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A probabilistic study of the explicit formula

Probabilistic arguments as well as numerical data suggests that for large moduli, the error term in the prime number theorem for arithmetic progressions is much smaller than what GRH predicts. Based on such arguments Montgomery formulated a conjecture which fits the numerical data and which implies several well believed conjectures for primes in arithmetic progressions, such as the Elliot-Halberstam Conjecture and the equidistribution of primes up to x modulo q as soon as x exceeds $q^{1+\epsilon}$. In formulating Montgomery's Conjecture, one should assume that Dirichlet L-functions do not vanish at the central point. We will show how to reformulate the conjecture without this assumption, and show how the modified conjecture implies that almost all Dirichlet L-functions do not vanish at the central point. We will then show that these arguments can be modified to other families of L-functions, and will focus on families of elliptic curve L-functions. In work in progress, our results are that a conjecture analogous to Montgomery's implies that the average analytic rank of the curves in the family is bounded above by $1/2$, and in some cases we can show that exactly half of the curves have algebraic rank 0, and the remaining half have algebraic rank 1.