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Another attempt at obtaining higher-order terms:

Taking results from last week:

$$f_N(\lambda, D) = \sum_{-\infty}^{\infty} \binom{N}{\alpha N + xD} e^{i\lambda x} \approx (\alpha N)^{-2\alpha N} N^N \sum_{x=-\infty}^{\infty} e^{-\alpha N\left(\frac{xD}{\alpha N}\right)^2} e^{-\frac{\alpha N}{6}\left(\frac{xD}{\alpha N}\right)^4} e^{-\frac{\alpha N}{15}\left(\frac{xD}{\alpha N}\right)^6} \ldots e^{i\lambda x} \quad k = \frac{D^2}{\alpha N}$$

$$\approx (\alpha N)^{-2\alpha N} N^N \int_{-\infty}^{\infty} e^{-\alpha N\left(\frac{xD}{\alpha N}\right)^2} \left(1 - \frac{1}{6}(\alpha N)\left(\frac{D}{\alpha N}\right)^4 x^4 + \ldots\right) e^{i\lambda x} dx$$

$$a = \alpha N \quad b = \frac{D}{\alpha N}$$

$$= \frac{(\alpha N)^{-2\alpha N} N^N}{96 D^6 \sqrt{\frac{N\alpha\lambda^2}{D^2}}} \left[-e^{-\frac{N\alpha\lambda}{4D^2}} \sqrt{\pi}\lambda \left(D^4(12 - 96N\alpha) - 12D^2 N\alpha\lambda^2 + N^2\alpha^2\lambda^4\right) \right]$$

$$\frac{1}{2\pi}\int_{-\pi}^{\pi} \ln\left(f_N(\lambda, D)\right) d\lambda = (difficult)$$