Integral involving a generalized multiple-index Mittag-Leffler function,hyperbolic functions, a class of polynomials multivariable Aleph-function and multivariable I-function I

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ABSTRACT
In the present paper we evaluate a general integral involving the product of a generalized multiple-index Mittag-Leffler function,hyperbolic functions, multivariable Aleph-function, the multivariable I-function defined by Prasad [4] and general class of polynomials of several variables. The importance of the result established in this paper lies in the fact they involve the Aleph-function of several variables which is sufficiently general in nature and capable to yielding a large of results merely by specializating the parameters their in.

Keywords:Multivariable Aleph-function, general class of polynomials, generalized multiple-index Mittag-Leffler function, multivariable I-function, multivariable H-function

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1.Introduction and preliminaries.

The function Aleph of several variables generalize the multivariable I-function recently study by C.K. Sharma and Ahmad [5] , itself is an a generalisation of G and H-functions of multiple variables. The multiple Mellin-Barnes integral occuring in this paper will be referred to as the multivariables Aleph-function throughout our present study and will be defined and represented as follows.

We define : $\aleph(z_1,\cdots,z_r)=\aleph^{0,N:M_1,N_1,\cdots,M_r,N_r}_{P_i,Q_i,\tau_i;R:P_{i^{(1)}},Q_{i^{(1)}},\tau_{i^{(1)}};R^{(1)};\cdots;P_{i^{(r)}},Q_{i^{(r)}};\tau_{i^{(r)}};R^{(r)}}\left(\begin{array}{c} \mathrm{z}_1 \\ \cdot \\ \cdot \\ \cdot \\ \mathrm{z}_r \end{array}\right|$

$[(\mathrm{a}_j;\alpha_j^{(1)},\cdots,\alpha_j^{(r)})_{1,N}]\ ,[\tau_i(a_{ji};\alpha_{ji}^{(1)},\cdots,\alpha_{ji}^{(r)})_{N+1,P_i}]:$
$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ ,[\tau_i(b_{ji};\beta_{ji}^{(1)},\cdots,\beta_{ji}^{(r)})_{M+1,Q_i}]:$

$\left.\begin{array}{l}[(\mathrm{c}_j^{(1)});\gamma_j^{(1)})_{1,N_1}],[\tau_{i^{(1)}}(c_{ji^{(1)}}^{(1)};\gamma_{ji^{(1)}}^{(1)})_{N_1+1,P_i^{(1)}}];\cdots;[(\mathrm{c}_j^{(r)});\gamma_j^{(r)})_{1,N_r}],[\tau_{i^{(r)}}(c_{ji^{(r)}}^{(r)};\gamma_{ji^{(r)}}^{(r)})_{N_r+1,P_i^{(r)}}]\\ [(\mathrm{d}_j^{(1)});\delta_j^{(1)})_{1,M_1}],[\tau_{i^{(1)}}(d_{ji^{(1)}}^{(1)};\delta_{ji^{(1)}}^{(1)})_{M_1+1,Q_i^{(1)}}];\cdots;[(\mathrm{d}_j^{(r)});\delta_j^{(r)})_{1,M_r}],[\tau_{i^{(r)}}(d_{ji^{(r)}}^{(r)};\delta_{ji^{(r)}}^{(r)})_{M_r+1,Q_i^{(r)}}]\end{array}\right)$

$$=\frac{1}{(2\pi\omega)^r}\int_{L_1}\cdots\int_{L_r}\psi(s_1,\cdots,s_r)\prod_{k=1}^{r}\theta_k(s_k)y_k^{s_k}\,\mathrm{d}s_1\cdots\mathrm{d}s_r \tag{1.1}$$

with $\omega=\sqrt{-1}$

$$\psi(s_1,\cdots,s_r)=\frac{\prod_{j=1}^{N}\Gamma(1-a_j+\sum_{k=1}^{r}\alpha_j^{(k)}s_k)}{\sum_{i=1}^{R}[\tau_i\prod_{j=N+1}^{P_i}\Gamma(a_{ji}-\sum_{k=1}^{r}\alpha_{ji}^{(k)}s_k)\prod_{j=1}^{Q_i}\Gamma(1-b_{ji}+\sum_{k=1}^{r}\beta_{ji}^{(k)}s_k)]} \tag{1.2}$$

and $$\theta_k(s_k)=\frac{\prod_{j=1}^{M_k}\Gamma(d_j^{(k)}-\delta_j^{(k)}s_k)\prod_{j=1}^{N_k}\Gamma(1-c_j^{(k)}+\gamma_j^{(k)}s_k)}{\sum_{i^{(k)}=1}^{R^{(k)}}[\tau_{i^{(k)}}\prod_{j=M_k+1}^{Q_{i^{(k)}}}\Gamma(1-d_{ji^{(k)}}^{(k)}+\delta_{ji^{(k)}}^{(k)}s_k)\prod_{j=N_k+1}^{P_{i^{(k)}}}\Gamma(c_{ji^{(k)}}^{(k)}-\gamma_{ji^{(k)}}^{(k)}s_k)]} \tag{1.3}$$

Suppose , as usual , that the parameters

$b_j, j = 1, \cdots, Q; a_j, j = 1, \cdots, P;$

$c_{ji^{(k)}}^{(k)}, j = n_k + 1, \cdots, P_{i^{(k)}}; c_j^{(k)}, j = 1, \cdots, N_k;$

$d_{ji^{(k)}}^{(k)}, j = M_k + 1, \cdots, Q_{i^{(k)}}; d_j^{(k)}, j = 1, \cdots, M_k;$

with $k = 1 \cdots, r, i = 1, \cdots, R, i^{(k)} = 1, \cdots, R^{(k)}$

are complex numbers , and the $\alpha' s, \beta' s, \gamma' s$ and $\delta' s$ are assumed to be positive real numbers for standardization purpose such that

$$U_i^{(k)} = \sum_{j=1}^{N} \alpha_j^{(k)} + \tau_i \sum_{j=N+1}^{P_i} \alpha_{ji}^{(k)} + \sum_{j=1}^{N_k} \gamma_j^{(k)} + \tau_{i^{(k)}} \sum_{j=n_k+1}^{P_{i^{(k)}}} \gamma_{ji^{(k)}}^{(k)} - \tau_i \sum_{j=1}^{Q_i} \beta_{ji}^{(k)} - \sum_{j=1}^{M_k} \delta_j^{(k)}$$

$$-\tau_{i^{(k)}} \sum_{j=M_k+1}^{Q_{i^{(k)}}} \delta_{ji^{(k)}}^{(k)} \leqslant 0 \tag{1.4}$$

