Contents

Introduction **1**

1 Preliminaries **8**
1.1 Transmission Tomography . . . 8
1.1.1 Transport Equation . . . 8
1.1.2 Radon transform in two-dimensional space . . . 10
1.1.3 Weighted Radon Transform . . . 13
1.2 Emission Tomography . . . 13
1.2.1 Transport equation with source . . . 13
1.2.2 Attenuated Radon Transform . . . 14
1.2.3 Exponential Radon Transform . . . 15
1.2.4 Simultaneous reconstruction problem . . . 16
1.3 Algebraic Reconstruction Algorithms . . . 17
1.3.1 Projection representation . . . 17

2 Single Photon Emission Tomography **20**
2.1 Introduction . . . 20
2.2 Model description . . . 21
2.2.1 Ballistic and first scattering measurements . . . 21
2.3 Inverse problem . . . 22
2.3.1 Albedo operator . . . 23
2.3.2 Linearized inverse problem . . . 24
2.4 Reconstruction algorithm . . . 25
2.4.1 Linear system and general algorithm . . . 25
2.4.2 Discretization and matrices construction . . . 26
2.5 Numerical experiments . . . 28

3 Light Sheet Fluorescence Microscopy **31**
3.1 Introduction . . . 31
3.2 Mathematical model in LSFM . . . 33
3.2.1 Notation and model scheme . . . 33
3.2.2 Excitation: the Fermi pencil–beam equation . . . 35
3.2.3 Fluorescence: Radiative Transfer Equation . . . 36
3.3 Inverse problem . . . 38
3.3.1 Physical Quantities . . . 38
3.3.2 Admissible domain . . . 38

3.3.3 Measurements and Inverse Problem . . . 40
3.4 Injectivity of the measurement operator . . . 40
3.5 A uniqueness result for the heat equation . . . 42
3.6 Discrete direct and inverse problems . . . 44
3.6.1 Direct model . . . 44
3.6.2 Inverse model . . . 47
3.7 Numerical results . . . 48
3.7.1 Stop criteria . . . 49
3.7.2 Initialization . . . 49

4 Fluorescence Lifetime Imaging and Optical Projection tomography 55
4.1 Introduction . . . 55
4.2 Mathematical model . . . 57
4.3 Inverse problem . . . 58
4.3.1 Linearized inverse problem . . . 59
4.3.2 Piece–wise constant lifetime . . . 62

Conclusion 65

Bibliography 67