



# CONTENTS

## Neutral Current Sheets in Plasmas in Space and in the Laboratory

S. I. Syrovatskii

1. Introduction	1
2. Production of a Quasisteady Neutral Sheet	2
3. The Neutral Sheet or Petschek Flow? . . .	5
4. Decrease in the Plasma Density near a Neutral Sheet	6
5. Stability of a Neutral Sheet	8
Literature Cited	10

## Hydrodynamic Plasma Flow in a Strong Magnetic Field

B. V. Somov and S. I. Syrovatskii

Introduction	13
Chapter I. Hydrodynamic Plasma Flow in a Strong Magnetic Field in the Absence of Null Lines	17
1. Existence of Continuous Plane (Two-Dimensional) Plasma Flows in a Strong Frozen-in Magnetic Field	17
A. Formalism of Two-Dimensional MHD Problems	17
B. Existence of Continuous Solutions	19
C. Plasma Motion in the Field of a Plane Magnetic Dipole Which Varies with the Time	21
2. Continuous Plasma Flows in a Strong, Poloidal, Axisymmetric Magnetic Field	23
A. General Formulation of the Problem	23
B. Case of a Dipole Magnetic Field	25
3. Plowing of the Interstellar Medium by the Magnetic Field of an Expanding Envelope	27
A. Observation of Gaseous Condensations in the Envelopes of Novae	27
B. Theoretical Models	28
C. Raking of the Interstellar Plasma by the Magnetic Field of the Expanding Envelope	29
4. Magnetic Raking of Plasma as a Possible Mechanism for the Formation of Certain Types of Solar Prominences	32
A. Observations and Classification of Solar Prominences	33
B. Theoretical Models for Surges	33
C. Magnetic Raking as a Mechanism for Surges	34

Chapter II. Appearance of a (Neutral) Current Sheet during Plasma Motion in the Field of a Plane Magnetic Dipole	37
1. Condition for the Absence of Continuous Two-Dimensional Plasma Flows with a Strong Frozen-in Magnetic Field; Appearance of a Current Sheet	37
2. Problem of the Appearance of a Current Sheet as a Plasma Moves in the Field of a Plane Magnetic Dipole	38
A. Possible Applications of the Problem	38
B. Formulation of the Problem. Field in the Absence of a Plasma.	39
C. Solution with a Current Sheet	41
D. Discussion	45
3. Some Comments Regarding Two-Dimensional Models of the Magnetosphere	46
4. Magnetic Field of a Contracting Plasma Cylinder	49
A. Magnetic Field Configuration in the Absence of a Plasma	49
B. Formulation and Solution of the Problem with a Current Sheet	51
5. Three-Dimensional Problems with a Current Sheet	52
Chapter III. Hydrodynamic Plasma Flow near a Current Sheet	54
1. General Formulation of the Problem	55
2. Hydrodynamic Plasma Flow near a Developing Current Sheet	58
A. Asymptotic Properties of the Solution	60
B. Results of Numerical Calculation	61
3. Hydrodynamic Plasma Flow near a Steady-State Current Sheet	64
4. Discussion of Results	66
Literature Cited	69
Numerical Integration of the MHD Equations near a Magnetic Null Line N. I. Gerlakh and S. I. Syrovatskii	
1. Equations for Two-Dimensional Flow	74
2. Small-Amplitude Waves	75
3. Numerical Integration	76
4. Calculated Results and Discussion	77
Literature Cited	85
Kinetics of a Neutral Current Sheet S. V. Bulanov and S. I. Syrovatskii	
Introduction	87
1. Equilibrium State	88
2. Stability of a Neutral Current Sheet	89
3. Simple Models for Charged-Particle Acceleration at Neutral Current Sheets	100
4. Model for the Decay of a Current Sheet	103
Literature Cited	105
Experimental Study of the Conditions for the Appearance of a Neutral Current Sheet in a Plasma: Some Characteristics of the Sheet A. G. Frank	
Introduction. . . . .	107
Chapter I. Events which Occur as a Plasma Moves in a Magnetic Field with a Null Line. . . . .	109

1. Magnetic Null Lines	109
2. Steady-State Models for the Conversion of Magnetic Energy into Plasma Energy near Null Lines	110
3. Plasma Motion near a Magnetic Null Line in the MHD Approximation	112
4. Formation of a Current Sheet as the Result of a Two-Dimensional Plasma Flow near a Magnetic Null Line	114
5. Effect of the Finite Plasma Conductivity on the Formation of a Neutral Current Sheet	117
Chapter II. Experimental Apparatus for Studying the Formation of a Current Sheet near a Magnetic Null Line	120
1. Basic Requirements Which Must be Met by the Experimental Apparatus	120
2. System for Producing a Magnetic Field with a Null Line	121
3. Plasma Injection into a Magnetic Field with a Null Line	123
4. System for Producing the Induction Electric Field $E_z$ along the Magnetic Null Line	126
Chapter III. Current Profile near a Magnetic Null Line; Turbulent Plasma Resistance	129
1. Measurements of the Total Current and the Resistance of a Plasma in a Magnetic Field with a Null Line	129
2. Measurements of the Current Profile in a Plasma in a Magnetic Field with a Null Line	131
3. Measurements of the Current Distribution in a Magnetic Field with a Null Line in a Plasma with a Density $n \lesssim 10^{13} \text{ cm}^{-3}$ ; Possible Ways to Produce a Neutral Current Sheet	134
Chapter IV. $\odot$ Discharge in a Quadrupole Magnetic Field as a Method for Producing a Dense Plasma	136
1. Influence of the Quadrupole Magnetic Field on Gas Breakdown in the Electric Field of a $\odot$ Discharge	137
2. Experiments on Gas Breakdown in a Quadrupole Field	139
Chapter V. Development of a Neutral Current Sheet in a Magnetic Field with a Null Line in a Plasma with a Density $n \geq 2 \cdot 10^{14} \text{ cm}^{-3}$	142
1. Measurement of the Total Plasma Current and the Resistance. Inductance of the Plasma Circuit as a Factor Limiting the Current	142
2. Properties of a Fast Magnetosonic Wave Converging on a Magnetic Null Line	144
3. Development of a Current Sheet near a Magnetic Null Line	149
4. Production of a Neutral Current Sheet	153
5. Discussion of Experimental Results and Comparison with Theory	157
Summary	158
Literature Cited.	160