## THE PHYSICS OF LASER PLASMA INTERACTIONS



ABP

William L. Kruer

## **Contents**

1.	Basic Concepts and Two-Fluid Description of Plasmas			
	1.1 Basic Plasma Concepts	2		
	1.2 The Vlasov Equation	5		
	1.3 The Moment Equations	6		
	1.4 The Two-Fluid Description of Plasma	10		
	1.5 Plasma Waves	11		
	1.6 Debye Shielding	14		
2.	Computer Simulation of Plasmas Using Particle Codes			
	2.1 Basic Ingredients of a Particle Code	19		
	2.2 A 1-D Electrostatic Particle Code	21		

3.	Ele	ectromagnetic Wave Propagation in Plasmas		
	3.1	Wave Equation for Light Waves in a Plasma	27	
	3.2	WKB Solution for Wave Propagation in an Inhomogeneous Plasma	30	
	3.3	Analytic Solution for Plasma with a Constant Density Gradient	32	
4. Propagation of Obliquely Incident Light Wain Inhomogeneous Plasmas				
	4.1	Obliquely Incident S-polarized Light Waves	38	
	4.2	Obliquely Incident P-polarized Light Waves  — Resonance Absorption	39	
5. Collisional Absorption of Electromagnetic Waves in Plasmas				
	5.1	Collisional Damping of Light Waves	46	
	5.2	Collisional Damping of a Light Wave in an Inhomogeneous Plasma	48	
	5.3	Collisional Absorption Including Oblique Incidence and a Density Dependent Collision Frequency	51	
	5.4	Derivation of the Damping Coefficient	52	
6.	Parametric Excitation of Electron and Ion Waves			
	6.1	Coupling via Ion Density Fluctuations	58	
	6.2	The Ponderomotive Force	60	
	6.3	Instabilities — A Physical Picture	61	
	6.4	Instability Analysis	62	
	6.5	Dispersion Relation	66	
		Instability Threshold due to Spatial Inhomogeneity	69	
	6.7	Effect of Incoherence in the Pump Wave	70	

7.	Stii	nulated Raman Scattering	
	7.1	Instability Analysis	74
	7.2	Dispersion Relation	77
	7.3	Instability Thresholds	79
	7.4	The $2\omega_{ m pe}$ Instability	81
8.	Stir	nulated Brillouin Scattering	
	8.1	Instability Analysis	88
	8.2	Dispersion Relation	90
	8.3	Instability Thresholds	91
	8.4	The Filamentation Instability	93
9.	Hea	ating by Plasma Waves	
	9.1	Collisional Damping	96
	9.2	Landau Damping	96
	9.3	Linear Theory Limitations — Trapping	100
	9.4	Wavebreaking of Electron Plasma Waves	101
	9.5	Electron Heating by the Oscillating-Two-Stream and Ion Acoustic Decay Instabilities	104
	9.6	Plasma Wave Collapse	108
l <b>0.</b>	Dei	nsity Profile Modification	-
	10.1	Freely Expanding Plasma	116
	10.2	Steepening of the Density Profile	117
	10.3	Resonance Absorption with Density Profile Modification	121

11.	Nonlinear Features of Underdense Plasma Instabilities			
	11.1	Nonlinear features of Brillouin Scattering	127	
	11.2	Nonlinear Features of Raman Scattering	132	
		Nonlinear Features of the Two-Plasmon Decay and Filamentation Instabilities	135	
12.	Electron Energy Transport			
	12.1	Electron Thermal Conductivity	144	
	12.2	Multigroup Flux-Limited Diffusion	146	
	12.3	Other Influences on Electron Heat Transport	147	
	12.4	Heat Transport in Laser-Irradiated Targets	149	
13.	Laser Plasma Experiments			
	13.1	Density Profile Steepening	155	
	13.2	Absorption of Intense, Short Pulse-Length Light	156	
	13.3	Heated Electron Temperatures	158	
	13.4	Brillouin Scattering	160	
	13.5	Raman Scattering	162	
	13.6	Other Plasma Processes	167	
	13.7	Wavelength Scaling of Laser Plasma Coupling	168	