

Chapter 6 Conclusions and Future Scope of the Work

In this thesis, we have provided a detailed analytical study of the effect of beam pre-bunching on gain and efficiency in free electron laser (FEL) and Cerenkov free electron laser (CFEL). The results are calculated on the parameters relevant to the experimental parameters for FEL and CFEL. The results for pre-bunched FEL are found to be consistent with the experimental observations of Cohen *et al.* [35] and it is shown that the beam bunching leads to considerable enhancement in the growth rate and hence gain and efficiency of the device. Our model of non local theory for pre-bunched FEL shows the decrease in the growth rate when compared to the local theory of Beniwal *et al.* [37]. Further, the slow wave pre-bunched FEL generates sub-millimeter waves with lower energy beams. The use of electromagnetic waves as a wiggler in a pre-bunched FEL has been analysed and shown that the scheme can be utilized for the generation of terahertz radiation. The finite geometry effects along with effect of a density pre-bunched beam has been studied in detail for CFEL.

The present work can be extended further as:

- The concept of beam pre-bunching used in FELs in order to achieve higher efficiency can be extended to Travelling Wave Tubes (TWTs). Hence the effect of pre-bunched electron beam can be studied and examined on energy extraction efficiency in a TWT.

- As all the microwave experimental devices are bounded, the effect of finite boundaries along with the effect of pre-bunched beam can be studied for TWTs, as it will provide a more practical perspective.
- Efficiency enhancement analysis in FELs and CFELs can be performed by better parameter optimization, as this is one of the major issues in FELs.
- The proposed scheme involving the design of alternate wigglers for FELs can be utilized and the effect of different electrostatic and electromagnetic wave wigglers along with beam pre-bunching can be studied for the generation of infrared and optical frequencies.
- The study and analysis of gyrotron employing a pre-bunched electron beam can be taken up for the future work.
- Numerical simulation can be done using numerical methods for all these above mentioned high power Microwave devices (FEL, CFEL, TWT and gyrotron) and the results can be compared with the present analytical findings and with the existing experimental observations.