The reals numbers τ_i are positives for $i = 1$ to R , $\tau_{i^{(k)}}$ are positives for $i^{(k)} = 1$ to $R^{(k)}$

The contour L_k is in the s_k-p lane and run from $\sigma - i\infty$ to $\sigma + i\infty$ where σ is a real number with loop , if necessary ,ensure that the poles of $\Gamma(d_j^{(k)} - \delta_j^{(k)} s_k)$ with $j = 1$ to m_k are separated from those of $\Gamma(1 - a_j + \sum_{i=1}^{r} \alpha_j^{(k)} s_k)$ with $j = 1$ to N and $\Gamma(1 - c_j^{(k)} + \gamma_j^{(k)} s_k)$ with $j = 1$ to N_k to the left of the contour L_k . The condition for absolute convergence of multiple Mellin-Barnes type contour (1.9) can be obtained by extension of the corresponding conditions for multivariable H-function given by as :

$|arg z_k| < \frac{1}{2} A_i^{(k)} \pi$, where

$$A_i^{(k)} = \sum_{j=1}^{N} \alpha_j^{(k)} - \tau_i \sum_{j=N+1}^{P_i} \alpha_{ji}^{(k)} - \tau_i \sum_{j=1}^{Q_i} \beta_{ji}^{(k)} + \sum_{j=1}^{N_k} \gamma_j^{(k)} - \tau_{i^{(k)}} \sum_{j=N_k+1}^{P_{i^{(k)}}} \gamma_{ji^{(k)}}^{(k)}$$

$$+ \sum_{j=1}^{M_k} \delta_j^{(k)} - \tau_{i^{(k)}} \sum_{j=M_k+1}^{Q_{i^{(k)}}} \delta_{ji^{(k)}}^{(k)} > 0, \quad \text{with } k = 1 \cdots, r, i = 1, \cdots, R, i^{(k)} = 1, \cdots, R^{(k)} \tag{1.5}$$

The complex numbers z_i are not zero.Throughout this document , we assume the existence and absolute convergence conditions of the multivariable Aleph-function.

We may establish the the asymptotic expansion in the following convenient form :

$\aleph(z_1, \cdots, z_r) = 0(|z_1|^{\alpha_1}, \cdots, |z_r|^{\alpha_r}), max(|z_1|, \cdots, |z_r|) \rightarrow 0$

$\aleph(z_1, \cdots, z_r) = 0(|z_1|^{\beta_1}, \cdots, |z_r|^{\beta_r}), min(|z_1|, \cdots, |z_r|) \rightarrow \infty$

where, with $k = 1, \cdots, r : \alpha_k = min[Re(d_j^{(k)} / \delta_j^{(k)})], j = 1, \cdots, M_k$ and

$$\beta_k = max[Re((c_j^{(k)} - 1)/\gamma_j^{(k)})], j = 1, \cdots, N_k$$

Serie representation of Aleph-function of several variables is given by

$$\aleph(y_1, \cdots, y_r) = \sum_{G_1, \cdots, G_r = 0}^{\infty} \sum_{g_1=0}^{M_1} \cdots \sum_{g_r=0}^{M_r} \frac{(-)^{G_1+\cdots+G_r}}{\delta_{g_1} G_1! \cdots \delta_{g_r} G_r!} \psi(\eta_{G_1,g_1}, \cdots, \eta_{G_r,g_r})$$

$$\times \ \theta_1(\eta_{G_1,g_1}) \cdots \theta_r(\eta_{G_r,g_r}) y_1^{-\eta_{G_1,g_1}} \cdots y_r^{-\eta_{G_r,g_r}} \tag{1.6}$$

Where $\psi(., \cdots, .), \theta_i(.), i = 1, \cdots, r$ are given respectively in (1.2), (1.3) and

$$\eta_{G_1,g_1} = \frac{d_{g_1}^{(1)} + G_1}{\delta_{g_1}^{(1)}}, \cdots, \ \eta_{G_r,g_r} = \frac{d_{g_r}^{(r)} + G_r}{\delta_{g_r}^{(r)}}$$

which is valid under the conditions $\delta_{g_i}^{(i)}[d_j^i + p_i] \neq \delta_j^{(i)}[d_{g_i}^i + G_i]$ (1.7)

for $j \neq M_i, M_i = 1, \cdots \eta_{G_i,g_i}; P_i, N_i = 0, 1, 2, \cdots, ; y_i \neq 0, i = 1, \cdots, r$ (1.8)

In the document , we will note :

$$G(\eta_{G_1,g_1}, \cdots, \eta_{G_r,g_r}) = \phi(\eta_{G_1,g_1}, \cdots, \eta_{G_r,g_r}) \theta_1(\eta_{G_1,g_1}) \cdots \theta_r(\eta_{G_r,g_r}) \tag{1.9}$$

where $\phi(\eta_{G_1,g_1}, \cdots, \eta_{G_r,g_r}), \theta_1(\eta_{G_1,g_1}), \cdots, \theta_r(\eta_{G_r,g_r})$ are given respectively in (1.2) and (1.3)

We will note the Aleph-function of r variables $\aleph_{u:w}^{0,N:v}\left(\begin{array}{c} z_1 \\ \cdots \\ z_r \end{array}\right)$ (1.10)

