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Integral Formulae's Involving Two $\overline{H}$-function and Multivariable Polynomials

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Ref.

1. A.A. Inayat-Hussain, New properties of hypergeometric series derivable from Feynman integrals: I. Transformation and reeducation formulae, J. Phys. A: Math.Gen.20 (1987), 4109-4117.

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Praveen Agarwal

Abstract - The aim of the present paper is to derive a new Integral formulae's for the $\bar{\mathbf{H}}$-function due to Inayat-Hussain whose based upon some integral formulae due to Qureshi et.al. The results are obtained in a compact form containing the multivariable Polynomials.

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I. Introduction

In 1987, Inayat-Hussain [1, 2] introduced generalization form of Fox's H-function, which is popularly known as $\bar{\mathrm{H}}$-function. Now $\bar{\mathrm{H}}$-function stands on fairly firm footing through the research contributions of various authors [1-3, 9, 10, 13-15].

$\bar{\mathrm{H}}$-function is defined and represented in the following manner [10].

$$\bar{\mathrm{H}}_{p,q}^{m,n}[z]=\bar{\mathrm{H}}_{p,q}^{m,n}\left[z\left|\begin{matrix}(a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p}\\(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q}\end{matrix}\right.\right]=\frac{1}{2\pi i}\int_L z^{\xi}\bar{\phi}(\xi)d\xi\ (z\neq 0) \tag{1.1}$$

where

$$\bar{\phi}(\xi)=\frac{\prod_{j=1}^{m}\Gamma(b_j-\beta_j\xi)\prod_{j=1}^{n}\{\Gamma(1-a_j+\alpha_j\xi)\}^{A_j}}{\prod_{j=m+1}^{q}\{\Gamma(1-b_j+\beta_j\xi)\}^{B_j}\prod_{j=n+1}^{p}\Gamma(a_j-\alpha_j\xi)} \tag{1.2}$$

It may be noted that the $\bar{\phi}(\xi)$ contains fractional powers of some of the gamma function and m,n,p,q are integers such that $1\leq m\leq q, 1\leq n\leq p$ $(\alpha_j)_{1,p},(\beta_j)_{1,q}$ are positive real numbers and $(A_j)_{1,n},(B_j)_{m+1,q}$ may take non-integer values, which we assume to be positive for standardization purpose. $(\alpha_j)_{1,p}$ and $(\beta_j)_{1,q}$ are complex numbers.

The nature of contour L, sufficient conditions of convergence of defining integral (1.1) and other details about the $\bar{\mathrm{H}}$-function can be seen in the papers [9, 10].

The behavior of the $\bar{\mathrm{H}}$-function for small values of $|z|$ follows easily from a result given by Rathie [3]:

$$\bar{\mathrm{H}}_{p,q}^{m,n}[z]=o(|z|^{\alpha});\ \text{Where}$$

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$$\alpha = \min_{1\le j\le m} \operatorname{Re}\left(\frac{b_j}{\alpha_j}\right), |z| \to 0 \tag{1.3}$$

$$\Omega = \sum_{j=1}^{m} |B_j| + \sum_{j=m+1}^{q} |b_j B_j| - \sum_{j=1}^{n} |a_j A_j| - \sum_{j=n+1}^{q} |A_j| > 0,\ 0 < |z| < \infty \tag{1.4}$$

The following function which follows as special cases of the $\bar{H}$-function will be required in the sequel [9]

$$ {}_p\bar{\Psi}_q\left[\begin{matrix}(a_j,\alpha_j;A_j)_{1,p}\\(b_j,\beta_j;B_j)_{1,q}\end{matrix};z\right] = \bar{H}^{1,p}_{p,q+1}\left[-z\left|\begin{matrix}(1-a_j,\alpha_j;A_j)_{1,p}\\(0,1),(1-b_j,\beta_j;B_j)_{1,q}\end{matrix}\right.\right] \tag{1.5}$$

The general class of multivariable polynomials is defined by Srivastava and Garg [7]:

$$S_L^{h_1,\ldots,h_r}[x_1,\ldots,x_r] = \sum_{k_1,\ldots,k_r=0}^{h_1k_1+\ldots+h_rk_r\le L} (-L)_{h_1k_1+\ldots+h_rk_r} A(L;k_1,\ldots k_r)\frac{x_1^{k_1}}{k_1!}\ldots\frac{x_r^{k_r}}{k_r!} \tag{1.6}$$

Where $h_1,\ldots,h_r$ are arbitrary positive integers and the coefficients $A(L;k_1,\ldots,k_r)$, $(L;h_i\in N;i=1,\ldots,r)$ are arbitrary constant, real or complex.

Evidently the case $r=1$ of the polynomials (1.6)

Would correspond to the polynomials given by Srivastava [5]

$$S_L^h[x] = \sum_{k=0}^{[L/h]} \frac{(-L)_{hk}}{k!} A_{L,k}x^k \ \{L\in N=(0,1,2,\ldots)\} \tag{1.7}$$

Where h is arbitrary positive integers and the coefficient $A_{L,k}(L,k\ge 0)$ are arbitrary constant, real or complex.

