On multiple eulerian integral involving the multivariable Aleph-function

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ABSTRACT

Recently, Raina and Srivastava [2] and Srivastava and Hussain [5] have provided closed-form expressions for a number of a general eulerian integrals involving multivariable H-functions. Motivated by these recent works, we aim at evaluating a general class of multiple eulerian integrals involving a multivariable Aleph-function with general arguments. These integrals will serve as a key formula from which one can deduce numerous useful integrals.

Keywords :Multivariable Aleph-function, multiple eulerian integral , Multivariable I-function, Aleph-function of two variables.

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1.Introduction and preliminaries.

The object of this document is to evaluate a multiple Eulerian integrals involving the Aleph-function of several variables. These function generalize the multivariable I-function recently study by C.K. Sharma and Ahmad [3], 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 have : $\aleph(z_1,\cdots,z_r) = \aleph^{0,\mathfrak{n}:m_1,n_1,\cdots,m_r,n_r}_{p_i,q_i,\tau_i;R:p_{i^{(1)}},q_{i^{(1)}},\tau_{i^{(1)}};R^{(1)};\cdots;p_{i^{(r)}},q_{i^{(r)}};\tau_{i^{(r)}};R^{(r)}}\left(\begin{array}{c} \mathrm{z}_1 \\ \cdot \\ \cdot \\ \cdot \\ \mathrm{z}_r \end{array}\right|$

$[(\mathrm{a}_j;\alpha_j^{(1)},\cdots,\alpha_j^{(r)})_{1,\mathfrak{n}}]$ $,[\tau_i(a_{ji};\alpha_{ji}^{(1)},\cdots,\alpha_{ji}^{(r)})_{\mathfrak{n}+1,p_i}]:$
$\cdots\cdots\cdots\cdots$ $,[\tau_i(b_{ji};\beta_{ji}^{(1)},\cdots,\beta_{ji}^{(r)})_{m+1,q_i}]:$

$[(\mathrm{c}_j^{(1)}),\gamma_j^{(1)})_{1,n_1}],[\tau_{i^{(1)}}(c_{ji^{(1)}}^{(1)},\gamma_{ji^{(1)}}^{(1)})_{n_1+1,p_i^{(1)}}];\cdots;\ ;[(\mathrm{c}_j^{(r)}),\gamma_j^{(r)})_{1,n_r}],[\tau_{i^{(r)}}(c_{ji^{(r)}}^{(r)},\gamma_{ji^{(r)}}^{(r)})_{n_r+1,p_i^{(r)}}]$
$[(\mathrm{d}_j^{(1)}),\delta_j^{(1)})_{1,m_1}],[\tau_{i^{(1)}}(d_{ji^{(1)}}^{(1)},\delta_{ji^{(1)}}^{(1)})_{m_1+1,q_i^{(1)}}];\cdots;;[(\mathrm{d}_j^{(r)}),\delta_j^{(r)})_{1,m_r}],[\tau_{i^{(r)}}(d_{ji^{(r)}}^{(r)},\delta_{ji^{(r)}}^{(r)})_{m_r+1,q_i^{(r)}}]\Bigg)$

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

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

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

and $$\zeta_k(s_k) = \frac{\prod_{j=1}^{m_k}\Gamma(d_j^{(k)}-\delta_j^{(k)}s_k)\prod_{j=1}^{n_k}\Gamma(1-c_j^{(k)}+\gamma_j^{(k)}s_k)}{\sum_{i^{(k)}=1}^{R^{(k)}}[\tau_{i^{(k)}}\prod_{j=m_k+1}^{q_{i^{(k)}}}\Gamma(1-d_{ji^{(k)}}^{(k)}+\delta_{ji^{(k)}}^{(k)}s_k)\prod_{j=n_k+1}^{p_{i^{(k)}}}\Gamma(c_{ji^{(k)}}^{(k)}-\gamma_{ji^{(k)}}^{(k)}s_k)]} \tag{1.3}$$

where $j=1$ to r and $k=1$ to r
Suppose , as usual , that the parameters
$a_j, j=1,\cdots,p; b_j, j=1,\cdots,q;$

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

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

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

$$U_i^{(k)} = \sum_{j=1}^{\mathfrak{n}} \alpha_j^{(k)} + \tau_i \sum_{j=\mathfrak{n}+1}^{p_i} \alpha_{ji}^{(k)} + \sum_{j=1}^{n_k} \gamma_j^{(k)} + \tau_{i^{(k)}} \sum_{j=n_k+1}^{p_{i^{(k)}}} \gamma_{ji^{(k)}}^{(k)} - \tau_i \sum_{j=1}^{q_i} \beta_{ji}^{(k)} - \sum_{j=1}^{m_k} \delta_j^{(k)}$$

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

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

$$A_i^{(k)} = \sum_{j=1}^{\mathfrak{n}} \alpha_j^{(k)} - \tau_i \sum_{j=\mathfrak{n}+1}^{p_i} \alpha_{ji}^{(k)} - \tau_i \sum_{j=1}^{q_i} \beta_{ji}^{(k)} + \sum_{j=1}^{n_k} \gamma_j^{(k)} - \tau_{i^{(k)}} \sum_{j=n_k+1}^{p_{i^{(k)}}} \gamma_{ji^{(k)}}^{(k)}$$

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

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 :