The multivariable I-function is defined in term of multiple Mellin-Barnes type integral :

$$I(z_1, z_2, ...z_s) = I_{p_2,q_2,p_3,q_3;\cdots;p_s,q_s:p',q';\cdots;p^{(s)},q^{(s)}}^{0,n_2;0,n_3;\cdots;0,n_r:m',n';\cdots;m^{(s)},n^{(s)}} \left(\begin{array}{c|c} z_1 & (a_{2j}; \alpha'_{2j}, \alpha''_{2j})_{1,p_2}; \cdots; \\ \cdot & \\ \cdot & \\ \cdot & \\ z_s & (b_{2j}; \beta'_{2j}, \beta''_{2j})_{1,q_2}; \cdots; \end{array}\right.$$

$$\left.\begin{array}{c} (a_{sj}; \alpha'_{sj}, \cdots, \alpha_{sj}^{(s)})_{1,p_s} : (a'_j, \alpha'_j)_{1,p'}; \cdots; (a_j^{(s)}, \alpha_j^{(s)})_{1,p^{(s)}} \\ \\ (b_{sj}; \beta'_{sj}, \cdots, \beta_{sj}^{(s)})_{1,q_s} : (b'_j, \beta'_j)_{1,q'}; \cdots; (b_j^{(s)}, \beta_j^{(s)})_{1,q^{(s)}} \end{array}\right) \tag{1.11}$$

$$= \frac{1}{(2\pi\omega)^s} \int_{L_1} \cdots \int_{L_s} \xi(t_1, \cdots, t_s) \prod_{i=1}^{s} \phi_i(t_i) z_i^{t_i} \mathrm{d}t_1 \cdots \mathrm{d}t_s \tag{1.12}$$

The defined integral of the above function, the existence and convergence conditions, see Y,N Prasad [3]. Throughout the present document, we assume that the existence and convergence conditions of the multivariable I-function.

The condition for absolute convergence of multiple Mellin-Barnes type contour (1.9) can be obtained by extension of the corresponding conditions for multivariable H-function given by as :

$|argz_k| < \frac{1}{2}\Omega_i^{(k)}\pi$, where

$$\Omega_i^{(k)} = \sum_{k=1}^{n^{(i)}}\alpha_k^{(i)} - \sum_{k=n^{(i)}+1}^{p^{(i)}}\alpha_k^{(i)} + \sum_{k=1}^{m^{(i)}}\beta_k^{(i)} - \sum_{k=m^{(i)}+1}^{q^{(i)}}\beta_k^{(i)} + \left(\sum_{k=1}^{n_2}\alpha_{2k}^{(i)} - \sum_{k=n_2+1}^{p_2}\alpha_{2k}^{(i)}\right) + \cdots +$$

$$\left(\sum_{k=1}^{n_s}\alpha_{sk}^{(i)} - \sum_{k=n_s+1}^{p_s}\alpha_{sk}^{(i)}\right) - \left(\sum_{k=1}^{q_2}\beta_{2k}^{(i)} + \sum_{k=1}^{q_3}\beta_{3k}^{(i)} + \cdots + \sum_{k=1}^{q_s}\beta_{sk}^{(i)}\right) \tag{1.13}$$

where $i = 1, \cdots, s$

The complex numbers z_i are not zero.Throughout this document , we assume the existence and absolute convergence conditions of the multivariable I-function.

We may establish the the asymptotic expansion in the following convenient form :

$I(z_1, \cdots, z_s) = 0(\,|z_1|^{\alpha'_1}, \cdots, |z_s|^{\alpha'_s}\,), max(\,|z_1|, \cdots, |z_s|\,) \rightarrow 0$

$I(z_1, \cdots, z_s) \; = 0(\,|z_1|^{\beta'_1}, \cdots, |z_s|^{\beta'_s}\,), min(\,|z_1|, \cdots, |z_s|\,) \rightarrow \infty$

where $k = 1, \cdots, z : \alpha'_k = min[Re(b_j^{(k)}/\beta_j^{(k)})], j = 1, \cdots, m_k$ and

$\beta'_k = max[Re((a_j^{(k)} - 1)/\alpha_j^{(k)})], j = 1, \cdots, n_k$

We will use these following notations in this paper :

$$U = p_2, q_2; p_3, q_3; \cdots; p_{s-1}, q_{s-1}; V = 0, n_2; 0, n_3; \cdots; 0, n_{s-1} \tag{1.14}$$

$$W = (p', q'); \cdots; (p^{(s)}, q^{(s)}); X = (m', n'); \cdots; (m^{(s)}, n^{(s)}) \tag{1.15}$$

$$A = (a_{2k}, \alpha'_{2k}, \alpha''_{2k}); \cdots; (a_{(s-1)k}), \alpha'_{(s-1)k}, \alpha''_{(s-1)k}, \cdots, \alpha_{(s-1)k}^{(s-1)}) \tag{1.16}$$

$$B = (b_{2k}, \beta'_{2k}, \beta''_{2k}); \cdots; (b_{(s-1)k}), \beta'_{(s-1)k}, \beta''_{(s-1)k}, \cdots, \beta_{(s-1)k}^{(s-1)}) \tag{1.17}$$

$$\mathfrak{A} = (a_{sk}; \alpha'_{sk}, \alpha''_{sk}, \cdots, \alpha_{sk}^{s}) : \mathfrak{B} = (b_{sk}; \beta'_{sk}, \beta''_{sk}, \cdots, \beta_{sk}^{s}) \tag{1.18}$$

$$A' = (a'_k, \alpha'_k)_{1,p'}; \cdots; (a_k^{(s)}, \alpha_k^{(s)})_{1,p^{(s)}}; B' = (b'_k, \beta'_k)_{1,q'}; \cdots; (b_k^{(s)}, \beta_k^{(s)})_{1,q^{(s)}} \tag{1.19}$$

The multivariable I-function write :

$$I(z_1,\cdots,z_s) = I_{U:p_s,q_s;W}^{V;0,n_s;X}\left(\begin{array}{c|c} \mathrm{z}_1 & \mathrm{A}\ ;\mathfrak{A};\mathrm{A'} \\ \cdot & \\ \cdot & \\ \cdot & \\ \mathrm{z}_s & \mathrm{B};\ \mathfrak{B};\ \mathrm{B'} \end{array}\right) \tag{1.20}$$

The generalized polynomials defined by Srivastava [6], is given in the following manner :

$$S_{N_1',\cdots,N_t'}^{M_1',\cdots,M_t'}[y_1,\cdots,y_t] = \sum_{K_1=0}^{[N_1'/M_1']}\cdots\sum_{K_t=0}^{[N_t'/M_t']}\frac{(-N_1')_{M_1'K_1}}{K_1!}\cdots\frac{(-N_t')_{M_t'K_t}}{K_t!}$$

$$A[N_1',K_1;\cdots;N_t',K_t]y_1^{K_1}\cdots y_t^{K_t} \tag{1.21}$$

Where $M_1',\cdots,M_s'$ are arbitrary positive integers and the coefficients $A[N_1',K_1;\cdots;N_t',K_t]$ are arbitrary constants, real or complex. In the present paper, we use the following notation

$$a_1 = \frac{(-N_1')_{M_1'K_1}}{K_1!}\cdots\frac{(-N_t')_{M_t'K_t}}{K_t!}A[N_1',K_1;\cdots;N_t',K_t] \tag{1.22}$$

