

# Pacific Journal of Mathematics

**NOTE ON A PAPER BY UPPULURI**

A. V. BOYD

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By using the Battacharya bounds for the variance of an unbiased estimator V. R. Rao Uppuluri [1] claims to have established the result

$$\frac{\Gamma(m+1)}{\Gamma(m+\frac{1}{2})} > \left\{ m + \frac{1}{4} + \frac{9}{48m+32} \right\}^{\frac{1}{2}} \quad \text{for } m = 1, 2, 3, \dots,$$

but a numerical calculation easily shows this to be incorrect, e.g. for  $m = 1$ . In fact Watson [2] has shown, by using Gauss' theorem

$$F(a, b; c; 1) = \frac{\Gamma(c)\Gamma(c-a-b)}{\Gamma(c-a)\Gamma(c-b)} \quad \text{for } c > a + b,$$

that

$$\begin{aligned} \frac{\Gamma^2(x+1)}{x\Gamma^2(x+\frac{1}{2})} &= \frac{\Gamma(x)\Gamma(x+1)}{\Gamma^2(x+\frac{1}{2})} \\ &= F(-\frac{1}{2}, -\frac{1}{2}; x; 1) \quad \text{for } x > -1 \\ &= 1 + \frac{1}{4x} + \frac{1}{32x(x+1)} \\ &\quad + \sum_{r=3}^{\infty} \frac{\{-\frac{1}{2} \cdot \frac{1}{2} \cdot \frac{3}{2} \cdots (r-\frac{3}{2})\}^2}{r! x(x+1) \cdots (x+r-1)}. \end{aligned}$$

It follows that

$$\frac{\Gamma^2(x+1)}{\Gamma^2(x+\frac{1}{2})} = x + \frac{1}{4} + \frac{1}{32x+32} + O(x^{-2}) \text{ as } x \rightarrow \infty,$$

so that it is not possible to have

$$\frac{\Gamma(m+1)}{\Gamma(m+\frac{1}{2})} > \left\{ m + \frac{1}{4} + \frac{1}{am+b} \right\}^{\frac{1}{2}}$$

for all positive integers  $m$  if  $a < 32$ .

It also follows that, for  $m = 1, 2, 3, \dots$ ,

$$\begin{aligned} \left\{ m + \frac{1}{4} + \frac{1}{32m+32} \right\}^{\frac{1}{2}} &< \frac{\Gamma(m+1)}{\Gamma(m+\frac{1}{2})} \\ &= (m+\frac{1}{2}) \frac{\Gamma(m+\frac{3}{2})}{\Gamma(m+1)} \\ &< \left\{ \frac{(m+\frac{1}{2})^2}{m+\frac{3}{4} + \frac{1}{32m+48}} \right\}^{\frac{1}{2}}. \end{aligned}$$

## REFERENCES

1. V. R. Rao Uppuluri, *On a stronger version of Wallis' formula*, Pacific J. Math. **19** (1966), 183-187.
2. G. N. Watson, *A note on gamma functions*, Proc. Edinburgh Math. Soc. **11** (1959), Notes, 7-9.

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