# PREFACE

Conventional microwave tubes cease to generate high power at millimetre and sub-millimetre wave frequencies due to miniaturization of their transverse dimensions at these frequencies. However, there exist a variety of applications both for military and civilian purposes, where high power millimeter wave sources and amplifiers are needed. This led to extensive research and development activities in fast-wave gyro-sources and amplifiers. Gyro-devices, by virtue of the interaction phenomena called cyclotron resonance maser (CRM) interaction, are capable of producing high power in the millimetre and sub-millimetre wave frequency range. Among many of the devices, one such gyro-source, namely, the gyrotron is now commercially available for applications such as in plasma heating and material processing. However, from the standpoint of application in the information carrying systems, like millimeter-wave radar and communication, the gyrotrons are far from being mature, still requiring much improvement with respect to signal coherence and spectral quality. For such applications, gyro-amplifiers such as gyroklystron or gyro-TWT would be a more appropriate choice than an oscillator.

The gyroklystron amplifier is unparalleled in the family of gyro-devices, mainly because of its capability to provide high power with larger gain and moderate bandwidth in the millimeter and sub-millimeter wave frequency range. It is a fast-wave electron beam device that combines the multi-cavity configuration of a klystron amplifier with the energy extraction mechanism of the CRM instability similar to gyrotron. In recent years, considerable interest has been aroused towards the research and development of the gyroklystron amplifier due to its requirements for the use in supercollider, mm-wave radars, plasma heating experiments, communications, nonlinear spectroscopy and many other applications. This aspect perhaps motivated the author to enlarge, and strengthen the knowledge in the field of the gyroklystron amplifier.

At higher frequencies, the gyroklystron operation at higher order modes results in the dense RF spectrum which can cause probability of switching to the unwanted modes. This results into the serious problem of mode competition which affects the performance of the device, such as, efficiency, and RF power etc. Additionally, at higher frequencies, the device operation at higher harmonic modes also results in the mode competition from the nearby higher harmonic competing modes as well as the fundamental harmonic modes. These important aspects of mode competition have motivated the author of the present thesis to take up the multimode analysis and simulation studies of higher harmonic gyroklystron amplifier as research problem. Studies have been also made for the performance improvement of the gyroklystron amplifier in terms of bandwidth using the clustered-cavity technique. The author, from time to time, has reported the present work part-wise at national and international conferences as well as in reputed journals, namely, Physics of Plasmas (POP), IEEE Transactions on Plasma Science, and Journal of Fusion Energy.