2. Generalized multiple-index Mittag-Leffler function

A further generalization of the Mittag-Leffler functions is proposed recently in Paneva-Konovska [2]. These are 3m-parametric Mittag-Leffler type functions generalizing the Prabhakar [3] 3-parametric function , defined as:

$$E_{(\alpha_i),(\beta_i)}^{(\gamma_i),m}(z) = \sum_{k=0}^{\infty}\frac{(\gamma_1)_k\cdots(\gamma_m)_k}{\Gamma(\alpha_1k+\beta_1)\cdots\Gamma(\alpha_mk+\beta_m)}\frac{z^k}{k!} \tag{2.1}$$

where $\alpha_i,\beta_i,\gamma_i\in\mathbb{C}, i=1,\cdots,m, Re(\alpha_i)>0$

Required formula

See Gradshteyn and Ryzhik ([1] , 3.518 , eq.4 page 576 and eq.5 page 577), we have respectively

Lemme 1

$$\int_0^\infty \frac{\sinh^{\mu-1}x(\cosh x+1)^{\upsilon-1}}{(b+\cosh x)^\rho}\mathrm{d}x = 2^{\mu+\upsilon-\rho-2}B\left(\frac{\mu}{2},\rho+2-\mu-\upsilon\right)\times{}_2F_1\left(\begin{array}{c}\rho+2-\mu-\upsilon,\rho\\ \cdots\\ \rho-\frac{\mu}{2}+2\end{array};\frac{1-b}{2}\right) \tag{3.1}$$

where $Re(\mu)>0, Re(\rho-\mu-\upsilon)>-2, |arg(1+b)|<\pi$

Lemme 2

$$\int_0^{\infty} \frac{\sinh^{\mu-1} x(\cosh x-1)^{\upsilon-1}}{(b+\cosh x)^{\rho}} \mathrm{d}x = 2^{\mu+\upsilon-\rho-2} B\left(\frac{\mu}{2}+\upsilon-1, \rho+2-\mu-\upsilon\right)$$

$$\times {}_2F_1\left(\begin{array}{c} \rho+2-\mu-\upsilon, \rho \\ \cdots \\ \rho-\frac{\mu}{2}+1 \end{array}; \frac{1-b}{2}\right) \tag{3.2}$$

where $b \notin (-\infty,1), Re(2+\rho) > Re(\mu+\upsilon), Re(2\upsilon+\mu) > 2$

3. General integral

Let $b_k = \frac{(\bar{\gamma}_1)_k \cdots (\bar{\gamma}_m)_k}{\Gamma(\bar{\alpha}_1 k+\bar{\beta}_1)\cdots\Gamma(\bar{\alpha}_m k+\bar{\beta}_m)}$ and $X_{c,d,e} = \frac{\sinh^c x(\cosh x+1)^d}{(b+\cosh x)^e}$, we have the following integrals,

Theorem 1

$$\int_0^{\infty} \frac{\sinh^{\mu-1} x(\cosh x+1)^{\upsilon-1}}{(b+\cosh x)^{\rho}} E^{(\bar{\gamma}_i),m}_{(\bar{\alpha}_i),(\bar{\beta}_i)}(zx^{\alpha})\ S^{M'_1,\cdots,M'_t}_{N_1,\cdots,N_t}\left(\begin{array}{c} \mathrm{y}_1 X_{\delta_1,\mu_1,\rho_1} \\ \cdots \\ \mathrm{y}_t X_{\delta_t,\mu_t,\rho_t} \end{array}\right) \aleph^{0,N:v}_{u:w}\left(\begin{array}{c} \mathrm{z}_1 X_{\alpha_1,\beta_1,\gamma_1} \\ \cdots \\ \mathrm{z}_r X_{\alpha_r,\beta_r,\gamma_r} \end{array}\right)$$

$$I^{V;0,n_s;X}_{U:p_s,q_s;W}\left(\begin{array}{c} \mathrm{Z}_1 X_{\eta_1,\epsilon_1,\xi_1} \\ \cdots \\ \mathrm{Z}_s X_{\eta_s,\epsilon_s,\xi_r} \end{array}\right) \mathrm{d}x = \frac{1}{4}\sum_{K_1=0}^{[N'_1/M'_1]} \cdots \sum_{K_t=0}^{[N'_t/M'_t]} \sum_{n=0}^{\infty}\sum_{k=0}^{\infty}\sum_{G_1,\cdots,G_r=0}^{\infty}\sum_{g_1=0}^{M_1}\cdots\sum_{g_r=0}^{M_r}$$

$$\frac{(-)^{G_1+\cdots+G_r}}{\delta_{g_1} G_1!\cdots\delta_{g_r} G_r!} G(\eta_{G_1,g_1},\cdots\eta_{G_r,g_r}) a_1 \frac{b_k z^k}{k!} z_1^{\eta_{G_1,g_1}} \cdots z_r^{\eta_{G_r,g_r}} y_1^{K_1}\cdots y_t^{K_t} \frac{(1-b)^n}{2^n n!}$$

$$2^{\mu+\alpha k+\sum_{i=1}^t K_i\delta_i+\sum_{i=1}^r \alpha_i\eta_{G_i,g_i}+\upsilon+\beta k+\sum_{i=1}^t K_i\mu_i+\sum_{i=1}^r \beta_i\eta_{G_i,g_i}-\rho-\gamma k-\sum_{i=1}^k \rho_i K_i-\sum_{i=1}^r \gamma_i\eta_{G_i,g_i}}$$

