

# Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
<b>2</b>	<b>The Basics</b>	<b>5</b>
2.1	The N-body Problem: Introduction and Solver . . . . .	5
2.2	Parallel Programming: Preface and Characteristics . . . . .	10
2.3	High Performance Computing Resources at JSC . . . . .	15
<b>3</b>	<b>PEPC – a State of the Art Parallel BH Tree Code</b>	<b>19</b>
3.1	The Parallel HOT-scheme . . . . .	20
3.1.1	Domain Decomposition . . . . .	23
3.1.2	Combination of Local Trees to a Single Data-Distributed Global Tree	25
3.1.3	Tree Traversal and Force Summation . . . . .	31
3.2	Scaling and Determination of Bottlenecks . . . . .	34
<b>4</b>	<b>Application of the Hilbert-curve to Tree Codes</b>	<b>39</b>
4.1	The Morton-curve . . . . .	42
4.1.1	Inverse Mapping from $mD$ to 1D . . . . .	42
4.1.2	Mapping from 1D to $mD$ . . . . .	44
4.2	The Hilbert-curve . . . . .	44
4.2.1	The Fast $m$ -Dimensional Hilbert Mapping Algorithm . . . . .	46
4.2.1.1	Inverse Mapping from $mD$ to 1D . . . . .	49
4.2.1.2	Mapping from 1D to $mD$ . . . . .	50
4.2.2	Patterns of the Hilbert-curve in 2D . . . . .	51
4.2.3	The Generalized Fast $m$ -Dimensional Hilbert Mapping Algorithm . . . . .	55
4.2.3.1	Definition of a Novel Space-Filling Curve . . . . .	56
4.3	Effects of the Hilbert-Curve in PEPC . . . . .	57
<b>5</b>	<b>Virtual Local Domains</b>	<b>63</b>
5.1	Idea of Virtual Local Domains . . . . .	65
5.2	Application of VLD to the Branching Algorithm . . . . .	69
5.3	The Cross Sum Branch Node Estimator . . . . .	72
5.4	Introduction of a Novel Branching Algorithm . . . . .	77

5.5	Capabilities of Virtual Local Domains . . . . .	78
5.6	Effects of Virtual Local Domains in PEPC . . . . .	79
5.6.1	Number of Global Branch Nodes . . . . .	79
5.6.2	Local Branch Nodes . . . . .	83
5.6.3	Power of the Cross Sum Branch Node Estimator . . . . .	84
5.6.4	Perspective of Virtual Local Domains . . . . .	87
<b>6</b>	<b>Compendium</b>	<b>89</b>
<b>A</b>	<b>Source Code of Selected Algorithms</b>	<b>91</b>
	<b>Bibliography</b>	<b>97</b>