

$$\Lambda_n^{shallow} = \frac{\pi^2}{\mu^2} \left[ \left( n + \frac{1}{2} \right)^2 + \frac{4 a^2}{3 \pi^2} - (-1)^n \frac{8 a}{\pi^3 (2 n + 1)} \right] + \mathcal{O} \left[ (n + 1/2)^{-2} \right]$$