$$I^{V;0,n_s+4;X}_{U:p_s+4,q_s+2;W}\left(\begin{array}{c} 2^{\eta_1+\epsilon_1-\xi_1} Z_1 \\ \cdots \\ \cdots \\ 2^{\eta_s+\epsilon_s-\xi_s} Z_s \end{array}\middle| \begin{array}{c} \mathrm{A}\ ;(1\text{-}\tfrac{1}{2}(\mu+\alpha k+\sum_{i=1}^t K_i\delta_i+\sum_{i=1}^r \eta_{G_i,g_i}\alpha_i); \tfrac{\eta_1}{2},\cdots,\tfrac{\eta_s}{2}), \\ \cdots \\ \mathrm{B}; \end{array}\right.$$

$$\left.\begin{array}{c} (1\text{-n-}(\rho+\gamma k+\sum_{i=1}^t K_i\rho_i+\sum_{i=1}^r \eta_{G_i,g_i}\gamma_i);\xi_1,\cdots,\xi_s), A_1, A_2, \mathfrak{A}; A' \\ \cdots \\ \cdots \\ (1\text{-}(\rho+\gamma k+\sum_{i=1}^t K_i\rho_i+\sum_{i=1}^r \eta_{G_i,g_i}\gamma_i);\xi_1,\cdots,\xi_s), B_1, \mathfrak{B}; B' \end{array}\right) \tag{4.1}$$

where : $A_1 = (-1 - n + \mu + \upsilon - \rho + (\alpha + \beta - \gamma)k + \sum_{i=1}^{t}(\delta_i + \mu_i - \rho_i)K_i + \sum_{i=1}^{r}(\alpha_i + \beta_i - \gamma_i)\eta_{G_i,g_i};$

$\xi_1 - \eta_1 - \epsilon_1, \cdots, \xi_s - \eta_s - \epsilon_s)$

and $B_1 = (1 - n + \frac{\mu}{2} - \rho + (\frac{\alpha}{2} - \gamma)k + \sum_{i=1}^{t}(\frac{\delta_i}{2} - \rho_i)K_i + \sum_{i=1}^{r}(\frac{\alpha_i}{2} - \gamma_i)\eta_{G_i,g_i}; \xi_1 - \frac{\eta_1}{2}, \cdots, \xi_s - \frac{\eta_s}{2})$

$A_2 = (1 + \frac{\mu}{2} - \rho + (\frac{\alpha}{2} - \gamma)k + \sum_{i=1}^{t}(\frac{\delta_i}{2} - \rho_i)K_i + \sum_{i=1}^{r}(\frac{\alpha_i}{2} - \gamma_i)\eta_{G_i,g_i}; \xi_1 - \frac{\eta_1}{2}, \cdots, \xi_s - \frac{\eta_s}{2})$

Provided

a) $min\{\alpha, \beta, \gamma, \delta_i, \mu_i, \rho_i, \alpha_j, \beta_j, \gamma_j, \eta_k, \epsilon_l, \xi_l\} > 0, i = 1, \cdots, t, j = 1, \cdots, r, k = 1, \cdots, s$

b) $Re(\mu + k\alpha) + \sum_{i=1}^{r} \alpha_i \min_{1 \leqslant j \leqslant M_i} Re\left(\frac{d_j^{(i)}}{\delta_j^{(i)}}\right) + \sum_{i=1}^{s} \eta_i \min_{1 \leqslant j \leqslant m^{(i)}} Re\left(\frac{b_j^{(i)}}{\beta_j^{(i)}}\right) > 0$

c) $Re(\rho - \mu - \upsilon + k(\gamma - \alpha - \beta) + \sum_{i=1}^{r}(\gamma_i - \alpha_i - \beta_i) \min_{1 \leqslant j \leqslant M_i} Re\left(\frac{d_j^{(i)}}{\delta_j^{(i)}}\right) + \sum_{i=1}^{s}(\xi_i - \eta_i - \epsilon_i) \min_{1 \leqslant j \leqslant m^{(i)}} Re\left(\frac{b_j^{(i)}}{\beta_j^{(i)}}\right) > -2$

d)$|argz_k| < \frac{1}{2}A_i^{(k)}\pi$, where $A_i^{(k)}$ is defined by (1.5) ; $i = 1, \cdots, r$

e) $|argZ_k| < \frac{1}{2}\Omega_i^{(k)}\pi$, where $\Omega_i^{(k)}$ is defined by (1.11) ; $i = 1, \cdots, s$

f) $|arg(1+b)| < \pi$ and $\bar{\alpha}_i, \bar{\beta}_i, \bar{\gamma}_i \in \mathbb{C}, i = 1, \cdots, m, Re(\bar{\alpha}_i) > 0$

g) The series occuring on the right-hand side of (4.1) is absolutely and uniformly convergent.

Theorem 2

$$\int_0^\infty \frac{\sinh^{\mu-1} x(\cosh x - 1)^{\upsilon-1}}{(b + \cosh x)^\rho} \; E_{(\bar{\alpha}_i),(\bar{\beta}_i)}^{(\bar{\gamma}_i),m}(zx^\alpha) \; S_{N_1,\cdots,N_t}^{M_1',\cdots,M_t'}\begin{pmatrix} \mathrm{y}_1 X_{\delta_1,\mu_1,\rho_1} \\ \cdot \cdot \cdot \\ \mathrm{y}_t X_{\delta_t,\mu_t,\rho_t} \end{pmatrix} \aleph_{u:w}^{0,N:v}\begin{pmatrix} \mathrm{z}_1 X_{\alpha_1,\beta_1,\gamma_1} \\ \cdot \cdot \cdot \\ \mathrm{z}_r X_{\alpha_r,\beta_r,\gamma_r} \end{pmatrix}$$

$$I_{U:p_s,q_s;W}^{V;0,n_s;X}\begin{pmatrix} \mathrm{Z}_1 X_{\eta_1,\epsilon_1,\xi_1} \\ \cdot \cdot \cdot \\ \mathrm{Z}_s X_{\eta_s,\epsilon_s,\xi_r} \end{pmatrix} \mathrm{d}x \;\; = \frac{1}{4}\sum_{K_1=0}^{[N_1'/M_1']} \cdots \sum_{K_t=0}^{[N_t'/M_t']} \sum_{n=0}^{\infty}\sum_{k=0}^{\infty}\sum_{G_1,\cdots,G_r=0}^{\infty}\sum_{g_1=0}^{M_1}\cdots\sum_{g_r=0}^{M_r}$$

