CHAPTER VI

SUMMARY AND CONCLUSIONS

We discussed in chapter I several evidences which indicate that even at high temperature essentially non-perturbative effects may determine the QGP properties. But so far mostly perturbative studies, except the lattice calculations, have been carried out to examine the collective properties of QGP. The results of such calculations have shown that, longitudinal oscillations and Debye screening length in QGP are similar to those in a Coulomb plasma. One of the aims of this work was to examine how the non-perturbative behavior can affect the various collective properties of the QGP. To achieve this aim we have adopted a classical approach to investigate various collective phenomena in the QGP. Classical approach was chosen because it has, unlike the quantal approach, many well-developed tools to examine the non-perturbative effects. It should be reemphasized that there are many applications of classical methods to study the collective properties of QGP. But in these works the plasma was considered to be essentially abelian (Coulomb type). Unlike these studies the present work considers the plasma to be genuinely non-abelian.

Following are the new features of the collective phenomena in QGP which our study reveals

(i) In the case of longitudinal oscillations, a new mode of the oscillations is found to be present. The basic equations of the problem contain a parameter ε which characterizes the strength of non-abelian terms. It was found that the oscillations have two

distinct modes: (1) the usual plasma mode where the oscillations have the same plasma frequency as that of the abelian plasma and the amplitude is nearly constant, (2) a nonlinear mode arising due to non-abelian terms with frequency higher than the abelian mode. Also the amplitude is greatly modified in this mode. It is also found that for higher values of ε chaotic behavior can sets in.

These are the characteristic features of the non-abelian oscillations which can persist even for very small values of ε. It is to be noted here that the second feature is not yet seen in any perturbative calculation.

(ii) In chapter IV it was shown that the screening of a moving source is considerably weaker than that of a static source. In this problem the test source is assumed to be moving with a velocity much less than the mean thermal velocity of plasma particles. Under this situation in a Coulomb plasma, screening behavior of a moving source does not show any departure from that of a static source . This is a novel non-abelian feature arising because in a non-abelian theory the color charge can flow from plasma particles to the gauge fields. Thus not surprisingly the perturbative treatments which consider QGP to be essentially abelian cannot obtain such result.

(iii) In our study of filamentation instability, Chapter V, we saw that when the non-abelian parameter k is non-zero the counter streaming color fluxes significantly lose their initial kinetic energy and converted it into randomly oscillating wave field and kinetic energies. But for the abelian plasma (k = 0) we saw a marginal reduction in the initial kinetic energy of the steams and hence less

stopping of the beams.

The results discussed above are qualitatively the new features of QGP collective behavior which perturbative treatments have not obtained It ought to be clear from this work that collective behavior in a non-abelian plasma, even in the simple situations considered here, is extremely rich in comparison with Coulomb plasma. However, at the same time it should be emphasized that many of these new features are not well understood. For example, in the case of the longitudinal oscillations in QGP it is not yet clear as to when the the crossover from abelian to non-abelian mode or vice versa takes place. The same holds true also for the stopping power - loss in initial kinetic energy - that we find from filamented states.

In view of the results obtained in this work, it seems worthwhile to systematically carry out non-perturbative studies of other interesting problems such as - magnetic screening, to study of different types of collective modes, solitonic solutions etc. It would also be worthwhile to investigate the implications, in relativistic heavy ion collisions, of the new collective behavior we have found.