The following formulas [11 , p.77, Ens. (3.1), (3.2) & (3.3)] will be required in our investigation.

$$\int_0^\infty \left[\left(ax+\frac{b}{x}\right)^2+c\right]^{-p-1} dx = \frac{\sqrt{\pi}}{2a(4ab+c)^{p+1/2}}\frac{\Gamma(p+1/2)}{\Gamma(p+1)},\ (a>0;b\ge 0;c+4ab>0;\operatorname{Re}(p)+1/2>0) \tag{1.8}$$

$$\int_0^\infty \frac{1}{x^2}\left[\left(ax+\frac{b}{x}\right)^2+c\right]^{-p-1} dx = \frac{\sqrt{\pi}}{2b(4ab+c)^{p+1/2}}\frac{\Gamma(p+1/2)}{\Gamma(p+1)},\ (a\ge 0;b>0;c+4ab>0;\operatorname{Re}(p)+1/2>0) \tag{1.9}$$

$$\int_0^\infty \left(a+\frac{b}{x^2}\right)\left[\left(ax+\frac{b}{x}\right)^2+c\right]^{-p-1} dx = \frac{\sqrt{\pi}}{(4ab+c)^{p+1/2}}\frac{\Gamma(p+1/2)}{\Gamma(p+1)},\ (a>0;b>0;c+4ab>0;\operatorname{Re}(p)+1/2>0) \tag{1.10}$$

II. Main Integral Formulae's

Let X stands for $\left(ax+\frac{b}{x}\right)^2+c$

Ref.

7. H.M. Srivastava and M. Garg, Some integrals involving a general class of polynomials and multivariable H-function, RevRoumaine Phys 32(1987), 685-692.

First Integral Formulae:

$$\int_0^\infty X^{-\eta-1} S_L^{h_1,\ldots,h_r}[c_1X^{\delta_1},\ldots,c_rX^{\delta_r}]\overline{H}_{P,Q}^{M,N}\left[X^\sigma\left|\begin{matrix}(a'_j,\alpha'_j;A'_j)_{1,N},(a'_j,\alpha'_j)_{N+1,P}\\(b'_j,\beta'_j;B'_j)_{1,M},(b'_j,\beta'_j)_{M+1,Q}\end{matrix}\right.\right]\overline{H}_{p,q}^{m,n}\left[zX^\rho\left|\begin{matrix}(a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p}\\(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q}\end{matrix}\right.\right]dx$$

$$=\frac{\sqrt{\pi}}{2a(4ab+c)^{\eta+1/2}}\sum_{k_1,\ldots,k_r=0}^{h_1k_1+\ldots+h_rk_r\le L}(-L)_{h_1k_1+\ldots+h_rk_r}A(L;k_1,\ldots k_r)\frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1}k_1!}\cdots\frac{c_r^{k_r}}{(4ab+c)^{k_r\delta_r}k_r!}$$

$$\frac{1}{2\pi!}\int_L\bar{\phi}(\xi)\overline{H}_{p+1,q+1}^{m+1,n}\left[z(4ab+c)^\rho\left|\begin{matrix}(a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p},(-\eta+\sigma\xi+\sum_{i=1}^r k_i\delta_i,\rho;1)\\(1/2-\eta+\sigma\xi+\sum_{i=1}^r k_i\delta_i,\rho;1),(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q}\end{matrix}\right.\right](4ab+c)^{\xi\sigma}d\xi \tag{2.1}$$

The above result will be converging under the following conditions:

(I) $a>0;b\ge0;c+4ab>0$ and $\eta>0,\delta_i\ge0,\sigma>0,\rho\ge0$

(II) $-\eta+\sigma\min_{1\le j\le M}\operatorname{Re}\left(\frac{b'_j}{\beta'_j}\right)+\rho\min_{1\le j\le m}\operatorname{Re}\left(\frac{b_j}{\beta_j}\right)<\frac{1}{2}$

(III) $|\arg z|<\frac{1}{2}\Omega\pi$, where Ω is given by equation (1.4)

Second Integral Formulae:

$$\int_0^\infty \frac{1}{x^2} X^{-\eta-1} S_L^{h_1,\ldots,h_r}[c_1X^{\delta_1},\ldots,c_rX^{\delta_r}]\overline{H}_{P,Q}^{M,N}\left[X^\sigma\left|\begin{matrix}(a'_j,\alpha'_j;A'_j)_{1,N},(a'_j,\alpha'_j)_{N+1,P}\\(b'_j,\beta'_j;B'_j)_{1,M},(b'_j,\beta'_j)_{M+1,Q}\end{matrix}\right.\right]\overline{H}_{p,q}^{m,n}\left[zX^\rho\left|\begin{matrix}(a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p}\\(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q}\end{matrix}\right.\right]dx$$

$$=\frac{\sqrt{\pi}}{2b(4ab+c)^{\eta+1/2}}\sum_{k_1,\ldots,k_r=0}^{h_1k_1+\ldots+h_rk_r\le L}(-L)_{h_1k_1+\ldots+h_rk_r}A(L;k_1,\ldots k_r)\frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1}k_1!}\cdots\frac{c_r^{k_r}}{(4ab+c)^{k_r\delta_r}k_r!}$$

$$\frac{1}{2\pi!}\int_L\bar{\phi}(\xi)\overline{H}_{p+1,q+1}^{m+1,n}\left[z(4ab+c)^\rho\left|\begin{matrix}(a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p},(-\eta+\sigma\xi+\sum_{i=1}^r k_i\delta_i,\rho;1)\\(1/2-\eta+\sigma\xi+\sum_{i=1}^r k_i\delta_i,\rho;1),(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q}\end{matrix}\right.\right](4ab+c)^{\xi\sigma}d\xi \tag{2.2}$$

The above result will be converging under the following conditions:

(I) $a\ge0;b>0;c+4ab>0$ and $\eta>0,\delta_i\ge0,\sigma>0,\rho\ge0$

(II) $-\eta+\sigma\min_{1\le j\le M}\operatorname{Re}\left(\frac{b'_j}{\beta'_j}\right)+\rho\min_{1\le j\le m}\operatorname{Re}\left(\frac{b_j}{\beta_j}\right)<\frac{1}{2}$

