development. The Nusselt number (Nu) is the extent of convective to conductive heat-transfer at a boundary in a fluid. The Sherwood number (Sh) may be a dimensionless number utilized in mass-transfer operation. It represents the extent of the convective mass transfer to the rate of diffusive mass transport. The Sherwood number speaks to the reasonability of mass convection at the surface.

$$Sh = \left( \frac{\partial \phi}{\partial y} \right)_{y=1} = \alpha$$

Table 1, 2, 3 portrays the effect of essential parameters on skin friction, Nusselt number and Sherwood number. The numerical values of essential skin and auxiliary skin friction are shown in Table 1 for distinctive values of Pr, Du, $\varepsilon$, $\omega$, $\alpha$, $K_r$, $\beta$, $m$, Gr, Gm, Sc, R, M. The numerical values of Nusselt number are shown in table 2 for different values of pr, Du and R. The numerical values of Sherwood number are shown in table 3 for diverse values of sc and kr.

### Table 1 Skin friction

<table>
<thead>
<tr>
<th>Pr</th>
<th>Du</th>
<th>$\varepsilon$</th>
<th>$\omega$</th>
<th>$\alpha$</th>
<th>$K_r$</th>
<th>$\beta$</th>
<th>$m$</th>
<th>Gr</th>
<th>Gm</th>
<th>Sc</th>
<th>R</th>
<th>M</th>
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<td>0.05</td>
<td>0.80</td>
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<td>0.1</td>
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<td>-0.010943</td>
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<td>$\pi/6$</td>
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<td>2</td>
<td>0.05</td>
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<td>2</td>
<td>0.05</td>
<td>0.05</td>
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### Table 2 - Nusselt Number

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<th>sh</th>
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<td>0.80</td>
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<td>0.061609</td>
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<tr>
<td>0.6</td>
<td>0.80</td>
<td>3</td>
<td>0.089190</td>
</tr>
</tbody>
</table>

### Table 3 - Sherwood Number

<table>
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<tr>
<th>Pr</th>
<th>Sc</th>
<th>Kr</th>
<th>sh</th>
</tr>
</thead>
<tbody>
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5 CONCLUSIONS
With the in the display ponder an examination has been carried out to consider the effect of Hall Current on MHD Casson Fluid Stream with Chemical Reaction, Dufour effect and Therma Radiation by utilizing the methodology of laplace transform amid the examination, the taking after focuses are watched.
[1] The essential speed falls down with rising values of α and β but increments with expanding values of M
[2] The auxiliary speed increments with expanding values of M but diminishes with increases of α and β
[3] Essential speed diminishes with expanding esteem of Du, the auxiliary speed diminishes with expanding esteem of Du
[4] It is watched that the essential speed increments with expanding values of Gm and the auxiliary speed diminishes with expanding values of Gm
[5] The essential speed diminishes with expanding values of M, the auxiliary speed increments with expanding values of M
[6] It is observed that the essential and auxiliary speed diminishes with expanding values of α
[7] The temperature lessens with extending values of R and Pr but increases with growing values of Du
[8] The concentration decays with rising values of kr and sc.

REFERENCES
APPENDIX

\[ A = \frac{M (1 - im)}{1 + m} \]

\[ A_1 = \frac{D u S c}{S_0 - P} \]

\[ A_2 = -\frac{K, D u}{S_0 - P} \]

\[ A_3 = \frac{S_K R - R}{S_0 - P} \]

\[ A_4 = \frac{R}{P} \]

\[ A_5 = \frac{R}{P} - A_1 \]

\[ A_6 = K_1 - A_3 \]

\[ A_7 = \frac{A_1}{A_3} \]

\[ A_8 = \frac{A_1}{A_1} \]

\[ A_9 = \frac{A_1}{A_3} \]

\[ A_{10} = \frac{1}{P - \mu} \]

\[ A_{11} = \frac{P A_1 - B A}{P - B} \]

