BIBLIOGRAPHICAL NOTES

In Chapter 1 statements of many inverse problems are given. In Chapter 2, Sections 2.1–2.3 contain material that can be found in [IVT], [Mor], [MG], [Gro], [VV], [TLY], [R121], [EHN]. There are some new results regarding regularization of unbounded nonlinear ill-posed operator equations, and a new version of the discrepancy principle. In the presentation of the Backus-Gilbert method the rate of convergence of the proposed version of this method is estimated. We did not discuss the optimality of the methods for solving ill-posed problems (see, e.g., [IVT], [EHN]), but argue that a stable solution of an ill-posed problem is not possible without a priori knowledge of the noise level in the data.

Section 2.4 presents the DSM (Dynamical systems method) and is based on papers [R216], [R217], [R218], [R220], [R212], [AR1], [ARS3]. This method was not discussed in the books on ill-posed problems earlier. The author thinks that this method is promising from the computational point of view.

Subsection 2.5.1 is based on [RSm5], where the reader can find many references regarding numerical differentiation of noisy data, see also [RSm3]. Subsection 2.5.2 is based on [R58], [R39].

Sections 3.1–3.11 are based on [R221], [R192], and other author's papers. The author thanks Cubo Mathematical Journal for permission to use paper [R221]. Chapter 3 contains many new results, and the presentation of the classical results contains many novel points, especially in the presentation of Gel'fand-Levitan's (GL) theory and Marchenko's theory. Krein's inversion theory is presented with complete proofs for the first time. Its presentation in Section 3.9, is based on [R197]. The analysis of the invertibility of the inversion steps in the GL's theory and in Marchenko's theory is discussed in detail, which was not done earlier. A detailed analysis of the Newton-Sabatier (NS) theory for inverting fixed-energy phase shifts is given in Section 3.6. This theory was presented in [N], [CS]. Our analysis concludes that the NS inversion theory is fundamentally wrong in the sense that its foundations are wrong. In [Sab] P. Sabatier made an attempt to disagree with the above conclusion but, in fact, failed to address the main point from [R206], namely, that there is no proof that the basic equation in the NS theory (equation (3.6.65) in Section 3.6.4) has a solution for all $r > 0$, and that this solution is unique. It is shown in [R206] (and in Section 3.6) that equation (3.6.65) generically does not have a unique solution for some $r > 0$ and in this case the NS inversion procedure breaks down. In [R207] a counterexample is given to a uniqueness theorem for a modified equation (3.6.65) proposed in [CT]. A reply to [Sab] is given in [R150]. In Section 3.6.5 a result from [RAI] is presented. In Section 3.7 some results from [R196] are presented. In [GS] a different approach to these results is given. In Section 3.8 the problem of finding a confining potential (a quarkonium system) from a few measurements is given. This problem was considered in [TQR], but the approach in [TQR] was not correct by the reasons explained in Section 3.8 (and in [R183]). Section 3.10 contains a solution of some new inverse problems for the heat and wave equations. In Section 3.11 the result from [R191] is presented. In Section 3.12 an inverse problem of ocean acoustics is solved ([R199]), and it is shown that the method used for the study of a related problem in [GX] is invalid. In Section 3.13 a theory of ground-penetrating radars is developed ([R185], [R195], [RSh]). The central role in Chapter 3 plays Property C for ordinary differential equations, a uniqueness theorem for I-function and its numerous applications. The I-function for the class of potentials, used in scattering theory, is equal to the Weyl's m-function, which is in one-to-one correspondence with the spectral function. In [GS] and [GS1] some properties of m-functions are given and their applications to inverse problems are discussed. In [R181], [R184] a uniqueness theorem and a convergent iterative method are given for the recovery of a compactly supported (or decaying faster than any exponential) potential from S-matrix alone, without the knowledge of bound states and norming constants.

Chapter 4 is based on the material in [R83], [R162], [R164], [R171], [R31], [R208], [R75], [R139], [R154], [R155], [R164], [RSa], [RPY], [GR5], [RGu2]. In [BLW], [CK], [CKi], [CCM] various numerical methods for solving inverse obstacle scattering problems are discussed. These methods and other numerical methods are analyzed in Section 4.5–4.6. The novel points in this Chapter include (but not limited to) the consideration of the scattering and inverse scattering problems for very rough boundaries, stability estimates for the solution of the obstacle inverse scattering problems with fixed-frequency data and with high-frequency data, and the analysis of the numerical methods for solving obstacle inverse scattering problems. In [Fed], [VH], [Maz], various classes of rough domains are studied, in particular, the class of domains with finite perimeter, which contains the class of Lipschitz domains as a proper subclass.

