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A perturbative PainlevÃ© approach to nonlinear differential equations

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Abstract

We further improve the PainlevÃ© test so that negative indices (â€œresonancesâ€) can be treated: we demand single valuedness not only for any pole-like expansion as in the usual PainlevÃ© test, but also for every solution close to it, represented as a perturbation series in a small parameter Îµ. Order zero is the usual test. Order one, already treated in a preliminary paper, reduces to a (linear) Fuchs analysis near a regular singularity and allows the introduction of all missing arbitrary coefficients. Higher orders lead to the analysis of a linear, Fuchsian type inhomogeneous equation.

We obtain an infinite sequence of necessary conditions for the absence of movable logarithmic branch points, arising at every integer index, whether positive or negative, and at every order; those arising at negative indices, including -1, are new, while some conditions may not arise before some high perturbation order. We present several illustrative examples.

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We discuss the understanding of negative indices, and conclude that they are indistinguishable from positive indices, just as in the Fuchs theory. In particular, negative indices give rise to doubly infinite Laurent series.

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