\[ A_{12} = \frac{1}{S_0 - B} \]

\[ A_{13} = \frac{S K_1 - B A}{S_0 - B} \]

\[ A_{15} = A_3 + A_4 \]

\[ A_{16} = K_1 - A_4 \]

\[ A_{17} = A - A_1 \]

\[ A_{18} = -A_4 + A_4 \]

\[ A_{19} = A - A_1 \]

\[ A_{20} = -A_1 + A_1 \]

\[ A_{21} = A - A_1 \]

\[ A_{22} = A - A_1 \]

\[ A_{23} = K_1 - A_4 \]

\[ A_{24} = K_1 - A_4 \]

\[ A_{25} = A_1 - A_1 \]

\[ A_{26} = A_4 - A_4 \]

\[ B_1 = -\sqrt{B} \sqrt{(A_1 - w) + (A_1 + w)} \]

\[ B_2 = \sqrt{B} \sqrt{(A_1 - w) + (A_1 + w)} \]

\[ B_3 = -\sqrt{B} \sqrt{(A_1 - w) + (A_1 - w)} \]

\[ B_4 = \sqrt{B} \sqrt{(A_1 - w) + (A_1 - w)} \]

\[ B_5 = -\sqrt{B} \sqrt{(A_1 - w) + (A_1 - w)} \]

\[ B_6 = \sqrt{B} \sqrt{(A_1 - w) + (A_1 - w)} \]

\[ B_7 = -\sqrt{B} \sqrt{(A_1 - w) + (A_1 - w)} \]

\[ B_8 = \sqrt{B} \sqrt{(A_1 - w) + (A_1 - w)} \]

\[ B_9 = -\sqrt{B} \sqrt{(A_1 - w) + (A_1 - w)} \]

\[ B_{10} = \sqrt{B} \sqrt{(A_1 - w) + (A_1 - w)} \]

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\[ B_{14} = \sqrt{B} \sqrt{(A_1 - w) + (A_1 - w)} \]

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\[ B_{16} = \sqrt{B} \sqrt{(A_1 - w) + (A_1 - w)} \]

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\[ B_{18} = \sqrt{B} \sqrt{(A_1 - w) + (A_1 - w)} \]

\[ B_{19} = -\sqrt{B} \sqrt{(A_1 - w) + (A_1 - w)} \]

\[ B_{20} = \sqrt{B} \sqrt{(A_1 - w) + (A_1 - w)} \]

\[ B_{21} = -\sqrt{B} \sqrt{(A_1 - w) + (A_1 - w)} \]

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\[ B_{55} = -\sqrt{B} \sqrt{(A_1 - w) + (A_1 - w)} \]

