

Contents

Preface	XIII
1. Elementary properties of a plasma	1
Introduction — Plasma — Equations of drift motion — Isothermal atmosphere in equilibrium — Types of wave — Effect of collisions — The continuity equations.	
2. Maxwell's equations	11
Introduction — Equations in terms of current and charge densities — Equations in terms of electric moment per unit volume — The exponential wave function — The concept of a dispersion relation — Calculation of the dispersion relation (electric current method) — Calculation of the dispersion relation (electric moment method).	
3. Isotropic plasma	23
Introduction — Mobility and conductivity of an isotropic plasma — Susceptibility and dielectric constant of a collisionless isotropic plasma — The plasma frequency — Refractive index of a collisionless isotropic plasma — Wave dispersion in a collisionless isotropic plasma — Effect of collisions in an isotropic plasma — Importance of ordered kinetic energy in a plasma — Poynting's theorem in a plasma — The energy significance of the complex dielectric constant of an isotropic plasma.	
4. Alternating current in a magnetoplasma	39
Introduction — Mobility tensor for a magnetoplasma — Conductivity tensor for a magnetoplasma — Low-frequency conduction properties of an infinite homogenous magnetoplasma — Low-frequency conduction properties of a slab of magnetoplasma — Effect of plasma scale on wave propagation.	
5. General properties of phase propagation in a magnetoplasma	51
Introduction — Susceptibility tensor for a magnetoplasma — Alternative	

expressions for the susceptibility tensor components in the absence of multiple ion species – Dispersion relation for a magnetoplasma – Elliptic polarization – Alternative derivation of the dispersion relation for a magnetoplasma – The radio and hydromagnetic approximations – Effect of collisions in a magnetoplasma.	
6. General properties of group propagation in a magnetoplasma	67
Introduction – Frequency and angular spectra – Velocity of a wave packet – Relation between phase and group propagation – Method for calculating group velocity in a magnetoplasma – Formulae for group velocity in a magnetoplasma – Beam radiation in a magnetoplasma.	
7. Propagation of phase along the imposed magnetic field	77
Introduction – Circular polarization – The dispersion relation for longitudinal propagation – Longitudinal Alfvén waves – The violin-string approach to longitudinal Alfvén waves – The hydromagnetic approximation for longitudinal propagation – The radio approximation for longitudinal propagation – The Eckersley approximation for longitudinal propagation – Comparison of approximations – Pass and stop bands of frequency for longitudinal propagation – Particle vibration for longitudinal propagation – Plasma motion in a longitudinal Alfvén wave – Longitudinal propagation in low-density and high-density magnetoplasmas – Effect of collisions on longitudinal propagation – Effect of an additional ion species on longitudinal propagation – Pass and stop bands of ionization density for longitudinal propagation.	
8. Energy flow and group velocity for longitudinal propagation	103
Introduction – Electromagnetic energy density for longitudinal propagation – Kinetic energy density for longitudinal propagation – Energy flow and group velocity for longitudinal propagation – Energy in a longitudinal Alfvén wave – Faraday rotation for longitudinal Alfvén waves – A resonator for longitudinal Alfvén waves – The mode of operation of a hydromagnetic violin-string – Freezing of the magnetic field in the plasma (longitudinal Alfvén waves) – Energy in a longitudinal whistler wave in the band $\omega_{Mi} \ll \omega \ll \omega_{Me}$ – A resonator for longitudinal whistler waves in the band $\omega_{Mi} \ll \omega \ll \omega_{Me}$ – Freezing of the magnetic field in the electron gas (longitudinal whistler wave) – Solid-state plasmas.	
9. Propagation of phase transverse to the imposed magnetic field	123
Introduction – The O wave – The X wave – Superposition of the O and X waves – Pass and stop bands of frequency for transverse propagation – The hybrid resonant frequencies – Transverse propagation in a low-	

density magnetoplasma – Pass and stop bands of ionization density for transverse propagation – Effect of collisions on transverse propagation.	
10. Elliptic polarization of the X wave for transverse propagation	139
Introduction – The electric ellipse for transverse propagation of the X wave – Frequency dependence of the electric ellipse – Particle vibration for transverse propagation of the X wave – Plasma compressions and dilations for transverse propagation of the X wave – Non-reciprocity.	
11. Energy behaviour of the X wave for transverse propagation	151
Introduction – Electromagnetic energy density for transverse propagation of the X wave – Kinetic energy density for transverse propagation of the X wave – Energy flow and group velocity for transverse propagation of the X wave – A resonator for transverse Alfvén waves – The mode of operation of a hydromagnetic organ-pipe – Freezing of the magnetic field in the plasma (transverse Alfvén waves).	
12. Propagation at any angle to the imposed magnetic field.	161
Introduction – The zeros in the frequency dispersion curves – Nomenclature for the characteristic waves – The cross-connection phenomenon for frequency dispersion curves – Frequency dispersion curves for nearly transverse propagation – Frequency dispersion curves for nearly longitudinal propagation – The elliptic polarizations of the O and X waves at the plasma frequency – Effect of an additional ion species on cross-connection phenomena – The infinities in the frequency dispersion curves – Permitted regions for the frequency dispersion curves – The cross-connection phenomenon for ionization dispersion curves – Permitted regions for the ionization dispersion curves – Propagation into a magnetoplasma from free space.	
13. The radio approximation	191
Introduction – The radio approximation to the dispersion relation – Frequency dispersion curves in the radio band – Frequency dependence of elliptic polarization in the radio band – Frequency dependence of the direction of group propagation in the radio band – Variation in the angle of squint of a rotating broadside antenna in the radio band – Dependence of refractive index on ionization density in the radio band – Dependence of elliptic polarization on ionization density in the radio band – Dependence of the direction of group propagation on ionization density in the radio band.	
14. The hydromagnetic approximation	213
Introduction – The hydromagnetic approximation to the dispersion	

