CHAPTER IX

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Concluding Remarks

Weather has affected man in most of his activities. In every part of the world, the weather patterns have determined the traditional patterns of food, clothing, housing, agriculture, social festivals, etc. The results of some of the worst wars in the world have been significantly affected by the weather (Neumann (1975)). The D-day operations during world war II definitely influenced the course of the war. Naturally, man has always liked to know how the weather will change in course of a few hours, a few days, a few months and a few years ahead. In ancient literature we have the evidence that atleast 3000 years BC, the Rig Veda of India contains several references to the seasons of northwest India including the arrival and withdrawal of the monsoons. In the Yajurveda of India, there are references to different types of rainfall. Recorded history gives how even the knowledge of local land sea breeze saved Greece from a disastrous defeat at the hands of the invading Persian Navy of King Xerxes in 480 BC (Neumann (1975)).

Figure 9.1 Shear instabilities in Sea straits

The monsoon winds are utilized by the commercial sailors of ancient India, China, Arabia and Egypt for steering their ships on high seas. More recently, questions are even being asked; 'Is the whole pattern of climate on the earth changing? Is man's activity responsible for the anomalies of weather which we are witnessing? Can we do something about it?'. To answer these questions, for an accurate weather prediction and for explaining many astronomical observations, it is essential to study the stability of flows in the atmosphere. Especially the real atmosphere has horizontal as well as vertical wind shears. Natural forces operating in the atmosphere tend to create these horizontal and vertical wind shears. It is, however, seen that when these wind shears exceed certain critical values, then the equilibrium configuration of the atmosphere in motion breaks down; The meteorologists recognized significant role of shear flows in monsoons.

Motivated by these we have attempted to carry out a detailed analysis of shear flow instability which will throw light on various atmospheric phenomena.

In this dissertation

Chapter I introduces various preliminary concepts required for the study.

Chapter II summarizes the significant earlier contributions related to the present study.

In Chapter III, we have derived analytical expressions to calculate the growth rate σ of the disturbances in an unsteady stratified shear layer bounded between two horizontal infinite rigid boundaries. These expressions were evaluated numerically for a linear basic flow i.e., U(z) = z. The following conclusions were drawn from these results.

- Richardson number plays a very important role on the stability of stratified shear flows.
- The flow is unstable when $4R_i \frac{N^2}{N_0^2} < 0$ which is in qualitative agreement with the results obtained by Taylor (1931), Howard (1961) and Farrell and Ioannou (1993)
- increase in Brunt – Vaisala frequency decreases the frequency of the disturbances thereby stabilizing the flow
- Frequency of the disturbances increases with increasing wave number a thereby increasing the region of instability.

In Chapter IV we have investigated the stability of inviscid, stratified electrically conducting non parallel shear flow. The fluid was considered to be in a state of non parallel flow with the basic velocity profile (U(y),0,W(y)). The governing equations were derived. These equations reduce to those obtained by Padmini and Subbaiah (1995) when $R_m = 0$. We have investigated the stability of inviscid, stratified electrically conducting non parallel shear flow. The fluid was considered to be in a state of non parallel flow with the basic velocity profile (U(y),0,W(y)). The governing equations were derived. These equations reduce to those obtained by Padmini and Subbaiah (1995) when $R_m = 0$. From the results obtained in the previous section, the following conclusions are made.

- The effect of the magnetic Reynolds number is to increase the magnitude of the growth rate and hence increases the region of stability or instability.
- The stability of the system is greatly affected by the Brunt- Vaisala frequency N^2. The system remains stable for small N^2 and tend to be unstable as N^2 increases.

In Chapter V, the onset of shear instability in an inviscid Boussinesq stratified fluid which is rotating about a vertical axis with the angular velocity Ω is considered. Effect of rotation on a stratified shear layer is studied for asymptotically small wave numbers. We have neglected viscous friction. The mathematical efforts are focused on a basic flow which is linear. Some significant findings of the study are as follows.

- Richardson number plays a vital role in enhancing the growth rate of the disturbances
- Due to increase in rotation number, the growth rate of the disturbances decreases thereby making the flow stable.
- Increasing Richardson number and wave number increase the stream function while increase in stratification and rotation lead to a decrease in stream function.

The stability of the flow in the above mentioned problems was analysed using normal mode approach and the analysis was restricted to a long wave approximation.

Chapter VI deals with the stability of a rotating non parallel shear layer. The flow is confined between two infinite horizontal rigid planes at $z= z_1$, $z=z_2$. Approximate solutions are determined for examining the linear stability of a non parallel shear flow in a rotating system with respect to long wave approximation for a general velocity profile. Formulas for the determination of the instability characteristics are obtained and solved numerically in the case of linear velocity profiles. Some of the important findings are the following.

- Rotation number, longitudinal wave number and transverse wave number play a very significant role in determining the stability of a bounded, nonparallel shear layer.
- Increase in rotation number, longitudinal and transverse wave numbers increase the growth rate of the disturbances due to which the flow becomes unstable.

Chapter VII deals with the stability of an unbounded, rotating non parallel shear layers. An asymptotic approach is developed for examining the linear stability of a plane parallel shear flow in a rotating system with respect to long wave approximation for a general velocity profile. Formulas for the determination of the instability characteristics are obtained and solved numerically in the case of hyperbolic tangent profile. Some of the important findings are the following.

- Rotation number, longitudinal wave number and transverse wave number play a very significant role in determining the stability of an unbounded, nonparallel shear layer.
- Increase in rotation number and wave numbers increase the growth rate of the disturbances due to which the flow becomes unstable.

In Chapter VIII we have discussed the stability of buoyancy driven shear flows in inclined long cavities with end wall temperature difference. Analytical expressions are found for the growth rate and stream as a function of wave number and the stability of the flow is discussed for different inclinations and a wide range of Prandtl number.

Some of the important finding are

- Rayleigh number plays a significant role in enhancing the stability of the flow. Real part of the growth rate decreases due to increase in Rayleigh number.
- Angle of inclination and Prandtl number are found to increase the growth rate.
- Increase in angle of inclination, Prandtl number and the wave number are found to decrease the stream function
- Temperature profile increases with the increase in the Rayleigh number, Prandtl number and wave number.
- Increase in the angle of inclination of the cavity decreases the temperature of the flow.

Stability of Non parallel stratified flows and shear flows in inclined cavities are complicated problems of practical interest. We find very few published analytical works considering the stability of these problems. Hence in this dissertation we have attempted to derive analytical formulas to analyze the stability characteristics of few problems which will be helpful in explaining some geophysical and astrophysical phenomena.

Suggestions for Future Research

- The present problem can be effectively extended by considering scenarios close to practical applications. To mention a few
- Future work may also include studies taking into account the effects of nonuniform magnetic field, surface potential gradient and surface concentration gradient under the Hall effect phenomenon.
- The present work is a theoretical prediction based on mathematical models. The solutions are arrived by using perturbation technique. Instead, we can study these problems using more sophisticated methods like Chebychev Tau method
- The mathematical models of this study involve rigid flat boundaries. Future study of these problems with wavy walls may produce interesting results.
- The present work is limited to linear stability analysis. Nonlinear stability of these problems may also be studied.
- Effect of magnetic buoyancy on the stability of the problems mentioned in this thesis may be studied in future.

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