\[ B_{56} = \sqrt{B} \sqrt{(A_1 - w) + (A_1 - w)} \]
\[ B_{39} = -y\sqrt{S_c} \sqrt[3]{(A_{23})^3 + A_{23}^t} \]
\[ B_{40} = y\sqrt{S_c} \sqrt[3]{(A_{23})^3 + A_{23}^t} \]
\[ B_{50} = b_{c,r} = -y\sqrt{S_c} \sqrt[3]{(K_r + K_r)^t} \]
\[ B_{35} = B_{34} = y\sqrt{S_c} \sqrt[3]{(K_r + K_r)^t} \]
\[ B_{36} = \sqrt{S_c} (A_{61}^t + A_{61}^t) \]
\[ B_{46} = y\sqrt{S_c} \sqrt[3]{(A_{61}^t + A_{61}^t)} \]
\[ C_1 = \frac{y\sqrt{B}}{2\sqrt{t}} = \sqrt{(t + A)^t} \]
\[ C_2 = \frac{y\sqrt{B}}{2\sqrt{t} + \sqrt{(t + A)^t}} \]
\[ C_3 = \frac{y\sqrt{B}}{2\sqrt{t} - \sqrt{(t + A)^t}} \]
\[ C_4 = \frac{y\sqrt{B}}{2\sqrt{t} + \sqrt{(t + A)^t}} \]
\[ C_5 = \frac{y\sqrt{B}}{2\sqrt{t} - \sqrt{(t + A)^t}} \]
\[ C_6 = \frac{y\sqrt{B}}{2\sqrt{t} - \sqrt{(t + A)^t}} \]
\[ C_7 = \frac{y\sqrt{B}}{2\sqrt{t} - \sqrt{(t + A)^t}} \]
\[ C_8 = \frac{y\sqrt{B}}{2\sqrt{t} + \sqrt{(t + A)^t}} \]
\[ C_9 = \frac{y\sqrt{B}}{2\sqrt{t} - \sqrt{(t + A)^t}} \]
\[ C_{10} = \frac{y\sqrt{B}}{2\sqrt{t} + \sqrt{(t + A)^t}} \]
\[ C_{11} = \frac{y\sqrt{B}}{2\sqrt{t} - \sqrt{(t + A)^t}} \]
\[ C_{12} = \frac{y\sqrt{B}}{2\sqrt{t} + \sqrt{(t + A)^t}} \]
\[ C_{13} = \frac{y\sqrt{B}}{2\sqrt{t} - \sqrt{(t + A)^t}} \]
\[ C_{14} = \frac{y\sqrt{B}}{2\sqrt{t} + \sqrt{(t + A)^t}} \]
\[ C_{15} = \frac{y\sqrt{B}}{2\sqrt{t} - \sqrt{(t + A)^t}} \]
\[ C_{16} = \frac{y\sqrt{B}}{2\sqrt{t} + \sqrt{(t + A)^t}} \]
\[ C_{17} = \frac{y\sqrt{B}}{2\sqrt{t} - \sqrt{(t + A)^t}} \]
\[ C_{18} = \frac{y\sqrt{B}}{2\sqrt{t} + \sqrt{(t + A)^t}} \]
\[ C_{19} = \frac{y\sqrt{B}}{2\sqrt{t} - \sqrt{(t + A)^t}} \]
\[ C_{20} = C_{11} = \frac{y\sqrt{P}}{2\sqrt{t}} + \sqrt{A_t^t} \]
\[ C_{21} = \frac{y\sqrt{P}}{2\sqrt{t}} - \sqrt{A_t^t} \]
\[ C_{22} = \frac{y\sqrt{P}}{2\sqrt{t}} + \sqrt{A_t^t} \]
\[ C_{23} = \frac{y\sqrt{P}}{2\sqrt{t}} - \sqrt{A_t^t} \]
\[ C_{24} = \frac{y\sqrt{P}}{2\sqrt{t}} + \sqrt{A_t^t} \]
\[ C_{25} = \frac{y\sqrt{P}}{2\sqrt{t}} - \sqrt{A_t^t} \]
\[ C_{26} = \frac{y\sqrt{P}}{2\sqrt{t}} + \sqrt{A_t^t} \]
\[ C_{27} = \frac{y\sqrt{P}}{2\sqrt{t}} - \sqrt{A_t^t} \]
\[ C_{28} = \frac{y\sqrt{P}}{2\sqrt{t}} + \sqrt{A_t^t} \]
\[ C_{29} = \frac{y\sqrt{P}}{2\sqrt{t}} - \sqrt{A_t^t} \]
\[ C_{30} = \frac{y\sqrt{P}}{2\sqrt{t}} + \sqrt{A_t^t} \]
\[ C_{31} = \frac{y\sqrt{P}}{2\sqrt{t}} - \sqrt{A_t^t} \]
\[ C_{32} = \frac{y\sqrt{P}}{2\sqrt{t}} + \sqrt{A_t^t} \]
\[ C_{33} = \frac{y\sqrt{P}}{2\sqrt{t}} - \sqrt{A_t^t} \]
\[ C_{34} = \frac{y\sqrt{P}}{2\sqrt{t}} + \sqrt{A_t^t} \]
\[ C_{35} = \frac{y\sqrt{P}}{2\sqrt{t}} - \sqrt{A_t^t} \]
\[ C_{36} = \frac{y\sqrt{P}}{2\sqrt{t}} + \sqrt{A_t^t} \]
\[ C_{37} = \frac{y\sqrt{P}}{2\sqrt{t}} - \sqrt{A_t^t} \]
\[ C_{38} = \frac{y\sqrt{P}}{2\sqrt{t}} + \sqrt{A_t^t} \]
\[ C_{39} = \frac{y\sqrt{P}}{2\sqrt{t}} - \sqrt{A_t^t} \]
\[ C_{40} = \frac{y\sqrt{P}}{2\sqrt{t}} + \sqrt{A_t^t} \]
\[ C_{41} = \frac{y\sqrt{P}}{2\sqrt{t}} - \sqrt{A_t^t} \]
\[ C_{42} = \frac{y\sqrt{P}}{2\sqrt{t}} + \sqrt{A_t^t} \]
\[ C_{43} = \frac{y\sqrt{P}}{2\sqrt{t}} - \sqrt{A_t^t} \]
\[ C_{44} = \frac{y\sqrt{P}}{2\sqrt{t}} + \sqrt{A_t^t} \]
\[ C_{45} = \frac{y\sqrt{P}}{2\sqrt{t}} - \sqrt{A_t^t} \]
\[ C_{46} = \frac{y\sqrt{P}}{2\sqrt{t}} + \sqrt{A_t^t} \]
\[ C_{47} = \frac{y\sqrt{P}}{2\sqrt{t}} - \sqrt{A_t^t} \]
\[ C_{48} = \frac{y\sqrt{P}}{2\sqrt{t}} + \sqrt{A_t^t} \]
\[ C_{49} = \frac{y\sqrt{P}}{2\sqrt{t}} - \sqrt{A_t^t} \]
\[ C_{50} = \frac{y\sqrt{P}}{2\sqrt{t}} + \sqrt{A_t^t} \]
\[ D_y = \frac{y\sqrt{P}}{2\sqrt{t}} + \sqrt{(A - iw)^t} \]
\[ E_y = \left(t - \frac{y\sqrt{P}}{2\sqrt{A}}\right)e^{j\theta_y} \]
\[ E_z = (t + \frac{y \sqrt{S_r}}{2 \sqrt{K_r}}) e^{-\sqrt{S_r} \sqrt{K_r}} \]