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

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

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

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

We will use these following notations in this paper

$$U = p_i, q_i, \tau_i; R \; ; \; V = m_1, n_1; \cdots; m_r, n_r \tag{1.6}$$

$$W = p_{i^{(1)}}, q_{i^{(1)}}, \tau_{i^{(1)}}; R^{(1)}, \cdots, p_{i^{(r)}}, q_{i^{(r)}}, \tau_{i^{(r)}}; R^{(r)} \tag{1.7}$$

$$A = \{(a_j;\alpha_j^{(1)},\cdots,\alpha_j^{(r)})_{1,n}\},\{\tau_i(a_{ji};\alpha_{ji}^{(1)},\cdots,\alpha_{ji}^{(r)})_{n+1,p_i}\} \quad (1.8)$$

$$B = \{\tau_i(b_{ji};\beta_{ji}^{(1)},\cdots,\beta_{ji}^{(r)})_{m+1,q_i}\} \quad (1.9)$$

$$C = \{(c_j^{(1)};\gamma_j^{(1)})_{1,n_1}\},\tau_{i^{(1)}}(c_{ji^{(1)}}^{(1)};\gamma_{ji^{(1)}}^{(1)})_{n_1+1,p_{i^{(1)}}}\},\cdots,\{(c_j^{(r)};\gamma_j^{(r)})_{1,n_r}\},\tau_{i^{(r)}}(c_{ji^{(r)}}^{(r)};\gamma_{ji^{(r)}}^{(r)})_{n_r+1,p_{i^{(r)}}}\} \quad (1.10)$$

$$D = \{(d_j^{(1)};\delta_j^{(1)})_{1,m_1}\},\tau_{i^{(1)}}(d_{ji^{(1)}}^{(1)};\delta_{ji^{(1)}}^{(1)})_{m_1+1,q_{i^{(1)}}}\},\cdots,\{(d_j^{(r)};\delta_j^{(r)})_{1,m_r}\},\tau_{i^{(r)}}(d_{ji^{(r)}}^{(r)};\delta_{ji^{(r)}}^{(r)})_{m_r+1,q_{i^{(r)}}}\} \quad (1.11)$$

The multivariable Aleph-function write :

$$\aleph(z_1,\cdots,z_r) = \aleph_{p_i,q_i,\tau_i;R:W}^{0,\mathfrak{n}:V}\left(\begin{array}{c|c} z_1 & \mathrm{A : C} \\ \cdot & \cdot\;\cdot\;\cdot \\ \cdot & \\ \cdot & \\ z_r & \mathrm{B : D} \end{array}\right) \quad (1.12)$$

2. Main integral

In this document, we shall establish the following Eulerian multiple integral of multivariable Aleph-function and we shall use the following notations (2.1) and (2.2).

Let $f(t_j) = (b_j - a_j) + \rho_j(t_j - a_j) + \sigma_j(b_j - t_j)$ (2.1)

$$g^{(i)}(t_j) = \frac{(t_j-a_j)^{\gamma_j^{(i)}}(b_j-t_j)^{\delta_j^{(i)}}\{f(t_j)\}^{1-\gamma_j^{(i)}-\delta_j^{(i)}}}{\beta_j(b_j-a_j)+(\beta_j\rho_j+\alpha_j-\beta_j)(t_j-a_j)+\beta_j\sigma_j(b_j-t_j)} \quad (2.2)$$

$j = 1,\cdots,n$

Formula 1 ([1] p.287)

$$\int_a^b \frac{(t-a)^{\alpha-1}(b-t)^{\beta-1}}{\{b-a+\lambda(t-a)+\mu(b-t)\}^{\alpha+\beta}}\mathrm{d}t = \frac{(1+\lambda)^{-\alpha}(1+\mu)^{-\beta}\Gamma(\alpha)\Gamma(\beta)}{(b-a)\Gamma(\alpha+\beta)} \quad (2.3)$$

with $t \in [a;b] \quad a \neq b, Re(\alpha) > 0, Re(\beta) > 0, \;\; \eta + \lambda(t-a) + \mu(b-t) \neq 0$

Formula 2

$$\int_{a_1}^{b_1}\cdots\int_{a_n}^{b_n}\prod_{i=1}^n \frac{(t_j-a_j)^{\lambda_j}(b_j-t_j)^{\mu_j}}{[f(t_j)]^{\lambda_j+\mu_j+2}}\aleph\left(\begin{array}{c} z_1\prod_{j=1}^n[g'(t_j)]^{v'_j} \\ \cdots \\ z_r\prod_{j=1}^n[g^{(r)}(t_j)]^{v_j^{(r)}}\end{array}\right)\mathrm{d}t_1\cdots\mathrm{d}t_n$$

$$=\prod_{j=1}^n\{(b_j-a_j)^{-1}(1+\rho_j)^{-\lambda_j-1}(1+\sigma_j)^{-\mu_j-1}\sum_{r_j=0}^\infty\frac{\{(\beta_j-\alpha_j)/\beta_j\}^{r_j}(1+\rho_j)^{-r_j}\}}{r_j!}$$

$$\aleph_{p_i+3n,q_i+2n,\tau_i;R:W}^{0,\mathfrak{n}+3n:V}\left(\begin{array}{c|c} z_1\prod_{j=1}^n\{\beta_j(1+\rho_j)^{\gamma'_j}(1+\sigma_j)^{\delta'_j}\}^{-v'_j} & (1\text{-r}_1;v'_1,\cdots,v_1^{(r)}),\cdots, \\ \cdot & \cdot\;\cdot\;\cdot \\ \cdot & \cdot\;\cdot\;\cdot \\ \cdot & \\ z_r\prod_{j=1}^n\{\beta_j(1+\rho_j)^{\gamma_j^{(n)}}(1+\sigma_j)^{\delta_j^{(n)}}\}^{-v_j^{(r)}} & (1\;;\,\mathrm{v'}_1,\cdots,v_1^{(r)}),\cdots, \end{array}\right.$$