relation – Frequency dispersion curves in the hydromagnetic band – Effect of ionic collisions in the hydromagnetic band – The fit between the hydromagnetic and radio approximations – Frequency dependence of elliptic polarization in the hydromagnetic band – Frequency dependence of the tilts of the electronic and current ellipses in the hydromagnetic band – Frequency dependence of the direction of group propagation in the hydromagnetic band – Polar diagrams for group velocity in the hydromagnetic band – Dependence of refractive index on ionization density in the hydromagnetic band – Dependence of elliptic polarization on ionization density in the hydromagnetic band – Dependence of the direction of group propagation on ionization density in the hydromagnetic band.	
15. The quasi-longitudinal and quasi-transverse approximations	243
Introduction – The transition angle between the quasi-longitudinal and quasi-transverse approximations – The regions of validity for the first-order angular approximations – Importance of avoiding angular approximations that upset an infinity of a refractive index – The regions of validity for angular approximations of practical value – Accuracy of $\partial^2 n / \partial \theta_p^2$ using angular approximations – The quasi-transverse approximation when $\omega \ll \omega_{Mi}$ – The quasi-longitudinal approximation when $\omega \gg \text{Max}(\omega_N, \omega_{Me})$ – The quasi-longitudinal approximation when $\omega_{Mi} \ll \omega < \omega_{Me} \ll \omega_N$ – Group propagation for the whistler wave when $\omega_{\infty 1} \ll \omega < \omega_{Me} \ll \omega_N$ – Comparison of the zero-order quasi-longitudinal approximation in the whistler band with the unapproximated formulae.	
16. Directional behaviour of group velocity in a magnetoplasma	265
Introduction – Group propagation of the X wave in the pass band $\omega > \omega_{C2}$ – Group propagation of the O wave in the pass band $\omega > \omega_N$ – Group propagation in the upper part of the whistler band [$\omega_{\infty 1} < \omega < \text{Min}(\omega_N, \omega_{Me})$] – Group propagation in the lower part of the whistler band ($\omega \leq \omega_{\infty 1}$) – Group propagation of the O wave in the pass band $\omega < \omega_{Mi}$ – Group propagation of the X wave in the pass band $\omega_{C1} < \omega < \omega_{\infty 2}$ when $\omega_N > \omega_{Me}$ – Group propagation of the X wave in the pass band $\omega_{C1} < \omega < \omega_{\infty 2}$ when $\omega_N < \omega_{Me}$.	
17. The field of an antenna in a magnetoplasma	283
Introduction – Axes of coordinates – Angular spectra of O and X waves – The predominant directions of group and phase propagation in the far field – The method of steepest descent – Simplification of the notation – The power density in the far field – Use of the angle of phase propagation as an independent variable – Radiation from a gaussian dipole in a homogeneous magnetoplasma – A reference isotropic medium – Radiation resistance for a gaussian dipole in a homogeneous magnetoplasma.	
18. Directional behaviour of the power radiated by a dipole in a magnetoplasma	303
Introduction – Specification of the magnetoplasma and the radiator – Radiation in the frequency band $\omega > \omega_{C2}$ – Radiation in the frequency band $\omega_{C2} > \omega > \omega_{\infty 2}$ – Radiation in the frequency band $\omega_{\infty 2} > \omega > \omega_N$ – Radiation in the frequency band $\omega_N > \omega > \omega_{C1}$ – Radiation in the frequency band $\omega_{Me} > \omega > \omega_{\infty 1}$ – Radiation in the frequency band $\omega_{\infty 1} > \omega > \omega_{Mi}$ – Radiation in the frequency band $\omega < \omega_{Mi}$ – Frequency dependence of radiation resistance – The relation between beaming and guidance in a homogeneous magnetoplasma – The relation between beaming and guidance for the whistler wave when $\omega_{\infty 1} < \omega \ll \text{Min}(\omega_N, \omega_{Me})$ – The relation between beaming and guidance for the O wave when $\omega \ll \omega_{Mi}$ – The relation between beaming and guidance for the combined O and X waves when $\omega \ll \omega_{Mi}$ – Effect of energy absorption on Alfvén guidance.	
Symbols	340
Index of subjects	345