$$\frac{(-)^{G_1+\cdots+G_r}}{\delta_{g_1}G_1!\cdots\delta_{g_r}G_r!}G(\eta_{G_1,g_1},\cdots\eta_{G_r,g_r})a_1\frac{b_k z^k}{k!} z_1^{\eta_{G_1,g_1}} \cdots z_r^{\eta_{G_r,g_r}} y_1^{K_1}\cdots y_t^{K_t}\frac{(1-b)^n}{2^n n!}$$

$$2^{\mu+\alpha k+\sum_{i=1}^t K_i\delta_i+\sum_{i=1}^r \alpha_i\eta_{G_i,g_i}+\upsilon+\beta k+\sum_{i=1}^t K_i\mu_i+\sum_{i=1}^r \beta_i\eta_{G_i,g_i}-\rho-\gamma k-\sum_{i=1}^k \rho_i K_i-\sum_{i=1}^r \gamma_i\eta_{G_i,g_i}}$$

$$I_{U:p_s+4,q_s+2;W}^{V;0,n_s+4;X}\left(\begin{array}{c} 2^{\eta_1+\epsilon_1-\xi_1}Z_1 \\ \cdot\ \cdot\ \cdot \\ \cdots \\ 2^{\eta_s+\epsilon_s-\xi_s}Z_s \end{array}\right| \begin{array}{c} \text{A};(1\text{-}\frac{1}{2}(\mu+\alpha k+\sum_{i=1}^{t}K_i\delta_i+\sum_{i=1}^{r}\eta_{G_i,g_i}\alpha_i);\frac{\eta_1}{2},\cdots,\frac{\eta_s}{2}), \\ \cdot\ \cdot\ \cdot \\ \text{B}; \end{array}$$

$$\left.\begin{array}{c} (1\text{-n-}(\rho+\gamma k+\sum_{i=1}^{t}K_i\rho_i+\sum_{i=1}^{r}\eta_{G_i,g_i}\gamma_i);\xi_1,\cdots,\xi_s),A_1,A_2,\mathfrak{A};A' \\ \cdot\ \cdot\ \cdot \\ \cdot\ \cdot\ \cdot \\ (1\text{-}(\rho+\gamma k+\sum_{i=1}^{t}K_i\rho_i+\sum_{i=1}^{r}\eta_{G_i,g_i}\gamma_i);\xi_1,\cdots,\xi_s),B_1,\mathfrak{B};B' \end{array}\right) \tag{4.2}$$

where : $A_1=(-1-n+\mu+\upsilon-\rho+(\alpha+\beta-\gamma)k+\sum_{i=1}^{t}(\delta_i+\mu_i-\rho_i)K_i+\sum_{i=1}^{r}(\alpha_i+\beta_i-\gamma_i)\eta_{G_i,g_i};$

$\xi_1-\eta_1-\epsilon_1,\cdots,\xi_s-\eta_s-\epsilon_s)$

and $B_1=\big(-n+\frac{\mu}{2}-\rho+(\frac{\alpha}{2}-\gamma)k+\sum_{i=1}^{t}(\frac{\delta_i}{2}-\rho_i)K_i+\sum_{i=1}^{r}(\frac{\alpha_i}{2}-\gamma_i)\eta_{G_i,g_i};\xi_1-\frac{\eta_1}{2},\cdots,\xi_s-\frac{\eta_s}{2})$

$$A_2=(\frac{\mu}{2}-\rho+(\frac{\alpha}{2}-\gamma)k+\sum_{i=1}^{t}(\frac{\delta_i}{2}-\rho_i)K_i+\sum_{i=1}^{r}(\frac{\alpha_i}{2}-\gamma_i)\eta_{G_i,g_i};\xi_1-\frac{\eta_1}{2},\cdots,\xi_s-\frac{\eta_s}{2})$$

Provided that :

a) $min\{\alpha,\beta,\gamma,\delta_i,\mu_i,\rho_i,\alpha_j,\beta_j,\gamma_j,\eta_k,\epsilon_l,\xi_l\}>0,i=1,\cdots,t,j=1,\cdots,r,k=1,\cdots,s$

b) $Re(2+\rho+k\gamma)+\sum_{i=1}^{r}\gamma_i\min_{1\leqslant j\leqslant M_i}Re\left(\frac{d_j^{(i)}}{\delta_j^{(i)}}\right)+\sum_{i=1}^{s}\xi_i\min_{1\leqslant j\leqslant m^{(i)}}Re\left(\frac{b_j^{(i)}}{\beta_j^{(i)}}\right)>$

$>Re(\mu+\upsilon+k(\alpha+\beta))+\sum_{i=1}^{r}(\alpha_i+\beta_i)\min_{1\leqslant j\leqslant M_i}Re\left(\frac{d_j^{(i)}}{\delta_j^{(i)}}\right)+\sum_{i=1}^{s}(\eta_i+\epsilon_i)\min_{1\leqslant j\leqslant m^{(i)}}Re\left(\frac{b_j^{(i)}}{\beta_j^{(i)}}\right)$

c) $Re(\mu+2\upsilon+k(\alpha+2\beta))+\sum_{i=1}^{r}(\alpha_i+2\beta_i)\min_{1\leqslant j\leqslant M_i}Re\left(\frac{d_j^{(i)}}{\delta_j^{(i)}}\right)+\sum_{i=1}^{s}(\eta_i+2\epsilon_i)\min_{1\leqslant j\leqslant m^{(i)}}Re\left(\frac{b_j^{(i)}}{\beta_j^{(i)}}\right)>2$

d)$|argz_k|<\frac{1}{2}A_i^{(k)}\pi$, where $A_i^{(k)}$ is defined by (1.5) ; $i=1,\cdots,r$

e) $|argZ_k|<\frac{1}{2}\Omega_i^{(k)}\pi$, where $\Omega_i^{(k)}$ is defined by (1.11) ; $i=1,\cdots,s$

f) $b\notin(-\infty,1)$ and $\bar{\alpha}_i,\bar{\beta}_i,\bar{\gamma}_i\in\mathbb{C},i=1,\cdots,m,Re(\bar{\alpha}_i)>0$

g) The series occuring on the right-hand side of (4.1) is absolutely and uniformly convergent.