(III) $|\arg z|<\frac{1}{2}\Omega\pi$, where Ω is given by equation (1.4)

Third Integral Formulae:

$$\int_0^\infty\left(a+\frac{b}{x^2}\right)X^{-\eta-1} S_L^{h_1,\ldots,h_r}[c_1X^{\delta_1},\ldots,c_rX^{\delta_r}]\overline{H}_{P,Q}^{M,N}\left[X^\sigma\left|\begin{matrix}(a'_j,\alpha'_j;A'_j)_{1,N},(a'_j,\alpha'_j)_{N+1,P}\\(b'_j,\beta'_j;B'_j)_{1,M},(b'_j,\beta'_j)_{M+1,Q}\end{matrix}\right.\right]\overline{H}_{p,q}^{m,n}\left[zX^\rho\left|\begin{matrix}(a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p}\\(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q}\end{matrix}\right.\right]dx$$

Notes

$$= \frac{\sqrt{\pi}}{(4ab+c)^{\eta+1/2}} \sum_{k_1,\dots,k_r=0}^{h_1k_1+\dots+h_rk_r \le L} (-L)_{h_1k_1+\dots+h_rk_r} A(L;k_1,\dots k_r) \frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1} k_1!} \cdots \frac{c_r^{k_r}}{(4ab+c)^{k_r\delta_r} k_r!}$$

$$\frac{1}{2\pi i}\int_L \bar{\phi}(\xi) \bar{H}_{p+1,q+1}^{m+1,n}\left[z(4ab+c)^{\rho} \left| \begin{matrix} (a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p},(-\eta+\sigma\xi+\sum_{i=1}^{r}k_i\delta_i,\rho;1) \\ (1/2-\eta+\sigma\xi+\sum_{i=1}^{r}k_i\delta_i,\rho;1),(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q} \end{matrix} \right. \right] (4ab+c)^{\xi\sigma} d\xi \quad (2.3)$$

The above result will be converging under the following conditions:

(I) $a>0; b>0; c+4ab>0$ and $\eta>0, \delta_i \ge 0, \sigma>0, \rho \ge 0$

(II) $-\eta+\sigma \min_{1\le j\le M} \mathrm{Re}\left(\frac{b'_j}{\beta'_j}\right)+\rho \min_{1\le j\le m} \mathrm{Re}\left(\frac{b_j}{\beta_j}\right)<\frac{1}{2}$

(III) $|\arg z|<\frac{1}{2}\Omega\pi$, where Ω is given by equation (1.4)

Proof: To prove the first integral, we first express $\bar{H}$-function occurring on the L.H.S. of equation (2.1) in terms of Mellin-Barnes type of contour integral given by equation (1.1) and general class of multivariable polynomials $S_L^{h_1,\dots,h_r}[x_1,\dots,x_r]$ in series form with the help of (1.6) and then interchanging the order of integration and summation. We get:

$$\sum_{k_1,\dots,k_r=0}^{h_1k_1+\dots+h_rk_r \le L} (-L)_{h_1k_1+\dots+h_rk_r} A(L;k_1,\dots k_r) \frac{c_1^{k_1}}{k_1!}\cdots\frac{c_r^{k_r}}{k_r!} \frac{1}{2\pi i}\int_L \bar{\phi}(\xi) \frac{1}{2\pi i}\int_L \bar{\varphi}(\zeta) z^{\zeta} \left[\int_0^{\infty} \left[\left(ax+\frac{b}{x}\right)^2+c \right]^{-\eta+\sigma\xi+\rho\zeta+\sum_{i=1}^{r}k_i\delta_i-1} dx \right] d\xi d\zeta \quad (2.4)$$

Further using the result (1.8) the above integral becomes

$$\sum_{k_1,\dots,k_r=0}^{h_1k_1+\dots+h_rk_r \le L} (-L)_{h_1k_1+\dots+h_rk_r} A(L;k_1,\dots k_r) \frac{c_1^{k_1}}{k_1!}\cdots\frac{c_r^{k_r}}{k_r!} \frac{1}{2\pi i}\int_L \bar{\phi}(\xi)$$

$$\left\{ \frac{1}{2\pi i}\int_L \bar{\varphi}(\zeta) z^{\zeta} \left[\frac{\sqrt{\pi}}{2a(4ab+c)^{\eta-\sigma\xi-\rho\zeta-\sum_{i=1}^{r}k_i\delta_i+1/2}} \frac{\Gamma(\eta-\sigma\xi-\rho\zeta-\sum_{i=1}^{r}k_i\delta_i+1/2)}{\Gamma(\eta-\sigma\xi-\rho\zeta-\sum_{i=1}^{r}k_i\delta_i+1)} \right] d\zeta \right\} d\xi \quad (2.5)$$

Then interpreting with the help of (1.1) and (2.5) provides first integral.

Proceeding on the same parallel lines, integral second and third given by equation (2.2) and (2.3) can be easily obtained by using the results (1.9) and (1.10) respectively.

III. Special Cases

(3.1) If we put $A'_j = B'_j = A_j = B_j = 1$, $\bar{H}$-function reduces to Fox's H-function [6, p. 10, Eqn. (2.1.1)], then the equations (2.1), (2.2) and (2.3) take the following form.

$$\int_0^{\infty} x^{-\eta-1} S_L^{h_1,\dots,h_r}[c_1x^{\delta_1},\dots,c_rx^{\delta_r}] H_{P,Q}^{M,N}\left[x^{\sigma} \left| \begin{matrix} (a'_j,\alpha'_j)_{1,P} \\ (b'_j,\beta'_j)_{1,Q} \end{matrix} \right. \right] H_{p,q}^{m,n}\left[zx^{\rho} \left| \begin{matrix} (a_j,\alpha_j)_{1,p} \\ (b_j,\beta_j)_{1,q} \end{matrix} \right. \right] dx$$

Ref.

