

CONTENTS

PARAXIAL WKB SOLUTION OF A SCALAR WAVE EQUATION

G. V. Pereverzev

Introduction	1
1. Eikonal approximation of the ray method	4
1.1. Wave equation and short-wavelength ordering	4
1.2. Debye asymptotic expansion, eikonal approximation	5
1.3. Ray tracing	5
2. Paraxial WKB approach	6
2.1. Short-wavelength asymptotic expansion . .	6
2.2. Reference ray	10
2.3. Wave-packet description	11
2.4. Paraxial expansion	13
3. Beam tracing	15
3.1. Ray coordinates	15
3.2. First form of the beam-tracing equations .	16
3.3. Second form of the beam-tracing equations	18
3.4. Initial conditions for the beam-tracing equations	19
3.5. Discussion of the beam-tracing equations .	21
4. Equation for the wave amplitude	23
4.1. Solving the transport equation	23
4.2. Accounting for dissipation	25
5. Solution of the wave equation	26
5.1. Partial solution	26
5.2. General solution	28
5.3. Applicability of the paraxial WKB approach	29

5.4.	Example of a pWKB solution	31
6.	Conclusions	36
Appendices	37
A.	Geometric properties of ray trajectories	37
A.1.	The Fermat principle for Eq. (1.1)	37
A.2.	Rays as geodesics in a Riemannian space	40
B.	Tensor form of the beam-tracing equations	43
B.1.	Ray coordinates	44
B.2.	Derivation of the beam-tracing equations	45
B.3.	Initial conditions	47
B.4.	Metric properties of the ray coordinates	48

MULTIPLE-MIRROR PLASMA CONFINEMENT

V. V. Mirnov and A. J. Lichtenberg

Introduction	53
1.	Qualitative consideration of multiple-mirror effects	59
2.	Plasma flow in a magnetic field with small-scale corrugation	68
2.1.	Derivation of the macroscopic equation	69
2.2.	Calculation of the distribution function correction	75
2.3.	Analysis of the macroscopic equations	79
2.4.	Plasma diffusion along a weakly corrugated magnetic field with small-scale corrugation	84
3.	Plasma dynamics with large-scale corrugation	89
3.1.	The description of plasma motion with two-fluid gas dynamic equations	90
3.2.	The intermediate regime in a multiple-mirror field with “point” mirrors	94
3.3.	The “plateau” regime of plasma motion in a weakly corrugated magnetic field	101

3.4.	The effect of heavy impurities on plasma multiple-mirror confinement	105
4.	Multiple-mirror reactor concepts	108
4.1.	Optimization of the axial confinement of a pulsed reactor	109
4.2.	The complete pulsed reactor concept	113
4.3.	Optimization of the axial confinement of a steady-state reactor	117
4.4.	Steady-state multiple-mirror reactor	122
5.	Experimental evidence of the multiple-mirror confinement	127
6.	Summary and discussion	133
References	140

PLASMA ROTATION IN TOKAMAKS

V. Rozhansky and M. Tendler

Introduction	147
1.	Momentum balance	151
1.1.	Plasma flows within a magnetic surface. The interrelation between the poloidal and the toroidal rotations	151
1.2.	Flux surface average momentum balance	158
2.	Drift kinetic equation	164
2.1.	Distribution function in the plateau regime	164
2.2.	Regimes with fast poloidal rotation ($ V_\theta \geq \Theta C_S$)	168
2.3.	Regimes with fast toroidal rotation	174
3.	The ontogeny of the poloidal and the toroidal rotations	179
3.1.	Linear relaxation	179
3.2.	Distinctive features of the theory in the banana regime	181
3.3.	Nonlinear effects resulting from fast rotations	184

4.	Fast poloidal rotation and L–H transitions	187
4.1.	Suppression of turbulence by a shear of the poloidal rotation	187
4.2.	Anomalous transport and steep radial profiles of the poloidal rotation velocity in edge plasmas	193
4.3.	The electric field at the separatrix	197
4.4.	Radial current in experiments with a biased electrode	200
4.5.	Comparison with experiments	206
5.	The effect of rotation on impurity transport . . .	211
5.1.	Poloidal perturbation of the impurity densities and their fluxes within a magnetic surface	211
5.2.	Radial transport of impurities	216
6.	Plasma rotation and flows within the scrape-off layer	218
6.1.	Convection within the SOL in a tokamak with a poloidal limiter	218
6.2.	Flows within the SOL in a tokamak with a divertor	224
6.3.	The impact of the biasing radial electric field on parameters of the SOL	231
	Conclusions	240
	Appendices	245
	A.1.	245
	A.2.	246
	References	249