Proof of theorem 1

First, expressing the generalized multiple-index Mittag-Leffler function $E_{(\bar{\alpha}_i),(\bar{\beta}_i)}^{(\bar{\gamma}_i),m}(zx^{\alpha})$ in serie with the help of equation (2.1), the Aleph-function of r variables in series with the help of equation (1.6), the general class of polynomial of several variables $S_{N_1,\cdots,N_t}^{M_1,\cdots,M_t}$ with the help of equation (1.22) and the Prasad's multivariable I-function of s variables in Mellin-Barnes contour integral with the help of equation (1.9), changing the order of integration ans summation (which is easily seen to be justified due to the absolute convergence of the integral and the summations involved in the process) and then evaluating the resulting integral with the help of equation (3.1) and expressing the generalized hypergeometric function ${}_3F_2$ in serie ,use several times the following relations $\Gamma(a)(a)_n = \Gamma(a+n)$ and $a = \frac{\Gamma(a+1)}{\Gamma(a)}$ with $Re(a) > 0$. Finally interpreting the result thus obtained with the Mellin-barnes contour integral, we arrive at the desired result. The proof of the theorem 2 use the similar methods.

The quantities $U, V, W, X, A\prime, B, \mathfrak{A}, \mathfrak{B}, A'$ and B' are defined by the equations (1.14) to (1;19)

5. Particular case

If $U = V = A = B = 0$, the multivariable I-function defined by Prasad degenere in multivariable H-function defined by Srivastava et al [7]. We have the following results.

Corollary 1

$$\int_0^\infty \frac{\sinh^{\mu-1} x(\cosh x+1)^{\upsilon-1}}{(b+\cosh x)^\rho} \ E_{(\bar{\alpha}_i),(\bar{\beta}_i)}^{(\bar{\gamma}_i),m}(zx^\alpha) \ S_{N_1,\cdots,N_t}^{M'_1,\cdots,M'_t}\left(\begin{array}{c} \mathrm{y}_1 X_{\delta_1,\mu_1,\rho_1} \\ \cdot\cdot\cdot \\ \mathrm{y}_t X_{\delta_t,\mu_t,\rho_t} \end{array}\right) \aleph_{u:w}^{0,N:v}\left(\begin{array}{c} \mathrm{z}_1 X_{\alpha_1,\beta_1,\gamma_1} \\ \cdot\cdot\cdot \\ \mathrm{z}_r X_{\alpha_r,\beta_r,\gamma_r} \end{array}\right)$$

$$H_{p_s,q_s;W}^{0,n_s;X}\left(\begin{array}{c} \mathrm{Z}_1 X_{\eta_1,\epsilon_1,\xi_1} \\ \cdot\cdot\cdot \\ \mathrm{Z}_s X_{\eta_s,\epsilon_s,\xi_r} \end{array}\right) \mathrm{d}x \ = \frac{1}{4} \sum_{K_1=0}^{[N'_1/M'_1]} \cdots \sum_{K_t=0}^{[N'_t/M'_t]} \sum_{n=0}^{\infty} \sum_{k=0}^{\infty} \sum_{G_1,\cdots,G_r=0}^{\infty} \sum_{g_1=0}^{M_1} \cdots \sum_{g_r=0}^{M_r}$$

$$\frac{(-)^{G_1+\cdots+G_r}}{\delta_{g_1} G_1! \cdots \delta_{g_r} G_r!} G(\eta_{G_1,g_1}, \cdots \eta_{G_r,g_r}) a_1 \frac{b_k z^k}{k!} z_1^{\eta_{G_1,g_1}} \cdots z_r^{\eta_{G_r,g_r}} y_1^{K_1} \cdots y_t^{K_t} \frac{(1-b)^n}{2^n n!}$$

$$2^{\mu+\alpha k+\sum_{i=1}^t K_i\delta_i+\sum_{i=1}^r \alpha_i\eta_{G_i,g_i}+\upsilon+\beta k+\sum_{i=1}^t K_i\mu_i+\sum_{i=1}^r \beta_i\eta_{G_i,g_i}-\rho-\gamma k-\sum_{i=1}^k \rho_i K_i-\sum_{i=1}^r \gamma_i\eta_{G_i,g_i}}$$

$$H_{p_s+4,q_s+2;W}^{0,n_s+4;X}\left(\begin{array}{c} 2^{\eta_1+\epsilon_1-\xi_1} Z_1 \\ \cdot\cdot\cdot \\ \ldots \\ 2^{\eta_s+\epsilon_s-\xi_s} Z_s \end{array}\middle| \begin{array}{c} (1\text{-}\frac{1}{2}(\mu+\alpha k+\sum_{i=1}^t K_i\delta_i+\sum_{i=1}^r \eta_{G_i,g_i}\alpha_i); \frac{\eta_1}{2}, \cdots, \frac{\eta_s}{2}), \\ \cdot\cdot\cdot \\ \cdot\cdot\cdot \end{array}\right.$$

$$\left.\begin{array}{c} (1\text{-n-}(\rho+\gamma k+\sum_{i=1}^t K_i\rho_i+\sum_{i=1}^r \eta_{G_i,g_i}\gamma_i); \xi_1, \cdots, \xi_s), A_1, A_2, \mathfrak{A}; A' \\ \cdot\cdot\cdot \\ \cdot\cdot\cdot \\ (1\text{-}(\rho+\gamma k+\sum_{i=1}^t K_i\rho_i+\sum_{i=1}^r \eta_{G_i,g_i}\gamma_i); \xi_1, \cdots, \xi_s), B_1, \mathfrak{B}; B' \end{array}\right) \quad (5.1)$$

where : $A_1 = (-1-n+\mu+\upsilon-\rho+(\alpha+\beta-\gamma)k+\sum_{i=1}^{t}(\delta_i+\mu_i-\rho_i)K_i+\sum_{i=1}^{r}(\alpha_i+\beta_i-\gamma_i)\eta_{G_i,g_i};$

$\xi_1-\eta_1-\epsilon_1,\cdots,\xi_s-\eta_s-\epsilon_s)$

and $B_1 = (1-n+\frac{\mu}{2}-\rho+(\frac{\alpha}{2}-\gamma)k+\sum_{i=1}^{t}(\frac{\delta_i}{2}-\rho_i)K_i+\sum_{i=1}^{r}(\frac{\alpha_i}{2}-\gamma_i)\eta_{G_i,g_i};\xi_1-\frac{\eta_1}{2},\cdots,\xi_s-\frac{\eta_s}{2})$

