state arising due to preponderance of various modes under different conditions, in which the energy supply to a plasma may be in harmony with energy dissipation from it. An extensive study of linear and nonlinear theories of these instabilities is important from the point of view of not only gaining a clear understanding of the basic behaviour of plasma instabilities, but also of applying the results in understanding of detailed structures of the irregularities observed.

Our principal objective is to study the generation mechanisms of the irregularities which can satisfactorily explain some of their important basic characteristics observed during both day and night time in the E- and F-regions of the equatorial ionosphere. With the advent of backscatter radar and in-situ rocket and satellite measurements, the irregularities with various properties have been observed over a wide range of wavelengths. Based on their spectral characteristics, their spatial extents and the existing conditions in the ionosphere, the electrojet (E-region) irregularities are distinctly classified as (1) Type I or Types Ms and Ss and (2) Type II or Types Mb and Sc irregularities. The equatorial F-region irregularities which are observed at night only, show wavelike structures with scale sizes ranging from a few meters to a few kms or even more.

The author has studied mainly three kinds of low frequency electrostatic instabilities, namely (i) Cross-Field or Gradient-Drift, (ii) Two-Stream and (iii) Gravitation-induced Rayleigh-Taylor instabilities. The investigation of these instabilities will, however, be restricted to the weakly nonlinear limit in
which case the amplitude of perturbation is sufficiently small and therefore, it does not deal with very large amplitude perturbations.

The first chapter contains a preliminary introduction to the ionospheric plasma and a summary of the related experimental observations of the irregularities in the equatorial E- and F-regions. This also includes a brief description of the specific physical mechanisms of the instabilities concerned, in terms of basic plasma physics concepts. The chapter is concluded with the motivation of the studies made in the thesis.

The second chapter deals with the investigation of the Cross-field (E x B) instability which is believed to be the potential candidate as the source of the Types II, Mc and Sc irregularities occurring in the E-region. This work is, however, confined mainly to the linear treatment of the theory. This study was, in fact, completed a long time ago with a primary objective to consider, for the first time, the effects of both the primary horizontal and vertical polarization electric fields, together (through a relation valid for equatorial ionosphere) which were not taken into account by any earlier workers. Furthermore, the treatment of the theory developed here, is more general because it includes the propagation of the waves along vertical direction also.

The dependence of growth rate and scale size on the variation in the horizontal electric field, background electron density and background density gradient is investigated further. The author also discusses the importance of vertical polarization
Low frequency incompressible waves in the equatorial F-region, which seem to be responsible for equatorial spread-F, are studied in Chapter IV. In this chapter, the author has made an investigation of the nonlinear evolution of the gravitation-induced Rayleigh-Taylor (R-T) instability which may be one of the possible mechanisms for the generation of spread-F irregularities. Following the method similar to one that is described in Chapter III and retaining the complete ion inertial term, ion neutral collisions, and ion finite Larmor radius corrections, we have looked for stabilization mechanism for R-T nodes.

The linear theory is first briefly outlined in this chapter and the linear results are then compared with those obtained by earlier workers. The existence of coherent, weakly nonlinear, almost sinusoidal stationary solutions to the nonlinear equations describing R-T nodes, the shapes in which these nodes would travel in the F-region and the physical conditions satisfied by such nonlinear nodes are discussed further in detail. The theoretical results in this chapter are then finally compared with the observations of equatorial spread-F irregularities in the ionosphere.

The last chapter presents a synoptic view of the whole work along with a short investigation of how the instability mechanisms described here, can support the formation of equatorial sporadic-E (E_{sq}) and spread-F, the disappearance of E_{sq} and its correlation with electrojet. The limitations of these investigations and the
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Scope for further work are pointed out towards the end of the thesis.

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