\[ E_x = (t - \frac{y \sqrt{S_r}}{2 \sqrt{K_r}}) e^{\sqrt{S_r} \sqrt{K_r}} \]

\[ E_y = (t + \frac{y \sqrt{S_r}}{2 \sqrt{K_r}}) e^{\sqrt{S_r} \sqrt{K_r}} \]

\[ E_{\gamma} = (t - \frac{y \sqrt{S_r}}{2 \sqrt{K_r}}) e^{-\sqrt{S_r} \sqrt{K_r}} \]

\[ E_\phi = (t + \frac{y \sqrt{S_r}}{2 \sqrt{K_r}}) e^{\sqrt{S_r} \sqrt{K_r}} \]

\[ \alpha_1 = \frac{A_{10}(1 - A_2)}{A_{41}^2} \quad \alpha_2 = \frac{A_{10}(1 - A_2)}{A_{41}} \]

\[ \alpha_4 = \frac{A_{10}(A_{15})}{A_{11}} \quad \alpha_5 = \frac{A_{10}(A_{15})}{A_{20}} \]

\[ \alpha_6 = \frac{A_{12}(A_{15})}{A_{13}} \]

\[ \alpha_7 = \frac{A_{12}A_2}{A_{13}^2} \quad \alpha_8 = \frac{A_{13}A_9}{A_{15}} \]

\[ \alpha_9 = \frac{A_{12}A_2}{A_{13}^2} \quad \alpha_{10} = \frac{A_{12}}{A_{13}} \]