

BOUNDARY VALUE PROBLEMS WITH SINGULAR BOUNDARY CONDITIONS

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Abstract. Singular boundary conditions are formulated for non-selfadjoint Sturm-Liouville operators with singularities and turning points. For boundary value problems with singular boundary conditions properties of the spectrum are studied and the completeness of the system of root functions is proved.

AMS Classification: 34B05, 34B24, 34L10, 47E05

1. Introduction. We consider a class of singular differential equations of the form

$$-\frac{d}{dt}\left(p_2(t)\frac{dz}{dt}\right) + p_1(t)z(t) = \lambda p_0(t)z(t), \quad t \in (a, b). \quad (1)$$

Here λ is the spectral parameter, and the complex-valued functions $p_k(t)$ have zeros or/and singularities at the endpoints of the interval (a, b) . More precisely,

$$p_k(t) = (t - a)^{s_{k0}}(b - t)^{s_{kb}}p_{k0}(t),$$

where s_{k0}, s_{kb} are real numbers, $p_{k0}(t) \in C^2[a, b]$, $p_{00}(t)p_{20}(t) \neq 0$, $p_{00}(t)/p_{20}(t) > 0$ for $t \in [a, b]$. Let $s_{200} < s_{000} + 2$, $s_{200} \leq s_{100} + 2$, $m = 0, 1$, i.e. we consider the case of so-called regular singularities. Operators with irregular singularities possess different qualitative properties and require different investigations.

Since the solutions of equation (1) may have singularities at the endpoints of the interval, and since in general the values of the solutions and their derivatives at the endpoints are not defined, an important question is how to introduce singular two-points boundary conditions in the general case under consideration. For some particular cases this problem has been studied in [1]-[6] and other works. For example, in [1] singular boundary conditions were constructed in the case when the endpoints are of *limit-circle* type.

In this paper we provide a general method for defining two-point singular boundary conditions in the above-mentioned general case. In Section 2 we construct singular boundary conditions and formulate the corresponding boundary value problems. In Section 3 properties of the spectrum are studied for boundary value problems with singular boundary conditions. In Section 4 the completeness of the system of eigen- and associated functions (e.a.f.) is proved for this class of boundary value problems.

We mention that the approach presented in this paper can serve as a basis for various investigations connected with the spectral theory of Sturm-Liouville equations and also for higher order differential equations and systems with singular boundary conditions. Further topics connected with problems with singular boundary conditions, like e.g. expansion theorems and inverse spectral problems, will be studied elsewhere.

For simplicity, we confine ourselves here to the case when there are no singularities and turning points *inside* the interval. We note that spectral problems for ordinary differential operators without singularities (or with integrable coefficients) were investigated in many works (see the monographs [7]-[12] and the references given therein). Some aspects of spectral problems for differential equations having singularities and/or turning

Singularities In Boundary Value Problems

Pierre Grisvard

A decorative red circular graphic with a gradient, appearing as a partial arc on the right side of the light blue horizontal bar.

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Singularities in Boundary Value Problems Henri G. Garnir, 1981 *Asymptotic Theory of Dynamic Boundary Value Problems in Irregular Domains* Dmitrii Korikov, Boris Plamenevskii, Oleg Sarafanov, 2021-04-01 This book considers dynamic boundary value problems in domains with singularities of two types The first type consists of edges of various dimensions on the boundary in particular polygons cones lenses polyhedra are domains of this type Singularities of the second type are singularly perturbed edges such as smoothed corners and edges and small holes A domain with singularities of such type depends on a small parameter whereas the boundary of the limit domain as the parameter tends to zero has usual edges i e singularities of the first type In the transition from the limit domain to the perturbed one the boundary near a conical point or an edge becomes smooth isolated singular points become small cavities and so on In an irregular domain with such singularities problems of elastodynamics electrodynamics and some other dynamic problems are discussed The purpose is to describe the asymptotics of solutions near singularities of the boundary The presented results and methods have a wide range of applications in mathematical physics and engineering The book is addressed to specialists in mathematical physics partial differential equations and asymptotic methods **Spectral Problems Associated with Corner Singularities of**

Solutions to Elliptic Equations Vladimir Kozlov, V. G. Maz'ya, Jürgen Rossmann, 2001 This book focuses on the analysis of eigenvalues and eigenfunctions that describe singularities of solutions to elliptic boundary value problems in domains with corners and edges The authors treat both classical problems of mathematical physics and general elliptic boundary value problems The volume is divided into two parts The first is devoted to the power logarithmic singularities of solutions to classical boundary value problems of mathematical physics The second deals with similar singularities for higher order elliptic equations and systems Chapter 1 collects basic facts concerning operator pencils acting in a pair of Hilbert spaces Related properties of ordinary differential equations with constant operator coefficients are discussed and connections with the theory of general elliptic boundary value problems in domains with conic vertices are outlined New results are presented Chapter 2 treats the Laplace operator as a starting point and a model for the subsequent study of angular and conic singularities of solutions Chapter 3 considers the Dirichlet boundary condition beginning with the plane case and turning to the space problems Chapter 4 investigates some mixed boundary conditions The Stokes system is discussed in Chapters 5 and 6 and Chapter 7 concludes with the Dirichlet problem for the polyharmonic operator Chapter 8 studies the Dirichlet problem for general elliptic differential equations of order $2m$ in an angle In Chapter 9 an asymptotic formula for the distribution of eigenvalues of operator pencils corresponding to general elliptic boundary value problems in an angle is obtained Chapters 10 and 11 discuss the Dirichlet problem for elliptic systems of differential equations of order 2 in an n dimensional cone Chapter 12 studies the Neumann problem for general elliptic systems in particular with eigenvalues of the corresponding operator pencil in the strip $\text{mid } \text{Re } \lambda \text{ mid } \text{Im } \lambda \leq 1/2$ It is shown that only integer numbers contained in this strip are eigenvalues Applications are placed within chapter introductions and as special sections at the end of chapters Prerequisites include standard PDE and functional analysis courses

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