$$\begin{pmatrix} (1\text{-r}_n; v'_n, \cdots, v_n^{(r)}), (-\lambda_1 - r_1; \gamma'_1 v'_1, \cdots, \gamma_1^{(r)} v_1^{(r)}), (-\mu_1; \delta'_1 v'_1, \cdots, \delta_1^{(r)} v_1^{(r)}), \cdots, \\ \cdots \\ \cdots \\ (1 ; \text{v'}_n, \cdots, v_n^{(r)}),\ (-\lambda_1 - \mu_1 - r_1 - 1; (\gamma'_1 + \delta'_1) v'_1, \cdots, (\gamma_1^{(r)} + \delta_1^{(r)}) v_1^{(r)}), \cdots, \end{pmatrix}$$

$$\left. \begin{matrix} (-\lambda_n - r_n; \gamma'_n v'_n, \cdots, \gamma_n^{(r)} v_n^{(r)}), (-\mu_n; \delta'_n v'_n, \cdots, \delta_n^{(r)} v_n^{(r)}), A : C \\ \cdots \\ \cdots \\ (-\lambda_n - \mu_n - r_n - 1; (\gamma'_n + \delta'_n) v'_n, \cdots, (\gamma_n^{(r)} + \delta_n^{(r)}) v_n^{(r)}), B : D \end{matrix} \right) \tag{2.4}$$

Provided that

a) $v_j^{(i)} > 0, \gamma_j^{(i)} > 0, \delta_j^{(i)} > 0, \beta_j \neq 0, b_j - a_j \neq 0, \rho_j \neq -1, \sigma_j \neq -1, j = 1, \cdots, n, i = 1, \cdots, r$

b) $(b_j - a_j) + \rho_j(t_j - a_j) + \sigma_j(b_j - t_j) \neq 0, t_j \in [a_j; b_j]$

c) $|arg z_k| < \frac{1}{2} A_i^{(k)} \pi$, where $A_i^{(k)}$ is given in (1.5)

d) $|(\beta_j - \alpha_j)(t_j - a_j)| < |\beta_j(b_j - a_j) + \rho_j(t_j - a_j) + \sigma_j(b_j - t_j)|$

e) $Re[\lambda_j + \sum_{i=1}^{r} \gamma_j^{(i)} v_j^{(i)} \min_{1 \leqslant j \leqslant m_i} \frac{d_j^{(i)}}{\delta_j^{(i)}}] + 1 > 0$; $Re[\mu_j + \sum_{i=1}^{r} \delta_j^{(i)} v_j^{(i)} \min_{1 \leqslant j \leqslant m_i} \frac{d_j^{(i)}}{\delta_j^{(i)}}] + 1 > 0$
with $j = 1, \cdots, n, i = 1, \cdots, r$

f) the multiple serie on the R.H.S of (2.4) converges absolutly

Proof

Let $M = \frac{1}{(2\pi\omega)^n} \int_{L_1} \cdots \int_{L_r} \psi(s_1, \cdots, s_n) \prod_{k=1}^{r} \zeta_k(s_k)$, we have

$$\int_{a_1}^{b_1} \cdots \int_{a_n}^{b_n} \prod_{i=1}^{n} \frac{(t_j - a_j)^{\lambda_j} (b_j - t_j)^{\mu_j}}{[f(t_j)]^{\lambda_j + \mu_j + 2}} \aleph \begin{pmatrix} z_1 \prod_{j=1}^{n} [g'(t_j)]^{v'_j} \\ \cdots \\ z_r \prod_{j=1}^{n} [g^{(r)}(t_j)]^{v_j^{(r)}} \end{pmatrix} \mathrm{d}t_1 \cdots \mathrm{d}t_n$$

$$= \int_{a_1}^{b_1} \cdots \int_{a_n}^{b_n} \prod_{i=1}^{n} \frac{(t_j - a_j)^{\lambda_j} (b_j - t_j)^{\mu_j}}{[f(t_j)]^{\lambda_j + \mu_j + 2}} M\{ \prod_{i=1}^{r} [z_i^{s_i} \prod_{j=1}^{n} [g^{(i)}(t_j)]^{v_j^{(i)} s_i}] \mathrm{d}s_1 \cdots \mathrm{d}s_r \} \mathrm{d}t_1 \cdots \mathrm{d}t_n$$

Now, changing the order of multiple integral (wich is justified under the conditions of (2.4)), we find that

$$M\{ \prod_{i=1}^{r} [z_i^{s_i}] \int_{a_1}^{b_1} \cdots \int_{a_n}^{b_n} \prod_{i=1}^{n} \frac{(t_j - a_j)^{\lambda_j} (b_j - t_j)^{\mu_j}}{[f(t_j)]^{\lambda_j + \mu_j + 2}} \prod_{j=1}^{n} [g^{(i)}(t_j)]^{v_j^{(i)} s_i}] \mathrm{d}t_1 \cdots \mathrm{d}t_n \} \mathrm{d}s_1 \cdots \mathrm{d}s_r$$

$$=M\{\prod_{i=1}^{r}z_i^{s_i}\prod_{j=1}^{n}[\int_{a_j}^{b_j}(t_j-a_j)^{\lambda_j+\sum_{i=1}^{r}\gamma_j^{(i)}v_j^{(i)}s_i}\frac{(b_j-t_j)^{\mu_j+\sum_{i=1}^{r}\delta_j^{(i)}v_j^{(i)}s_i}}{[f(t_j)]^{\lambda_j+\mu_j+\sum_{i=1}^{r}(\gamma_j^{(i)}+\delta_j^{(i)})v_j^{(i)}s_i+2}}$$

$$\{1-\frac{(\beta_j-\alpha_j)(t_j-a_j)}{\beta_j f(t_j)}\}^{-\sum_{i=1}^{r}v_j^{(i)}s_i}dt_j]\}\mathrm{d}s_1\cdots\mathrm{d}s_r \tag{2.5}$$