6. H.M. Srivastava, K.C. Gupta and S.P. Goyal, The H-function of one and two variables with applications, South Asian Publishers, New Delhi, Madras (1982).

$$= \frac{\sqrt{\pi}}{2a(4ab+c)^{\eta+1/2}} \sum_{k_1,\dots,k_r=0}^{h_1k_1+\dots+h_rk_r\le L} (-L)_{h_1k_1+\dots+h_rk_r} A(L;k_1,\dots k_r) \frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1}\, k_1!} \cdots \frac{c_r^{k_r}}{(4ab+c)^{k_r\delta_r}\, k_r!}$$

$$\frac{1}{2\pi!}\int_L \bar{\phi}(\xi) H_{p+1,q+1}^{m+1,n}\left[z(4ab+c)^{\rho} \left| \begin{matrix} (a_j,\alpha_j)_{1,p}, \left(-\eta+\sigma\xi+\sum_{i=1}^{r} k_i\delta_i,\rho\right) \\ \left(1/2-\eta+\sigma\xi+\sum_{i=1}^{r} k_i\delta_i,\rho\right),(b_j,\beta_j)_{1,q} \end{matrix} \right. \right] (4ab+c)^{\xi\sigma}\, d\xi \qquad (3.1.1)$$

$$\int_0^\infty \frac{1}{x^2} X^{-\eta-1} S_L^{h_1,\dots,h_r}[c_1X^{\delta_1},\dots,c_rX^{\delta_r}] H_{P,Q}^{M,N}\left[X^{\sigma} \left| \begin{matrix} (a'_j,\alpha'_j)_{1,P} \\ (b'_j,\beta'_j)_{1,Q} \end{matrix} \right. \right] H_{p,q}^{m,n}\left[zX^{\rho} \left| \begin{matrix} (a_j,\alpha_j)_{1,p} \\ (b_j,\beta_j)_{1,q} \end{matrix} \right. \right] dx$$

$$= \frac{\sqrt{\pi}}{2b(4ab+c)^{\eta+1/2}} \sum_{k_1,\dots,k_r=0}^{h_1k_1+\dots+h_rk_r\le L} (-L)_{h_1k_1+\dots+h_rk_r} A(L;k_1,\dots k_r) \frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1}\, k_1!} \cdots \frac{c_r^{k_r}}{(4ab+c)^{k_r\delta_r}\, k_r!}$$

$$\frac{1}{2\pi!}\int_L \bar{\phi}(\xi) H_{p+1,q+1}^{m+1,n}\left[z(4ab+c)^{\rho} \left| \begin{matrix} (a_j,\alpha_j)_{1,p}, \left(-\eta+\sigma\xi+\sum_{i=1}^{r} k_i\delta_i,\rho\right) \\ \left(1/2-\eta+\sigma\xi+\sum_{i=1}^{r} k_i\delta_i,\rho\right),(b_j,\beta_j)_{1,q} \end{matrix} \right. \right] (4ab+c)^{\xi\sigma}\, d\xi \qquad (3.1.2)$$

$$\int_0^\infty \left(a+\frac{b}{x^2}\right) X^{-\eta-1} S_L^{h_1,\dots,h_r}[c_1X^{\delta_1},\dots,c_rX^{\delta_r}] H_{P,Q}^{M,N}\left[X^{\sigma} \left| \begin{matrix} (a'_j,\alpha'_j)_{1,P} \\ (b'_j,\beta'_j)_{1,Q} \end{matrix} \right. \right] H_{p,q}^{m,n}\left[zX^{\rho} \left| \begin{matrix} (a_j,\alpha_j)_{1,p} \\ (b_j,\beta_j)_{1,q} \end{matrix} \right. \right] dx$$

$$= \frac{\sqrt{\pi}}{(4ab+c)^{\eta+1/2}} \sum_{k_1,\dots,k_r=0}^{h_1k_1+\dots+h_rk_r\le L} (-L)_{h_1k_1+\dots+h_rk_r} A(L;k_1,\dots k_r) \frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1}\, k_1!} \cdots \frac{c_r^{k_r}}{(4ab+c)^{k_r\delta_r}\, k_r!}$$

$$\frac{1}{2\pi!}\int_L \bar{\phi}(\xi) H_{p+1,q+1}^{m+1,n}\left[z(4ab+c)^{\rho} \left| \begin{matrix} (a_j,\alpha_j)_{1,p}, \left(-\eta+\sigma\xi+\sum_{i=1}^{r} k_i\delta_i,\rho\right) \\ \left(1/2-\eta+\sigma\xi+\sum_{i=1}^{r} k_i\delta_i,\rho\right),(b_j,\beta_j)_{1,q} \end{matrix} \right. \right] (4ab+c)^{\xi\sigma}\, d\xi \qquad (3.1.3)$$

The conditions of convergence of (3.1.1), (3.1.2) and (3.1.3) can be easily obtained from those of (2.1), (2.2) and (2.3) respectively.

Further If we put $A'_j = B'_j = A_j = B_j = 1; \alpha'_j = \beta'_j = \alpha_j = \beta_j = 1$, then the $\overline{\text{H}}$-function reduces to general type of G-function [12], which is also the new special case.

