

JOURNAL  
OF THE  
RADIO RESEARCH LABORATORIES

UDC 551.510.535

A THEORETICAL STUDY OF THE DYNAMICAL STRUCTURE  
OF THE IONOSPHERE

By

Tatsuo SHIMAZAKI

---

**MARCH 1959**

---

**CONTENTS**

Abstract .....	109
Chapter I General Introduction.....	113
Chapter II Chapman's Theory of the Production of an Ionized Layer and Its Reformation .....	116
2. 1 Chapman's function and the distribution of electron density .....	116
2. 2 Physical state of the upper atmosphere .....	118
2. 3 Reformation of the Chapman theory.....	121
2. 3. 1 Electron production rate in the atmosphere with variable scale height .....	122
2. 3. 2 Non-uniform decay coefficient .....	125
2. 3. 3 Small changes in electron density distribution due to small verti- cal motions .....	126
Chapter III Motion of the Ionized Medium in the High Atmosphere.....	128
3. 1 Motion of expansion and contraction due to temperature variations.....	128
3. 2 Tidal motions in the ionosphere.....	130
3. 2. 1 $S_q$ current system and the dynamo region .....	130
3. 2. 2 Non-uniform vertical drift motions .....	133
3. 3 Non-recurrent vertical motions in the ionosphere.....	137
3. 4 Ambipolar diffusion in regions above 300 km .....	140
3. 4. 1 Introduction.....	140
3. 4. 2 General formulation of diffusion velocity and its divergence of ionized medium in the upper atmosphere with variable scale height .....	140

3. 4. 3	Some considerations of special cases of electron density distribution .....	142
3. 4. 4	Application to some cases of practical interest .....	148
Appendix to Chapter III	Some detailed calculations of electron density distribution under the influences of electron-ion diffusion .....	153
Chapter IV	Mathematical Formulation of the Method of Calculating Daily variations in the Ionosphere .....	158
4. 1	Differential equation of continuity .....	158
4. 2	Case of recurrent motions .....	159
4. 3	Case of non-recurrent motions .....	161
Chapter V	Observed World-Wide Variations in the Ionosphere.....	164
5. 1	Some evidences of the combined effect of temperature and tidal variations .....	164
5. 1. 1	Meridional distribution of the minimum virtual height of the $F2$ layer .....	164
5. 1. 2	Observed variations of $f_0E$ and $f_0F1$ with the solar zenith distance... ..	176
5. 2	World-wide daily variations in the $F2$ layer .....	177
5. 2. 1	Maximum electron density .....	177
5. 2. 2	Height of the maximum electron density .....	182
Appendix to Chapter V	Relation of $h_pF2$ to $(M3000)F2$ .....	186
(a)	Theoretical consideration.....	186
(b)	Comparison with observational data .....	189
Chapter VI	Dynamical Structure of the $F2$ Layer .....	197
6. 1	Introduction .....	197
6. 2	Ionospheric model of the $F2$ layer.....	197
6. 3	Effect of motions on the daily variations in the $F2$ layer .....	201
6. 3. 1	Effect of temperature variations .....	202
(a)	Effect of spatial variations.....	202
(b)	Effect of temporal variations .....	205
6. 3. 2	Effect of non-uniform vertical tidal drift motions .....	208
(a)	Effect of semi-diurnal motions .....	209
(b)	Effect of diurnal motions .....	214
Chapter VII	Detailed Structure of the $E$ and $F1$ Layers .....	217
7. 1	Introduction .....	217
7. 2	Theoretical consideration on the relationship between the critical frequency and the solar zenith distance .....	217
7. 3	Observed non-Chapmanlike variations in the $E$ and $F1$ layers.....	218
7. 3. 1	Equinoxes .....	218
7. 3. 2	Solstices .....	224
7. 4	Interpretation of the observed non-Chapmanlike variations .....	229
7. 4. 1	$F1$ layer .....	229
7. 4. 2	$E$ layer (Effect of the $S_q$ current system).....	230
Chapter VIII	Summary and Conclusions .....	235
Acknowledgments	.....	238
References	.....	239