If $|(\beta_j-\alpha_j)(t_j-a_j)|<|\beta_j f(t_j)|$, then we can use binomial expansion and we thus find from (2.5)

$$\int_{a_1}^{b_1}\cdots\int_{a_n}^{b_n}\prod_{i=1}^{n}\frac{(t_j-a_j)^{\lambda_j}(b_j-t_j)^{\mu_j}}{[f(t_j)]^{\lambda_j+\mu_j+2}}\aleph\begin{pmatrix} \mathrm{z}_1\prod_{j=1}^{n}[g'(t_j)]^{v_j'} \\ \cdots \\ \mathrm{z}_r\prod_{j=1}^{n}[g^{(r)}(t_j)]^{v_j^{(r)}}\end{pmatrix}\mathrm{d}t_1\cdots\mathrm{d}t_n$$

$$=\prod_{j=1}^{n}\sum_{r_j=0}^{\infty}\frac{\{(\beta_j-\alpha_j)/\beta_j\}^{r_j}\}}{r_j!}M\{\prod_{i=1}^{r}[z_i^{s_i}\beta_j^{-\sum_{i=1}^{r}v_j^{(i)}}\frac{\Gamma(r_j+\sum_{i=1}^{n}v_j^{(i)}s_i)}{\Gamma(\sum_{i=1}^{n}v_j^{(i)}s_i)}$$

$$\int_{a_j}^{b_j}\frac{(t_j-a_j)^{\lambda_j+r_j+\sum_{i=1}^{r}\gamma_j^{(i)}v_j^{(i)}s_i}}{[f(t_j)]^{\lambda_j+\mu_j+\sum_{i=1}^{r}(\gamma_j^{(i)}+\delta_j^{(i)})v_j^{(i)}s_i+2}}(b_j-t_j)^{\mu_j+\sum_{i=1}^{r}\delta_j^{(i)}v_j^{(i)}s_i}\mathrm{d}t_j]\}\mathrm{d}s_1\cdots\mathrm{d}s_r \tag{2.6}$$

provided that the order of summation and integration can be inversed. Now evaluating the inner-integral in (2.6) with the help of equation (2.1). We finally obtain the formula (2.4)

3. Particular cases

a) For $n=1$, the equation (2.4) reduces in the following formula after making slight ajustement in parameters.

$$\int_a^b\frac{(t-a)^{\lambda}(b-t)^{\mu}}{[f(t)]^{\lambda+\mu+2}}\aleph\begin{pmatrix}\mathrm{z}_1[g'(t)]^{v'} \\ \cdots \\ \mathrm{z}_r[g^{(r)}(t)]^{v^{(r)}}\end{pmatrix}\mathrm{d}t_1\cdots\mathrm{d}t_n$$

$$=\{(b-a)^{-1}(1+\rho)^{-\lambda-1}(1+\sigma)^{-\mu-1}\sum_{r'=0}^{\infty}\frac{\{(\beta-\alpha)/\beta\}^{r'}(1+\rho)^{-r'}\}}{r'!}$$

$$\aleph_{p_i+3,q_i+2,\tau_i;R:W}^{0,\mathfrak{n}+3:V}\left(\begin{matrix}\mathrm{z}_1\{\beta(1+\rho)^{\gamma}(1+\sigma)^{\delta}\}^{-v'} \\ \cdot \\ \cdot \\ \cdot \\ \mathrm{z}_r\{\beta(1+\rho)^{\gamma}(1+\sigma)^{\delta}\}^{-v^{(r)}}\end{matrix}\ \middle|\ \begin{matrix}(1\text{-r}'\ ;\ \text{v}'_1,\cdots,v_1^{(r)}), \\ \cdots \\ \cdots \\ (1\ ;\ \text{v}'_1,\cdots,v_1^{(r)}),\end{matrix}\right.$$

$$\left.\begin{matrix}(\text{-}\lambda-r';\gamma'v',\cdots,\gamma^{(r)}v^{(r)}),(-\mu;\delta'v',\cdots,\delta^{(r)}v^{(r)}),A:C \\ \cdots \\ \cdots \\ (\text{-}\lambda-\mu-r'-1;(\gamma'+\delta')v',\cdots,(\gamma^{(r)}+\delta^{(r)})v^{(r)}),B:D\end{matrix}\right) \tag{3.1}$$

which holds true under the same conditions from (2.4) with $n = 1$

b)Taking $\beta_j = \alpha_j, j = 1, \cdots, n$ in the formula (2.4), we get

$$\int_{a_1}^{b_1} \cdots \int_{a_n}^{b_n} \prod_{i=1}^{n} \frac{(t_j - a_j)^{\lambda_j}(b_j - t_j)^{\mu_j}}{[f(t_j)]^{\lambda_j+\mu_j+2}} \aleph \left(\begin{array}{c} z_1 \prod_{j=1}^{n} [g'(t_j)]^{v'_j} \\ \cdots \\ z_r \prod_{j=1}^{n} [g^{(r)}(t_j)]^{v_j^{(r)}} \end{array} \right) dt_1 \cdots dt_n$$

$$= \prod_{j=1}^{n} \{(b_j - a_j)^{-1}(1+\rho_j)^{-\lambda_j - 1}(1+\sigma_j)^{-\mu_j - 1}\}$$

$$\aleph^{0,\mathfrak{n}+2n:V}_{p_i+2n,q_i+n,\tau_i;R:W} \left(\begin{array}{c} z_1 \prod_{j=1}^{n} \{\beta_j(1+\rho_j)^{\gamma'_j}(1+\sigma_j)^{\delta'_j}\}^{-v'_j} \\ \cdot \\ \cdot \\ \cdot \\ z_r \prod_{j=1}^{n} \{\beta_j(1+\rho_j)^{\gamma_j^{(n)}}(1+\sigma_j)^{\delta_j^{(n)}}\}^{-v_j^{(r)}} \end{array} \right|$$