(3.2) If we put $n = p,\ m = 1,\ q = q+1,\ b_1 = 0, \beta_1 = 1,\ a_j = 1-a_j,\ b_j = 1-b_j$, then the $\overline{\text{H}}$-function reduces to generalized wright hypergeometric function [9] i.e. $\overline{H}_{p,q+1}^{1,p}\left[z \left| \begin{matrix} (1-a_j,\alpha_j;A_j)_{1,p} \\ (0,1),(1-b_j,\beta_j;B_j)_{1,q} \end{matrix} \right. \right] = {}_p\overline{\psi}_q\left[\begin{matrix} (a_j,\alpha_j;A_j)_{1,p} \\ (b_j,\beta_j;B_j)_{1,q} \end{matrix} ;-z \right]$, the equations (2.1), (2.2) and (2.3) take the following form.

$$\int_0^\infty X^{-\eta-1} S_L^{h_1,\dots,h_r}[c_1X^{\delta_1},\dots,c_rX^{\delta_r}] \overline{H}_{P,Q}^{M,N}\left[X^{\sigma} \left| \begin{matrix} (a'_j,\alpha'_j;A'_j)_{1,N},(a'_j,\alpha'_j)_{N+1,P} \\ (b'_j,\beta'_j;B'_j)_{1,M},(b'_j,\beta'_j)_{M+1,Q} \end{matrix} \right. \right] {}_p\overline{\psi}_q\left[\begin{matrix} (a_j,\alpha_j;A_j)_{1,p} \\ (b_j,\beta_j;B_j)_{1,q} \end{matrix} ;-zX^{\rho} \right] dx$$

Ref.

9. K.C. Gupta and R.C. Soni, On a basic integral formula involving the product of the H-function and Fox H-function, J.Raj.Acad.Phy. Sci., 4 (3) (2006), 157-164.

$$= \frac{\sqrt{\pi}}{2a(4ab+c)^{\eta+1/2}} \sum_{k_1,\dots,k_r=0}^{h_1k_1+\dots+h_rk_r\le L} (-L)_{h_1k_1+\dots+h_rk_r} A(L;k_1,\dots k_r) \frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1} k_1!} \dots \frac{c_r^{k_r}}{(4ab+c)^{k_r\delta_r} k_r!}$$

$$\frac{1}{2\pi!}\int_L \bar{\phi}(\xi)\ {}_{p+1}\bar{\Psi}_{q+1}\left[\begin{matrix}(a_j,\alpha_j;A_j)_{1,p},\left(-\eta+\sigma\xi+\sum_{i=1}^{r}k_i\delta_i,\rho;1\right)\\ \left(1/2-\eta+\sigma\xi+\sum_{i=1}^{r}k_i\delta_i,\rho;1\right),(b_j,\beta_j;B_j)_{1,q}\end{matrix};-z(4ab+c)^{\rho}\right](4ab+c)^{\xi\sigma}\,d\xi \quad (3.2.1)$$

$$\int_0^\infty \frac{1}{x^2} X^{-\eta-1} S_L^{h_1,\dots,h_r}[c_1X^{\delta_1},\dots,c_rX^{\delta_r}]\bar{H}_{P,Q}^{M,N}\left[X^{\sigma}\left|\begin{matrix}(a'_j,\alpha'_j;A'_j)_{1,N},(a'_j,\alpha'_j)_{N+1,P}\\ (b'_j,\beta'_j;B'_j)_{1,M},(b'_j,\beta'_j)_{M+1,Q}\end{matrix}\right.\right]{}_p\bar{\Psi}_q\left[\begin{matrix}(a_j,\alpha_j;A_j)_{1,p}\\ (b_j,\beta_j;B_j)_{1,q}\end{matrix};-zX^{\rho}\right]dx$$

$$= \frac{\sqrt{\pi}}{2b(4ab+c)^{\eta+1/2}} \sum_{k_1,\dots,k_r=0}^{h_1k_1+\dots+h_rk_r\le L} (-L)_{h_1k_1+\dots+h_rk_r} A(L;k_1,\dots k_r) \frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1} k_1!} \dots \frac{c_r^{k_r}}{(4ab+c)^{k_r\delta_r} k_r!}$$

$$\frac{1}{2\pi!}\int_L \bar{\phi}(\xi)\ {}_{p+1}\bar{\Psi}_{q+1}\left[\begin{matrix}(a_j,\alpha_j;A_j)_{1,p},\left(-\eta+\sigma\xi+\sum_{i=1}^{r}k_i\delta_i,\rho;1\right)\\ \left(1/2-\eta+\sigma\xi+\sum_{i=1}^{r}k_i\delta_i,\rho;1\right),(b_j,\beta_j;B_j)_{1,q}\end{matrix};-z(4ab+c)^{\rho}\right](4ab+c)^{\xi\sigma}\,d\xi \quad (3.2.2)$$

$$\int_0^\infty \left(a+\frac{b}{x^2}\right) X^{-\eta-1} S_L^{h_1,\dots,h_r}[c_1X^{\delta_1},\dots,c_rX^{\delta_r}]\bar{H}_{P,Q}^{M,N}\left[X^{\sigma}\left|\begin{matrix}(a'_j,\alpha'_j;A'_j)_{1,N},(a'_j,\alpha'_j)_{N+1,P}\\ (b'_j,\beta'_j;B'_j)_{1,M},(b'_j,\beta'_j)_{M+1,Q}\end{matrix}\right.\right]{}_p\bar{\Psi}_q\left[\begin{matrix}(a_j,\alpha_j;A_j)_{1,p}\\ (b_j,\beta_j;B_j)_{1,q}\end{matrix};-zX^{\rho}\right]dx$$

