A Cesàro Average of Hardy-Littlewood numbers

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Let Λ be the von Mangoldt function and (r_{\textit{HL}}(n) = \sum_{m_1 + m_2^2 = n} \Lambda(m_1),) be the counting function for the Hardy-Littlewood numbers. Let N be a sufficiently large integer. We prove that \sum_{n \le N} r_{\textit{HL}}(n) \frac{(1 - n/N)^k}{\Gamma(k + 1)} &= \frac{\pi^{1 / 2}}2 \frac{N^{3 / 2}}{\Gamma(k + 5 / 2)} - \frac 12 \frac{N}{\Gamma(k + 2)} - \frac{\pi^{1 / 2}}2 \sum_{\rho} \frac{\Gamma(\rho)}{\Gamma(k + 3 / 2 + \rho)} N^{1 / 2 + \rho} + 1/2 \sum_{\rho} \frac{\Gamma(\rho)}{\Gamma(k + 1 + \rho)} N^{\rho} + \frac{N^{3 / 4 - k / 2}}{\pi^{k + 1}} \sum_{\ell \ge 1} \frac{J_{k + 3 / 2} (2 \pi \ell N^{1 / 2})}{\ell^{k + 3 / 2}} - \frac{N^{1 / 4 - k / 2}}{\pi^k} \sum_{\rho} \Gamma(\rho) \frac{N^{\rho / 2}}{\pi^\rho} \sum_{\ell \ge 1} \frac{J_{k + 1 / 2 + \rho} (2 \pi \ell N^{1 / 2})} {\ell^{k + 1 / 2 + \rho}} + \Odip{k}{1}. for $k > 1$, where ρ runs over the non-trivial zeros of the Riemann zeta-function $\zeta(s)$ and $J_{\nu} (u)$ denotes the Bessel function of complex order ν and real argument u.

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