$$\begin{array}{c} (\text{-}\lambda_1; \gamma'_1 v'_1, \cdots, \gamma_1^{(r)} v_1^{(r)}), (-\mu_1; \delta'_1 v'_1, \cdots, \delta_1^{(r)} v_1^{(r)}), \cdots, \\ \cdots \\ \cdots \\ (\text{-}\lambda_1 - \mu_1 - 1; (\gamma'_1 + \delta'_1)v'_1, \cdots, (\gamma_1^{(r)} + \delta_1^{(r)})v_1^{(r)}), \cdots, \end{array}$$

$$\left. \begin{array}{c} (\text{-}\lambda_n -; \gamma'_n v'_n, \cdots, \gamma_n^{(r)} v_n^{(r)}), (-\mu_n; \delta'_n v'_n, \cdots, \delta_n^{(r)} v_n^{(r)}), A : C \\ \cdots \\ \cdots \\ (\text{-}\lambda_n - \mu_n - 1; (\gamma'_n + \delta'_n)v'_n, \cdots, (\gamma_n^{(r)} + \delta_n^{(r)})v_n^{(r)}), B : D \end{array} \right) \tag{3.2}$$

which holds true under the same conditions from (2.4)

c) For $\sigma = \rho = 0$ and $z_i = (b-t)^{\gamma+\delta-1)v^{(i)}}$, (3.1) becomes

$$\int_a^b \frac{(t-a)^{\lambda}(b-t)^{\mu}}{[(b-a)]^{\lambda+\mu+2}} \aleph \left(\begin{array}{c} z_1 \{(b-a)/\beta\}^{v'} \\ \cdots \\ z_r \{(b-a)/\beta\}^{v^{(r)}} \end{array} \right) dt_1 \cdots dt_n$$

$$= \{(b-a)^{-1} \sum_{r'=0}^{\infty} \frac{\{(\beta-\alpha)/\beta\}^{r'}\}}{r'!} \aleph^{0,\mathfrak{n}+3:V}_{p_i+3,q_i+2,\tau_i;R:W} \left(\begin{array}{c} \{(\text{b-a})/\beta\}^{(\gamma+\delta-1)v'} \\ \cdot \\ \cdot \\ \cdot \\ \{(\text{b-a})/\beta\}^{(\gamma+\delta-1)v^{(r)}} \end{array} \right|$$

$$\left.\begin{matrix} (1\text{-r'} ; \text{v'}_1,\cdots,v_1^{(r)}),(\text{-}\lambda-r';\gamma'v',\cdots,\gamma^{(r)}v^{(r)}),(-\mu;\delta'v',\cdots,\delta^{(r)}v^{(r)}),A:C \\ \cdots \qquad \cdots \\ \cdots \qquad \cdots \\ (1 ; \text{v'}_1,\cdots,v_1^{(r)}),\ (\text{-}\lambda-\mu-r'-1;(\gamma'+\delta')v',\cdots,(\gamma^{(r)}+\delta^{(r)})v^{(r)}),B:D \end{matrix}\right) \tag{3.3}$$

which holds true under the same conditions from (2.4) with $n=1$

4; Multivariable I-function

Let $\tau_i=\tau_{i^{(1)}}=\cdots=\tau_{i^{(r)}}=1$, the multivariable Aleph-function degenere to multivariable I-function defined by Sharma et al [3].

a) $$\int_{a_1}^{b_1}\cdots\int_{a_n}^{b_n}\prod_{i=1}^{n}\frac{(t_j-a_j)^{\lambda_j}(b_j-t_j)^{\mu_j}}{\left[f(t_j)\right]^{\lambda_j+\mu_j+2}}I\left(\begin{matrix} \text{z}_1\prod_{j=1}^{n}\left[g'(t_j)\right]^{v'_j} \\ \cdots \\ \text{z}_r\prod_{j=1}^{n}\left[g^{(r)}(t_j)\right]^{v_j^{(r)}} \end{matrix}\right)\mathrm{d}t_1\cdots\mathrm{d}t_n$$

$$=\prod_{j=1}^{n}\left\{(b_j-a_j)^{-1}(1+\rho_j)^{-\lambda_j-1}(1+\sigma_j)^{-\mu_j-1}\sum_{r_j=0}^{\infty}\frac{\left\{(\beta_j-\alpha_j)/\beta_j\right\}^{r_j}(1+\rho_j)^{-r_j}\right\}}{r_j!}$$

$$I_{p_i+3n,q_i+2n;R:W}^{0,\text{n}+3n:V}\left(\begin{matrix} \text{z}_1\prod_{j=1}^{n}\left\{\beta_j(1+\rho_j)^{\gamma'_j}(1+\sigma_j)^{\delta'_j}\right\}^{-v'_j} \\ \cdot \\ \cdot \\ \cdot \\ \text{z}_r\prod_{j=1}^{n}\left\{\beta_j(1+\rho_j)^{\gamma_j^{(n)}}(1+\sigma_j)^{\delta_j^{(n)}}\right\}^{-v_j^{(r)}} \end{matrix}\ \middle|\ \begin{matrix} (1\text{-r}_1;v'_1,\cdots,v_1^{(r)}),\cdots, \\ \cdots \\ \cdots \\ (1 ; \text{v'}_1,\cdots,v_1^{(r)}),\cdots, \end{matrix}\right.$$

$$\begin{matrix} (1\text{-r}_n;v'_n,\cdots,v_n^{(r)}),(\text{-}\lambda_1-r_1;\gamma'_1v'_1,\cdots,\gamma_1^{(r)}v_1^{(r)}),(-\mu_1;\delta'_1v'_1,\cdots,\delta_1^{(r)}v_1^{(r)}),\cdots, \\ \cdots \qquad \cdots \\ \cdots \qquad \cdots \\ (1 ; \text{v'}_n,\cdots,v_n^{(r)}),\ (\text{-}\lambda_1-\mu_1-r_1-1;(\gamma'_1+\delta'_1)v'_1,\cdots,(\gamma_1^{(r)}+\delta_1^{(r)})v_1^{(r)}),\cdots, \end{matrix}$$