$$= \frac{\sqrt{\pi}}{(4ab+c)^{\eta+1/2}} \sum_{k_1,\dots,k_r=0}^{h_1k_1+\dots+h_rk_r\le L} (-L)_{h_1k_1+\dots+h_rk_r} A(L;k_1,\dots k_r) \frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1} k_1!} \dots \frac{c_r^{k_r}}{(4ab+c)^{k_r\delta_r} k_r!}$$

$$\frac{1}{2\pi!}\int_L \bar{\phi}(\xi)\ {}_{p+1}\bar{\Psi}_{q+1}\left[\begin{matrix}(a_j,\alpha_j;A_j)_{1,p},\left(-\eta+\sigma\xi+\sum_{i=1}^{r}k_i\delta_i,\rho;1\right)\\ \left(1/2-\eta+\sigma\xi+\sum_{i=1}^{r}k_i\delta_i,\rho;1\right),(b_j,\beta_j;B_j)_{1,q}\end{matrix};-z(4ab+c)^{\rho}\right](4ab+c)^{\xi\sigma}\,d\xi \quad (3.2.3)$$

The conditions of convergence of (3.2.1), (3.2.2) and (3.2.3) can be easily obtained from those of (2.1), (2.2) and (2.3) respectively.

(3.3) If we put r=1 the general class of multivariable polynomials given by Srivastava and Garg [7] reduces to the polynomials given by Srivastava [5], the equations (2.1), (2.2) and (2.3) take the following form:

$$\int_0^\infty X^{-\eta-1} S_L^{h_1}[c_1X^{\delta_1}]\bar{H}_{P,Q}^{M,N}\left[X^{\sigma}\left|\begin{matrix}(a'_j,\alpha'_j;A'_j)_{1,N},(a'_j,\alpha'_j)_{N+1,P}\\ (b'_j,\beta'_j;B'_j)_{1,M},(b'_j,\beta'_j)_{M+1,Q}\end{matrix}\right.\right]\bar{H}_{p,q}^{m,n}\left[zX^{\rho}\left|\begin{matrix}(a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p}\\ (b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q}\end{matrix}\right.\right]dx$$

$$= \frac{\sqrt{\pi}}{2a(4ab+c)^{\eta+1/2}} \sum_{k_1=0}^{[L/h_1]} \frac{(-L)_{h_1k_1} A_{L,k_1}}{k_1!} \frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1}}$$

Ref.

5. H.M. Sarivastava, A contour integral involving Fox's H-function, Indian J. Math. 14(1972), 1-6.

$$\frac{1}{2\pi !}\int_L \bar{\phi}(\xi)\overline{H}^{m+1,n}_{p+1,q+1}\left[z(4ab+c)^{\rho}\left|\begin{matrix}(a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p},(-\eta+\sigma\xi+k_1\delta_1,\rho;1)\\(1/2-\eta+\sigma\xi+k_1\delta_1,\rho;1),(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q}\end{matrix}\right.\right](4ab+c)^{\xi\sigma}\,d\xi \tag{3.3.1}$$

Notes

$$\int_0^\infty \frac{1}{x^2}X^{-\eta-1}S_L^{h_1}[c_1X^{\delta_1}]\overline{H}^{M,N}_{P,Q}\left[X^{\sigma}\left|\begin{matrix}(a'_j,\alpha'_j;A'_j)_{1,N},(a'_j,\alpha'_j)_{N+1,P}\\(b'_j,\beta'_j;B'_j)_{1,M},(b'_j,\beta'_j)_{M+1,Q}\end{matrix}\right.\right]\overline{H}^{m,n}_{p,q}\left[zX^{\rho}\left|\begin{matrix}(a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p}\\(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q}\end{matrix}\right.\right]dx$$

$$=\frac{\sqrt{\pi}}{2b(4ab+c)^{\eta+1/2}}\sum_{k_1=0}^{[L/h_1]}\frac{(-L)_{h_1k_1}A_{L,k_1}}{k_1!}\frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1}}$$

$$\frac{1}{2\pi !}\int_L \bar{\phi}(\xi)\overline{H}^{m+1,n}_{p+1,q+1}\left[z(4ab+c)^{\rho}\left|\begin{matrix}(a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p},(-\eta+\sigma\xi+k_1\delta_1,\rho;1)\\(1/2-\eta+\sigma\xi+k_1\delta_1,\rho;1),(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q}\end{matrix}\right.\right](4ab+c)^{\xi\sigma}\,d\xi \tag{3.3.2}$$

$$\int_0^\infty\left(a+\frac{b}{x^2}\right)X^{-\eta-1}S_L^{h_1}[c_1X^{\delta_1}]\overline{H}^{M,N}_{P,Q}\left[X^{\sigma}\left|\begin{matrix}(a'_j,\alpha'_j;A'_j)_{1,N},(a'_j,\alpha'_j)_{N+1,P}\\(b'_j,\beta'_j;B'_j)_{1,M},(b'_j,\beta'_j)_{M+1,Q}\end{matrix}\right.\right]\overline{H}^{m,n}_{p,q}\left[zX^{\rho}\left|\begin{matrix}(a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p}\\(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q}\end{matrix}\right.\right]dx$$

$$=\frac{\sqrt{\pi}}{(4ab+c)^{\eta+1/2}}\sum_{k_1=0}^{[L/h_1]}\frac{(-L)_{h_1k_1}A_{L,k_1}}{k_1!}\frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1}}$$

$$\frac{1}{2\pi !}\int_L \bar{\phi}(\xi)\overline{H}^{m+1,n}_{p+1,q+1}\left[z(4ab+c)^{\rho}\left|\begin{matrix}(a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p},(-\eta+\sigma\xi+k_1\delta_1,\rho;1)\\(1/2-\eta+\sigma\xi+k_1\delta_1,\rho;1),(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q}\end{matrix}\right.\right](4ab+c)^{\xi\sigma}\,d\xi \tag{3.3.3}$$

The conditions of convergence of (3.3.1), (3.3.2) and (3.3.3) can be easily obtained from those of (2.1), (2.2) and (2.3) respectively.

