$$M_n = \sum_{j=0}^{n}(n-j+4)\tfrac{4}{\pi}2^{2j}\tfrac{1}{(n-j)!}\left(\tfrac{\pi}{2}\right)^{n-j} < \left(\tfrac{16}{\pi}+\tfrac{1}{2}\right)e^{\pi/8}2^{2n} < 8.3\cdot 2^{2n}$$
$$= \sum_{j=0}^{n}\tfrac{4}{\pi}2^{2j}\tfrac{1}{(n-j)!}\left(\tfrac{\pi}{2}\right)^{n-j} < \tfrac{4}{\pi}e^{\pi/8}2^{2n} < 1.9\cdot 2^{2n}.$$