

# On Value Distribution Theory of Second Order Periodic ODEs, Special Functions and Orthogonal Polynomials

*Dedicated to the memory of Noel Baker, a dear friend.*

Yik-Man Chiang and Mourad E. H. Ismail

*Abstract.* We show that the value distribution (complex oscillation) of solutions of certain periodic second order ordinary differential equations studied by Bank, Laine and Langley is closely related to confluent hypergeometric functions, Bessel functions and Bessel polynomials. As a result, we give a complete characterization of the zero-distribution in the sense of Nevanlinna theory of the solutions for two classes of the ODEs. Our approach uses special functions and their asymptotics. New results concerning finiteness of the number of zeros (finite-zeros) problem of Bessel and Coulomb wave functions with respect to the parameters are also obtained as a consequence. We demonstrate that the problem for the remaining class of ODEs not covered by the above “special function approach” can be described by a classical Heine problem for differential equations that admit polynomial solutions.

## 1 Introduction and Main Results

We consider value distribution problems of the solutions of certain ordinary differential equations of the form

$$(1.1) \quad f''(z) + A(z)f(z) = 0,$$

where

$$(1.2) \quad A(z) = B(e^z), \quad B(\zeta) = \frac{K_0}{\zeta^k} + \dots + K_0 + \dots + K_1 \zeta^l, \quad K_l K_k \neq 0.$$

Such equations always admit entire solutions. We recall that the order of  $f$  is defined by  $\sigma(f) = \limsup_{r \rightarrow \infty} \log \log M(r, f) / \log r$ , where  $M(r, f) = \max_{|z|=r} |f(z)|$  denotes the maximum modulus of  $f$ . The “density” of the zeros of  $f$  is given by  $\lambda(f) = \limsup_{r \rightarrow \infty} \log n(r, f) / \log r$ , known as the exponent of convergence of  $f$ , where  $n(r, f)$  denote the number of the zeros of  $f$  in  $|z| < r$ . It is elementary to use Nevanlinna theory [25, 34] to deduce that any solution  $f$  of (1.1), where  $A(z)$  can

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# Value Distribution Theory 2vol

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