(3.4) By applying the our results given in (3.3.1), (3.3.2) and (3.3.3) to the case of Hermite polynomials [8] by setting $S_n^2[x]=x^{n/2}H_n\left[\frac{1}{2\sqrt{x}}\right]$ in which $L=n, h_1=2, A_{L,k_1}=(-1)^{k_1}$, we have the following interesting results:

$$\int_0^\infty X^{-\eta-1}\left(c_1X^{\delta_1}\right)^{n/2}H_n\left[\frac{1}{2\sqrt{c_1X^{\delta_1}}}\right]\overline{H}^{M,N}_{P,Q}\left[X^{\sigma}\left|\begin{matrix}(a'_j,\alpha'_j;A'_j)_{1,N},(a'_j,\alpha'_j)_{N+1,P}\\(b'_j,\beta'_j;B'_j)_{1,M},(b'_j,\beta'_j)_{M+1,Q}\end{matrix}\right.\right]\overline{H}^{m,n}_{p,q}\left[zX^{\rho}\left|\begin{matrix}(a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p}\\(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q}\end{matrix}\right.\right]dx$$

$$=\frac{\sqrt{\pi}}{2a(4ab+c)^{\eta+1/2}}\sum_{k_1=0}^{[n/2]}\frac{(-n)_{2k_1}(-1)^{k_1}}{k_1!}\frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1}}$$

$$\frac{1}{2\pi !}\int_L \bar{\phi}(\xi)\overline{H}^{m+1,n}_{p+1,q+1}\left[z(4ab+c)^{\rho}\left|\begin{matrix}(a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p},(-\eta+\sigma\xi+k_1\delta_1,\rho;1)\\(1/2-\eta+\sigma\xi+k_1\delta_1,\rho;1),(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q}\end{matrix}\right.\right](4ab+c)^{\xi\sigma}\,d\xi \tag{3.4.1}$$

$$\int_0^\infty \frac{1}{x^2} X^{-\eta-1}\left(c_1 X^{\delta_1}\right)^{n/2} H_n\left[\frac{1}{2\sqrt{c_1 X^{\delta_1}}}\right] \overline{H}^{M,N}_{P,Q}\left[X^\sigma \left| \begin{matrix} (a'_j,\alpha'_j;A'_j)_{1,N},(a'_j,\alpha'_j)_{N+1,P} \\ (b'_j,\beta'_j;B'_j)_{1,M},(b'_j,\beta'_j)_{M+1,Q} \end{matrix}\right.\right] \overline{H}^{m,n}_{p,q}\left[zX^\rho \left| \begin{matrix} (a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p} \\ (b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q} \end{matrix}\right.\right] dx$$

$$= \frac{\sqrt{\pi}}{2b(4ab+c)^{\eta+1/2}} \sum_{k_1=0}^{[n/2]} \frac{(-n)_{2k_1}(-1)^{k_1}}{k_1!} \frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1}}$$

$$\frac{1}{2\pi!}\int_L \overline{\phi}(\xi) \overline{H}^{m+1,n}_{p+1,q+1}\left[z(4ab+c)^\rho \left| \begin{matrix} (a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p},(-\eta+\sigma\xi+k_1\delta_1,\rho;1) \\ (1/2-\eta+\sigma\xi+k_1\delta_1,\rho;1),(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q} \end{matrix}\right.\right](4ab+c)^{\xi\sigma} d\xi \qquad (3.4.2)$$

$$\int_0^\infty \left(a+\frac{b}{x^2}\right) X^{-\eta-1}\left(c_1 X^{\delta_1}\right)^{n/2} H_n\left[\frac{1}{2\sqrt{c_1 X^{\delta_1}}}\right] \overline{H}^{M,N}_{P,Q}\left[X^\sigma \left| \begin{matrix} (a'_j,\alpha'_j;A'_j)_{1,N},(a'_j,\alpha'_j)_{N+1,P} \\ (b'_j,\beta'_j;B'_j)_{1,M},(b'_j,\beta'_j)_{M+1,Q} \end{matrix}\right.\right]$$

$$\overline{H}^{m,n}_{p,q}\left[zX^\rho \left| \begin{matrix} (a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p} \\ (b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q} \end{matrix}\right.\right] dx$$

$$= \frac{\sqrt{\pi}}{(4ab+c)^{\eta+1/2}} \sum_{k_1=0}^{[n/2]} \frac{(-n)_{2k_1}(-1)^{k_1}}{k_1!} \frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1}}$$

$$\frac{1}{2\pi!}\int_L \overline{\phi}(\xi) \overline{H}^{m+1,n}_{p+1,q+1}\left[z(4ab+c)^\rho \left| \begin{matrix} (a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p},(-\eta+\sigma\xi+k_1\delta_1,\rho;1) \\ (1/2-\eta+\sigma\xi+k_1\delta_1,\rho;1),(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q} \end{matrix}\right.\right](4ab+c)^{\xi\sigma} d\xi \qquad (3.4.3)$$

The conditions of convergence of (3.4.1), (3.4.2) and (3.4.3) can be easily obtained from those of (2.1), (2.2) and (2.3) respectively.

