Summary and Concluding Remarks

Channeling and channeling radiation have been studied and reviewed by various authors classically and in quantum mechanical frameworks. Study of defects has been one of the main applications of this channeling phenomena from the very beginning. The effects of defects on the charged particle motion in solids in general and on channeling in particular have been studied extensively during last 4 decades. In most of the analytical calculations, continuum model for axial and planar channeling has been used as starting point. The influence of external fields on the channeling process is of recent interest mainly due to its relevance and usefulness in the phenomena of emission of electromagnetic radiation such as undulator radiation.

The basic motivation of the work presented in this thesis has been to study the interactions of both internal and external perturbations on the channeling process. The internal perturbations are defects like dislocations and the external ones are mechanical periodic perturbations like hypersonic/acoustic waves (both longitudinal
and transverse). We have investigated the quantum aspects of all these processes.

The motion of a positively charged particle is usually represented by a harmonic oscillator potential. In our formulations we have included the anharmonicity effects and found considerable variation in the channeling and channeling radiation parameters due to it. In all previous analytical investigations on the effects of dislocations on channeling, the distortion induced curvature is assumed to give rise to an additional centrifugal force term. Thus the equations for transverse motion were solved with this centrifugal term without incorporating longitudinal motion. We have successfully developed an improved model to include the longitudinal motion by using the polar co-ordinate system. The continuity of the particle wavefunction in the longitudinal motion are the main highlights of this formulation. These same ideas are extended to investigate the effects of dislocations on undulator radiation problem.

Summing up the results, the presentation is divided into three parts:

(i) Effects of hypersonic field on channeling radiation

The effects of both longitudinal and transverse hypersonic waves on channeling radiation are considered. Also the influence of anharmonicity of the planar transverse continuum potential on the wavefunction of the positron and the fractional change in frequency due to these anharmonic effects are calculated. The spectral distribution of radiation intensity which is affected by the external hypersonic field and additionally by anharmonicity, proves the earlier predictions that radiation intensity can be increased by the interaction of external fields [86]. The transverse perturbation effects (with acoustic waves of lower amplitudes) are to be given special mention, which is a first step in the study of undulator radiation, where waves of higher amplitudes are being used [87].
(ii) Effects of dislocations on channeling radiation

Effects of dislocations on channeling are studied for both positron and electron channeling. A quantum mechanical model, where the affected region is divided into four parts separated by 3 boundaries, has been developed. Continuity of wave functions and their derivatives across these boundaries gave channeling and dechanneling co-efficients [85]. A comparison of the dechanneling probabilities due to electron and positron channeling in a dislocation effected region is done in detail in this study [88].

The effects of anharmonic term in the positron planar potential on the distortion coefficient and number of bound states and other channeling parameters like frequency of radiation, are studied and compared with those obtained in the harmonic case. The change in the channeling probabilities for particle in the ground state (an initially well-channeled particle) and that in the first excited state due to anharmonicity are calculated. We found an increase in the radius of dechanneling cylinder due to anharmonicity [89].

(iii) Effects of dislocations on channeling in a periodically bent crystal

The effects of dislocations on channeling phenomena in a periodically bent crystal (crystalline undulator) are studied for the first time. The distortion effects of both the dislocation affected regions and the periodically bent channels are represented in terms of waves with comparable amplitudes and wavelengths. Therefore, the distortion effects due to dislocations can be modulated on the periodic distortions (resulting for example due to undulators). In this analysis, we consider both the situations namely; $\lambda_d > \lambda_u$ (low dislocation density) and $\lambda_d < \lambda_u$ (high dislocation density), where $\lambda_d$ and $\lambda_u$ represent the wavelength of both dislocation affected region and periodically bent channel respectively. It is found that for low dislocation density,
the crystalline undulator parameters play a major role where as in the case of high dislocation density, undulator parameters have minimal effects on the radiation [90].

In summary, since no crystal is perfect (just as no human being is perfect!) any study of channeling/channeling radiation and crystalline undulators is incomplete without the consideration of defects and other field interactions. The present work is a broad study of these effects of distortions and field interactions on channeling of both positive and negative particles through crystals.
Future outlook

In our study on the effects of internal and external perturbations, we have used various aspects of quantum formulations of the positive and negative charged particle propagation in a crystal. The theoretical methods we have developed can be used in the study of various other applications of channeling and channeling radiation. The formulations on the study of the effects of longitudinal hypersonic field on channeling radiation were helpful in the analysis of the effects of transverse perturbations (lower amplitude) as in section 2.3 of chapter 2. The same theory can be extended to study the crystalline undulator which was previously based on classical assumptions.

The method developed in chapter 3 to study the effects of the curvature due to dislocations were extended to study its effects on a periodically bent channel (chapter 5). This methodology can form the basis to study the channeling and dechanneling phenomena due to any kinds of distortions in the crystal. Focussing of beams by the bent channels is well known application of this formulation where one uses bent crystal channeling concepts. Another possible application of these investigations and results presented, can be in study of volume reflection, where the particles are deflected from a curved channel. This is a phenomena complimentary to bent crystal channeling and has applications in shielding from radiation, both in the contexts of high energy accelerators as well as outer space radiation.

In our final chapter we have tried to find the channeling conditions in a periodically bent channel affected by dislocations. All the earlier investigations on undulators are classical predictions and never considered any effects of defects in the channel. Our formulations can give a better model for realization of the crystalline undulators.