$$\left.\begin{matrix} (\text{-}\lambda_n-r_n;\gamma'_nv'_n,\cdots,\gamma_n^{(r)}v_n^{(r)}),(-\mu_n;\delta'_nv'_n,\cdots,\delta_n^{(r)}v_n^{(r)}),A:C \\ \cdots \\ \cdots \\ (\text{-}\lambda_n-\mu_n-r_n-1;(\gamma'_n+\delta'_n)v'_n,\cdots,(\gamma_n^{(r)}+\delta_n^{(r)})v_n^{(r)}),B:D \end{matrix}\right) \tag{4.1}$$

which holds true under the same conditions from (2.4)

b)Taking $\beta_j=\alpha_j,j=1,\cdots,n$ in the formula (4.1), we get

$$\int_{a_1}^{b_1}\cdots\int_{a_n}^{b_n}\prod_{i=1}^{n}\frac{(t_j-a_j)^{\lambda_j}(b_j-t_j)^{\mu_j}}{\left[f(t_j)\right]^{\lambda_j+\mu_j+2}}I\left(\begin{matrix} \text{z}_1\prod_{j=1}^{n}\left[g'(t_j)\right]^{v'_j} \\ \cdots \\ \text{z}_r\prod_{j=1}^{n}\left[g^{(r)}(t_j)\right]^{v_j^{(r)}} \end{matrix}\right)\mathrm{d}t_1\cdots\mathrm{d}t_n$$

$$=\prod_{j=1}^{n}\left\{(b_j-a_j)^{-1}(1+\rho_j)^{-\lambda_j-1}(1+\sigma_j)^{-\mu_j-1}\right\}$$

$$I_{p_i+2n,q_i+n;R:W}^{0,\mathfrak{n}+2n:V}\left(\begin{array}{c} z_1\prod_{j=1}^{n}\left\{\beta_j(1+\rho_j)^{\gamma_j'}(1+\sigma_j)^{\delta_j'}\right\}^{-v_j'} \\ \cdot \\ \cdot \\ \cdot \\ z_r\prod_{j=1}^{n}\left\{\beta_j(1+\rho_j)^{\gamma_j^{(n)}}(1+\sigma_j)^{\delta_j^{(n)}}\right\}^{-v_j^{(r)}} \end{array}\right|$$

$$\begin{array}{c} (\text{-}\lambda_1;\gamma_1'v_1',\cdots,\gamma_1^{(r)}v_1^{(r)}),(-\mu_1;\delta_1'v_1',\cdots,\delta_1^{(r)}v_1^{(r)}),\cdots, \\ \cdots \\ \cdots \\ (\text{-}\lambda_1-\mu_1-1;(\gamma_1'+\delta_1')v_1',\cdots,(\gamma_1^{(r)}+\delta_1^{(r)})v_1^{(r)}),\cdots, \end{array}$$

$$\left.\begin{array}{c} (\text{-}\lambda_n-;\gamma_n'v_n',\cdots,\gamma_n^{(r)}v_n^{(r)}),(-\mu_n;\delta_n'v_n',\cdots,\delta_n^{(r)}v_n^{(r)}),A:C \\ \cdots \\ \cdots \\ (\text{-}\lambda_n-\mu_n-1;(\gamma_n'+\delta_n')v_n',\cdots,(\gamma_n^{(r)}+\delta_n^{(r)})v_n^{(r)}),B:D \end{array}\right) \tag{4.2}$$

which holds true under the same conditions from (2.4)

c) For $n=1,\beta=\alpha,$ and $z_i=(b-t)^{\gamma+\delta-1)v^{(i)}}$, (4.1) becomes

$$\int_a^b\frac{(t-a)^{\lambda}(b-t)^{\mu}}{\left[(b-a)\right]^{\lambda+\mu+2}}I\left(\begin{array}{c} z_1\left\{(b-a)/\beta\right\}^{v'} \\ \cdots \\ z_r\left\{(b-a)/\beta\right\}^{v^{(r)}} \end{array}\right)\mathrm{d}t_1\cdots\mathrm{d}t_n$$

$$=\left\{(b-a)^{-1}\sum_{r'=0}^{\infty}\frac{\left\{(\beta-\alpha)/\beta\right\}^{r'}\}}{r'!}I_{p_i+3,q_i+2.R:W}^{0,\mathfrak{n}+3:V}\left(\begin{array}{c} \left\{(\text{b-a})/\beta\right\}^{(\gamma+\delta-1)v'} \\ \cdot \\ \cdot \\ \cdot \\ \left\{(\text{b-a})/\beta\right\}^{(\gamma+\delta-1)v^{(r)}} \end{array}\right|\right.$$

$$\left.\begin{array}{c} (1\text{-}r';\text{v'}_1,\cdots,v_1^{(r)}),(\text{-}\lambda-r';\gamma'v',\cdots,\gamma^{(r)}v^{(r)}),(-\mu;\delta'v',\cdots,\delta^{(r)}v^{(r)}),A:C \\ \cdots \qquad \cdots \\ \cdots \qquad \cdots \\ (1;\text{v'}_1,\cdots,v_1^{(r)}),\ (\text{-}\lambda-\mu-r'-1;(\gamma'+\delta')v',\cdots,(\gamma^{(r)}+\delta^{(r)})v^{(r)}),B:D \end{array}\right) \tag{4.3}$$

which holds true under the same conditions from (2.4) with $n=1$

5. Aleph-function of two variables

In these section, $r=2$ and we obtain the Aleph-function of two variables defined by K. Sharma [4].