(3.5) By applying the our results given in (3.3.1), (3.3.2) and (3.3.3) to the case of Lagurre polynomials [8] by setting $S_n^1[x] \to L_n^{(\alpha)}[x]$ in which $L=n, h_1=1, A_{L,k_1}=\binom{n+\alpha}{n}\frac{1}{(\alpha+1)_{k_1}}$, we have the following interesting results:

$$\int_0^\infty X^{-\eta-1} L_n^{(\alpha)}\left[c_1 X^{\delta_1}\right] \overline{H}^{M,N}_{P,Q}\left[X^\sigma \left| \begin{matrix} (a'_j,\alpha'_j;A'_j)_{1,N},(a'_j,\alpha'_j)_{N+1,P} \\ (b'_j,\beta'_j;B'_j)_{1,M},(b'_j,\beta'_j)_{M+1,Q} \end{matrix}\right.\right] \overline{H}^{m,n}_{p,q}\left[zX^\rho \left| \begin{matrix} (a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p} \\ (b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q} \end{matrix}\right.\right] dx$$

$$= \frac{\sqrt{\pi}}{2a(4ab+c)^{\eta+1/2}} \sum_{k_1=0}^{[n]} \frac{(-n)_{k_1}}{k_1!} \binom{n+\alpha}{n} \frac{1}{(\alpha+1)_{k_1}} \frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1}}$$

$$\frac{1}{2\pi!}\int_L \overline{\phi}(\xi) \overline{H}^{m+1,n}_{p+1,q+1}\left[z(4ab+c)^\rho \left| \begin{matrix} (a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p},(-\eta+\sigma\xi+k_1\delta_1,\rho;1) \\ (1/2-\eta+\sigma\xi+k_1\delta_1,\rho;1),(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q} \end{matrix}\right.\right](4ab+c)^{\xi\sigma} d\xi \qquad (3.5.1)$$

Notes

Notes

$$\int_0^\infty \frac{1}{x^2} X^{-\eta-1} L_n^{(\alpha)}\left[c_1 X^{\delta_1}\right] \bar{H}_{P,Q}^{M,N}\left[X^\sigma \left| \begin{matrix} (a'_j,\alpha'_j;A'_j)_{1,N},(a'_j,\alpha'_j)_{N+1,P} \\ (b'_j,\beta'_j;B'_j)_{1,M},(b'_j,\beta'_j)_{M+1,Q} \end{matrix}\right.\right] \bar{H}_{p,q}^{m,n}\left[zX^\rho \left| \begin{matrix} (a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p} \\ (b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q} \end{matrix}\right.\right] dx$$

$$= \frac{\sqrt{\pi}}{2b(4ab+c)^{\eta+1/2}} \sum_{k_1=0}^{[n]} \frac{(-n)_{k_1}}{k_1!} \binom{n+\alpha}{n} \frac{1}{(\alpha+1)_{k_1}} \frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1}}$$

$$\frac{1}{2\pi!}\int_L \bar{\phi}(\xi) \bar{H}_{p+1,q+1}^{m+1,n}\left[z(4ab+c)^\rho \left| \begin{matrix} (a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p},(-\eta+\sigma\xi+k_1\delta_1,\rho;1) \\ (1/2-\eta+\sigma\xi+k_1\delta_1,\rho;1),(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q} \end{matrix}\right.\right] (4ab+c)^{\xi\sigma} d\xi \tag{3.5.2}$$

$$\int_0^\infty \left(a+\frac{b}{x^2}\right) X^{-\eta-1} L_n^{(\alpha)}\left[c_1 X^{\delta_1}\right] \bar{H}_{P,Q}^{M,N}\left[X^\sigma \left| \begin{matrix} (a'_j,\alpha'_j;A'_j)_{1,N},(a'_j,\alpha'_j)_{N+1,P} \\ (b'_j,\beta'_j;B'_j)_{1,M},(b'_j,\beta'_j)_{M+1,Q} \end{matrix}\right.\right] \bar{H}_{p,q}^{m,n}\left[zX^\rho \left| \begin{matrix} (a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p} \\ (b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q} \end{matrix}\right.\right] dx$$

$$= \frac{\sqrt{\pi}}{(4ab+c)^{\eta+1/2}} \sum_{k_1=0}^{[n]} \frac{(-n)_{k_1}}{k_1!} \binom{n+\alpha}{n} \frac{1}{(\alpha+1)_{k_1}} \frac{c_1^{k_1}}{(4ab+c)^{k_1\delta_1}}$$

$$\frac{1}{2\pi!}\int_L \bar{\phi}(\xi) \bar{H}_{p+1,q+1}^{m+1,n}\left[z(4ab+c)^\rho \left| \begin{matrix} (a_j,\alpha_j;A_j)_{1,n},(a_j,\alpha_j)_{n+1,p},(-\eta+\sigma\xi+k_1\delta_1,\rho;1) \\ (1/2-\eta+\sigma\xi+k_1\delta_1,\rho;1),(b_j,\beta_j;B_j)_{1,m},(b_j,\beta_j)_{m+1,q} \end{matrix}\right.\right] (4ab+c)^{\xi\sigma} d\xi \tag{3.5.3}$$

The conditions of convergence of (3.5.1), (3.5.2) and (3.5.3) can be easily obtained from those of (2.1), (2.2) and (2.3) respectively.

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Notes