The results of Chapter 5 are obtained from a series of the author's papers, and summarized in [R203]. Chapter 5 is based on this paper. The author thanks Birkhäuser for permission to use this paper. The notion of Property C was introduced in [R87] and applied to many inverse problems, for example, [R100], [R102], [R103], [R105], [R109], [R112], [R114], [R115], [R120], [R125], [R126], [RX], [R127], [RSj], [R129], [R130], [R132], [R133], [R143], [R145], [R146], [R149]. Sections 5.7, and 5.8 are based on [R128] and [R124] respectively. Section 5.5 is based on [R172]. The inverse potential scattering problem has been studied in [Fad], [N4], [No], [NK], [No1], [RW1], [RW2], and in other works.

Chapter 6 is based on the papers [R165], [RRa], and uses some material from [R139]. Section 6.4 is based on [Ro1]. The example of non-uniqueness in Section 6.1 shows that the usage of numerical parameter-fitting as a method for solving inverse problems may be meaningless. This is important to have in mind, because many published papers on inverse problems are based on just such parameter-fitting procedures and neglect the analysis of the inverse problem, in particular, the analysis of the uniqueness of the solution to an inverse problem. This analysis is crucial.

Chapter 7 is based on the material from [R139], [R21], [R73]. There is a large body of literature on antenna synthesis, see [MJ], [ZK], [R23], [R26], [R28], [R26], which we had not discussed.

Chapter 8 is based on [R198]. Most of the uniqueness results for multidimensional inverse problems are obtained for overdetermined problems. We formulate several basic non-overdetermined inverse problems which are still open: even uniqueness theorems are not obtained for these problems.

Chapter 9 is based on a series of author's papers, starting with [R68], [R77], and summarized in the monographs [R83]. Our presentation is based on these papers and on the book [R139]. Almost all of the results in this Chapter are from these sources. However, equation (9.1.7) was derived earlier in [LRS], but not studied mathematically there.

Chapter 10 is based on a series of author's papers on wave scattering by small bodies of arbitrary shapes. This is a classical area of research, originated by Lord Rayleigh in 1871, who understood that the main term in the acoustic field, scattered by a small in comparison with the wavelength body is given by a dipole radiation. Lord Rayleigh had published many papers on this subject before his death in 1919. There are hundreds of papers, mostly dealing with applied sciences, which use wave scattering theory by small bodies. However, there were no analytic formulas for calculation of this dipole radiation for bodies of arbitrary shapes. Such formulas were found in [R22], [R25], [R32], and the theory was presented in [R50], [R51] and summarized in [R65]. Our basic results include analytic formulas, which allow one to calculate the capacitances of conductors of arbitrary shapes and the polarizability tensors of homogeneous dielectric bodies of arbitrary shapes with arbitrary accuracy in terms of the geometry of these bodies and their dielectric constant. These formulas allow one to derive an analytic formula for the scattering matrix for electromagnetic wave scattering by small bodies of arbitrary shapes. This formula allows one to solve an inverse problem of radiomeasurements ([R65], [R33]). Section 10.2 deals with waves in a media consisting of many small bodies and is based on [R215]. An interesting book [MK], deals with the wave scattering in a medium consisting of many small particles. There is a large body of literature on wave scattering in random media [Ish]. Section 10.3 is based on [R193], and numerical results obtained by the proposed method are given in [GR1].

Chapter 11 deals with the Pompeiu problem. It is based on papers [R177], [R186]. There are many papers on this problem, see [Z], [BST], [Av], [Ber1], [GaS], [Kob], and references therein.

In the book of relatively small size, like this book, many problems of the theory of inverse problems have not been discussed. A short and incomplete list of these include Carleman estimates and their applications, inverse problems for systems, in particular, for elasticity and Maxwell's equations, control theory methods, integral geometry problems, to say nothing about many concrete inverse problems.

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