a) $$\int_{a_1}^{b_1}\cdots\int_{a_n}^{b_n}\prod_{i=1}^{n}\frac{(t_j-a_j)^{\lambda_j}(b_j-t_j)^{\mu_j}}{\left[f(t_j)\right]^{\lambda_j+\mu_j+2}}\aleph\left(\begin{array}{c}\mathrm{z}_1\prod_{j=1}^{n}\left[g'(t_j)\right]^{v'_j}\\ \cdots\\ \mathrm{z}_2\prod_{j=1}^{n}\left[g^{(2)}(t_j)\right]^{v_j^{(2)}}\end{array}\right)\mathrm{d}t_1\cdots\mathrm{d}t_n$$

$$=\prod_{j=1}^{n}\left\{(b_j-a_j)^{-1}(1+\rho_j)^{-\lambda_j-1}(1+\sigma_j)^{-\mu_j-1}\sum_{r_j=0}^{\infty}\frac{\left\{(\beta_j-\alpha_j)/\beta_j\right\}^{r_j}(1+\rho_j)^{-r_j}\}}{r_j!}\right.$$

$$\aleph^{0,\mathfrak{n}+3n:V}_{p_i+3n,q_i+2n,\tau_i;R:W}\left(\begin{array}{c}\mathrm{z}_1\prod_{j=1}^{n}\left\{\beta_j(1+\rho_j)^{\gamma'_j}(1+\sigma_j)^{\delta'_j}\right\}^{-v'_j}\\ \cdot\\ \cdot\\ \mathrm{z}_2\prod_{j=1}^{n}\left\{\beta_j(1+\rho_j)^{\gamma_j^{(n)}}(1+\sigma_j)^{\delta_j^{(n)}}\right\}^{-v_j^{(2)}}\end{array}\left|\begin{array}{c}(1\text{-}\mathrm{r}_1;v'_1,v_1^{(2)}),\cdots,\\ \cdots\\ \cdots\\ (1\,;\,\mathrm{v'}_1,v_1^{(2)}),\cdots,\end{array}\right.\right.$$

$$\begin{array}{c}(1\text{-}\mathrm{r}_n;v'_n,v_n^{(2)}),\ (\text{-}\lambda_1-r_1;\gamma'_1v'_1,\gamma_1^{(2)}v_1^{(2)}),(-\mu_1;\delta'_1v'_1,\delta_1^{(2)}v_1^{(2)}),\cdots,\\ \cdots\qquad\cdots\\ \cdots\qquad\cdots\\ (1\,;\,\mathrm{v'}_n,v_n^{(2)}),(\text{-}\lambda_1-\mu_1-r_1-1;(\gamma'_1+\delta'_1)v'_1,(\gamma_1^{(2)}+\delta_1^{(2)})v_1^{(2)}),\cdots,\end{array}$$

$$\left.\begin{array}{c}(\text{-}\lambda_n-r_n;\gamma'_nv'_n,\gamma_n^{(2)}v_n^{(2)}),(-\mu_n;\delta'_nv'_n,\delta_n^{(2)}v_n^{(2)}),A:C\\ \cdots\\ \cdots\\ (\text{-}\lambda_n-\mu_n-r_n-1;(\gamma'_n+\delta'_n)v'_n,(\gamma_n^{(2)}+\delta_n^{(2)})v_n^{(2)}),B:D\end{array}\right) \qquad (5.1)$$

which holds true under the same conditions from (2.4) with $r=2$

b) If $r=n=2$,we get

$$\int_{a_1}^{b_1}\int_{a_2}^{b_2}\prod_{i=1}^{2}\frac{(t_j-a_j)^{\lambda_j}(b_j-t_j)^{\mu_j}}{\left[f(t_j)\right]^{\lambda_j+\mu_j+2}}\aleph\left(\begin{array}{c}\mathrm{z}_1\prod_{j=1}^{2}\left[g'(t_j)\right]^{v'_j}\\ \cdots\\ \mathrm{z}_2\prod_{j=1}^{2}\left[g^{(2)}(t_j)\right]^{v_j^{(2)}}\end{array}\right)\mathrm{d}t_1\mathrm{d}t_2$$

$$=\prod_{j=1}^{2}\left\{(b_j-a_j)^{-1}(1+\rho_j)^{-\lambda_j-1}(1+\sigma_j)^{-\mu_j-1}\sum_{r_j=0}^{\infty}\frac{\left\{(\beta_j-\alpha_j)/\beta_j\right\}^{r_j}(1+\rho_j)^{-r_j}\}}{r_j!}\right.$$

$$\aleph^{0,\mathfrak{n}+6:V}_{p_i+6,q_i+4,\tau_i;R:W}\left(\begin{array}{c}\mathrm{z}_1\prod_{j=1}^{2}\left\{\beta_j(1+\rho_j)^{\gamma'_j}(1+\sigma_j)^{\delta'_j}\right\}^{-v'_j}\\ \cdot\\ \cdot\\ \mathrm{z}_2\prod_{j=1}^{2}\left\{\beta_j(1+\rho_j)^{\gamma_j^{(n)}}(1+\sigma_j)^{\delta_j^{(n)}}\right\}^{-v_j^{(2)}}\end{array}\left|\begin{array}{c}(1\text{-}\mathrm{r}_1;v'_1,v_1^{(2)}),(1\text{-}\mathrm{r}_2;v'_2,v_2^{(2)}),\\ \cdots\qquad\cdots\\ \cdots\qquad\cdots\\ (1\,;\,\mathrm{v'}_1,v_1^{(2)}),\ (1\,;\,\mathrm{v'}_2,v_2^{(2)}),\end{array}\right.\right.$$