$A_2 = (1+\frac{\mu}{2}-\rho+(\frac{\alpha}{2}-\gamma)k+\sum_{i=1}^{t}(\frac{\delta_i}{2}-\rho_i)K_i+\sum_{i=1}^{r}(\frac{\alpha_i}{2}-\gamma_i)\eta_{G_i,g_i};\xi_1-\frac{\eta_1}{2},\cdots,\xi_s-\frac{\eta_s}{2})$

under the same conditions that (4.1)

Corollary 2

$$\int_0^\infty \frac{\sinh^{\mu-1}x(\cosh x-1)^{\upsilon-1}}{(b+\cosh x)^\rho}\; E_{(\bar{\alpha}_i),(\bar{\beta}_i)}^{(\bar{\gamma}_i),m}(zx^\alpha)\; S_{N_1,\cdots,N_t}^{M_1',\cdots,M_t'}\begin{pmatrix} \mathrm{y}_1X_{\delta_1,\mu_1,\rho_1}\\ \cdots\\ \mathrm{y}_tX_{\delta_t,\mu_t,\rho_t}\end{pmatrix}\aleph_{u:w}^{0,N:v}\begin{pmatrix} \mathrm{z}_1X_{\alpha_1,\beta_1,\gamma_1}\\ \cdots\\ \mathrm{z}_rX_{\alpha_r,\beta_r,\gamma_r}\end{pmatrix}$$

$$H_{p_s,q_s;W}^{0,n_s;X}\begin{pmatrix} \mathrm{Z}_1X_{\eta_1,\epsilon_1,\xi_1}\\ \cdots\\ \mathrm{Z}_sX_{\eta_s,\epsilon_s,\xi_r}\end{pmatrix}\mathrm{d}x \;=\frac{1}{4}\sum_{K_1=0}^{[N_1'/M_1']}\cdots\sum_{K_t=0}^{[N_t'/M_t']}\sum_{n=0}^{\infty}\sum_{k=0}^{\infty}\sum_{G_1,\cdots,G_r=0}^{\infty}\sum_{g_1=0}^{M_1}\cdots\sum_{g_r=0}^{M_r}$$

$$\frac{(-)^{G_1+\cdots+G_r}}{\delta_{g_1}G_1!\cdots\delta_{g_r}G_r!}G(\eta_{G_1,g_1},\cdots\eta_{G_r,g_r})a_1\frac{b_kz^k}{k!}z_1^{\eta_{G_1,g_1}}\cdots z_r^{\eta_{G_r,g_r}}y_1^{K_1}\cdots y_t^{K_t}\frac{(1-b)^n}{2^nn!}$$

$$2^{\mu+\alpha k+\sum_{i=1}^t K_i\delta_i+\sum_{i=1}^r\alpha_i\eta_{G_i,g_i}+\upsilon+\beta k+\sum_{i=1}^t K_i\mu_i+\sum_{i=1}^r\beta_i\eta_{G_i,g_i}-\rho-\gamma k-\sum_{i=1}^k\rho_iK_i-\sum_{i=1}^r\gamma_i\eta_{G_i,g_i}}$$

$$H_{p_s+4,q_s+2;W}^{0,n_s+4;X}\left(\begin{array}{c|c} 2^{\eta_1+\epsilon_1-\xi_1}Z_1 & (1\text{-}\frac{1}{2}(\mu+\alpha k+\sum_{i=1}^t K_i\delta_i+\sum_{i=1}^r\eta_{G_i,g_i}\alpha_i);\frac{\eta_1}{2},\cdots,\frac{\eta_s}{2}),\\ \cdots & \cdots\\ \cdots & \cdots\\ 2^{\eta_s+\epsilon_s-\xi_s}Z_s & \end{array}\right.$$

$$\left.\begin{array}{c} (1\text{-n-}(\rho+\gamma k+\sum_{i=1}^t K_i\rho_i+\sum_{i=1}^r\eta_{G_i,g_i}\gamma_i);\xi_1,\cdots,\xi_s),A_1,A_2,\mathfrak{A};A'\\ \cdots\\ \cdots\\ (1\text{-}(\rho+\gamma k+\sum_{i=1}^t K_i\rho_i+\sum_{i=1}^r\eta_{G_i,g_i}\gamma_i);\xi_1,\cdots,\xi_s),B_1,\mathfrak{B};B'\end{array}\right) \qquad (5.2)$$

where : $A_1 = (-1-n+\mu+\upsilon-\rho+(\alpha+\beta-\gamma)k+\sum_{i=1}^{t}(\delta_i+\mu_i-\rho_i)K_i+\sum_{i=1}^{r}(\alpha_i+\beta_i-\gamma_i)\eta_{G_i,g_i};$

$\xi_1-\eta_1-\epsilon_1,\cdots,\xi_s-\eta_s-\epsilon_s)$

and $B_1 = \big(-n + \frac{\mu}{2} - \rho + (\frac{\alpha}{2} - \gamma)k + \sum_{i=1}^{t}(\frac{\delta_i}{2} - \rho_i)K_i + \sum_{i=1}^{r}(\frac{\alpha_i}{2} - \gamma_i)\eta_{G_i,g_i}; \xi_1 - \frac{\eta_1}{2}, \cdots, \xi_s - \frac{\eta_s}{2})$

$$A_2 = (\frac{\mu}{2} - \rho + (\frac{\alpha}{2} - \gamma)k + \sum_{i=1}^{t}(\frac{\delta_i}{2} - \rho_i)K_i + \sum_{i=1}^{r}(\frac{\alpha_i}{2} - \gamma_i)\eta_{G_i,g_i}; \xi_1 - \frac{\eta_1}{2}, \cdots, \xi_s - \frac{\eta_s}{2})$$

6.Conclusion

In this paper we have evaluated a generalized finite integral involving the generalized multiple-index Mittag-Leffler function, the hyperbolic functions, the multivariable Aleph-function, a class of polynomials of several variables a sequence of functions and the multivariable I-function defined by Prasad. The integral established in this paper is of very general nature as it contains Multivariable Aleph-function, which is a general function of several variables studied so far. Thus, the integral established in this research work would serve as a key formula from which, upon specializing the parameters, as many as desired results involving the special functions of one and several variables can be obtained.

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