$$(-\lambda_1 - r_1; \gamma_1' v_1', \gamma_1^{(2)} v_1^{(2)}), (-\mu_1; \delta_1' v_1', \delta_1^{(2)} v_1^{(2)}),$$
$$\cdots$$
$$\cdots$$
$$(-\lambda_1 - \mu_1 - r_1 - 1; (\gamma_1' + \delta_1')v_1', (\gamma_1^{(2)} + \delta_1^{(2)})v_1^{(2)}),$$

$$\left. \begin{matrix} (-\lambda_2 - r_2; \gamma_2' v_2', \gamma_2^{(2)} v_2^{(2)}), (-\mu_2; \delta_2' v_2', \delta_2^{(2)} v_2^{(2)}), A : C \\ \cdots \\ \cdots \\ (-\lambda_2 - \mu_2 - r_2 - 1; (\gamma_2' + \delta_2')v_2', (\gamma_2^{(2)} + \delta_2^{(2)})v_2^{(2)}), B : D \end{matrix} \right) \tag{5.2}$$

which holds true under the same conditions from (2.4) with $r = 2$

c) Taking $\beta_j = \alpha_j, j = 1, \cdots, n$ in the formula (5.1), we get

$$\int_{a_1}^{b_1} \cdots \int_{a_n}^{b_n} \prod_{i=1}^{n} \frac{(t_j - a_j)^{\lambda_j}(b_j - t_j)^{\mu_j}}{[f(t_j)]^{\lambda_j + \mu_j + 2}} \aleph \begin{pmatrix} z_1 \prod_{j=1}^{n} [g'(t_j)]^{v_j'} \\ \cdots \\ z_2 \prod_{j=1}^{n} [g^{(2)}(t_j)]^{v_j^{(2)}} \end{pmatrix} dt_1 \cdots dt_n$$

$$= \prod_{j=1}^{n} \{(b_j - a_j)^{-1}(1 + \rho_j)^{-\lambda_j - 1}(1 + \sigma_j)^{-\mu_j - 1}\}$$

$$\aleph_{p_i + 2n, q_i + n, \tau_i; R : W}^{0, \mathfrak{n} + 2n : V} \left(\begin{matrix} z_1 \prod_{j=1}^{n} \{\beta_j (1 + \rho_j)^{\gamma_j'} (1 + \sigma_j)^{\delta_j'}\}^{-v_j'} \\ \cdot \\ \cdot \\ z_2 \prod_{j=1}^{n} \{\beta_j (1 + \rho_j)^{\gamma_j^{(n)}} (1 + \sigma_j)^{\delta_j^{(n)}}\}^{-v_j^{(2)}} \end{matrix} \right|$$

$$(-\lambda_1; \gamma_1' v_1', \gamma_1^{(2)} v_1^{(2)}), (-\mu_1; \delta_1' v_1', \delta_1^{(2)} v_1^{(2)}), \cdots,$$
$$\cdots$$
$$\cdots$$
$$(-\lambda_1 - \mu_1 - 1; (\gamma_1' + \delta_1')v_1', (\gamma_1^{(2)} + \delta_1^{(2)})v_1^{(2)}), \cdots,$$

$$\left. \begin{matrix} (-\lambda_n -; \gamma_n' v_n', \gamma_n^{(2)} v_n^{(2)}), (-\mu_n; \delta_n' v_n', \delta_n^{(2)} v_n^{(2)}), A : C \\ \cdots \\ \cdots \\ (-\lambda_n - \mu_n - 1; (\gamma_n' + \delta_n')v_n', (\gamma_n^{(2)} + \delta_n^{(2)})v_n^{(2)}), B : D \end{matrix} \right) \tag{5.3}$$

which holds true under the same conditions from (2.4) with $r = 2$

d) For $n = 1, \beta_j = \alpha_j, j = 1, \cdots, n,$ and $z_i = (b - t)^{\gamma + \delta - 1)v^{(i)}}$, (5.1) becomes

$$\int_a^b \frac{(t-a)^{\lambda}(b-t)^{\mu}}{[(b-a)]^{\lambda + \mu + 2}} \aleph \begin{pmatrix} z_1 \{(b-a)/\beta\}^{v'} \\ \cdots \\ z_2 \{(b-a)/\beta\}^{v^{(2)}} \end{pmatrix} dt_1 \cdots dt_n$$

$$=\{(b-a)^{-1}\sum_{r'=0}^{\infty}\frac{\{(\beta-\alpha)/\beta\}^{r'}\}}{r'!}\aleph^{0,\mathfrak{n}+3:V}_{p_i+3,q_i+2,\tau_i;R:W}\left(\begin{array}{c|c}\{(\text{b-a})/\beta\}^{(\gamma+\delta-1)v'} & (1\text{-r}';\ \text{v}'_1, v_1^{(2)}),\\ \cdot & \cdots\\ \cdot & \cdots\\ \{(\text{b-a})/\beta\}^{(\gamma+\delta-1)v^{(2)}} & (1;\ \text{v}'_1, v_1^{(2)}),\end{array}\right.$$

$$\left.\begin{array}{c}(\text{-}\lambda-r';\gamma'v',\gamma^{(2)}v^{(2)}),(-\mu;\delta'v',\delta^{(2)}v^{(2)}),A:C\\ \cdots\\ \cdots\\ (\text{-}\lambda-\mu-r'-1;(\gamma'+\delta')v',(\gamma^{(2)}+\delta^{(2)})v^{(2)}),B:D\end{array}\right) \quad (5.4)$$

6. Conclusion

The aleph-function of several variables presented in this paper, is quite basic in nature. Therefore , on specializing the parameters of this function, we may obtain various other special functions such as , multivariable H-function , defined by Srivastava et al [6] , the Aleph-function of two variables defined by K.sharma [4].

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